ORIGINAL ARTICLE

The Benson Complex Figure Test: Normative Data for the Healthy Iranian Population

Minoo Sisakhti [1], Helia Hosseini [2], Seyed Amir Hossein Batouli [3], Hassan Farrahi [4*]

[1] *Department of Cognitive Psychology, Institute for Cognitive Sciences Studies, Tehran, Iran*

[2] *School of Medicine, Tehran University of Medical Sciences, Tehran, Iran*

[3] *Department of Neuroscience and Addiction Studies, School of Advanced Technologies in Medicine, Tehran University of Medical Sciences, Tehran, Iran*

[4] *Kavosh Cognitive Behavior Sciences and Addiction Research Center, Department of Psychiatry, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran*

*Corresponding Author: Hassan Farrahi
Email: h.farrahi14@gmail.com

Received: 03 May 2023 / Accepted: 21 November 2023

Abstract

Purpose: Visual-related abilities such as visual memory and visuo-constructional skills are among the cognitive abilities with fundamental importance for normal cognitive function, and their impairment is manifested in many neurological and psychiatric disorders. The present study aimed to generate normative data for the Benson Complex Figure Test (BCFT), a well-known simplified version of the Rey-Osterrieth Complex Figure Test, in Iran and to assess the effect of demographic variables of age, gender, and education on its various measures.

Materials and Methods: The present study was conducted in 2017-2018 as part of the Iranian Brain Imaging Database (IBID) project. The study sample consisted of 300 normal individuals in the age range of 20 to 70 years, with an equal number of participants and an equal proportion of genders in each age decade (#60). Independent and dependent variables, respectively, were age (classified by five decades including 20-30-year-olds, 31-40-year-olds, 41-50-year-olds, 51-60-year-olds, and 61-70-year-olds) and performance in the BCFT (defined in terms of 3 scores on a copy, recall, and recognition of the geometric figure and 2 scores on time of copy and recall).

Results: The correlation matrix among the variables showed that age and education have a significant correlation with most of the BCFT scores, while gender only has a significant correlation with recognition score. Multivariate analysis of variance showed the effect of age, gender, and their interaction on scores, while education did not make a significant difference in the BCFT scores. Also, the t-test showed a significant difference between men and women in recall and recognition, so women and men showed better performance in recall and recognition, respectively.

Conclusion: In summary, our results suggest that demographic variables of age, gender, and education affect visual memory and visuospatial abilities, and it is essential to generate normative data for research or clinical settings.

Keywords: Complex Figure; Cognition; Visuospatial; Memory.

DOI: https://doi.org/10.18502/fbt.v11i2.15339

1. Introduction

The efficiency of human performance is evaluated based on various levels of cognitive abilities or capabilities in facing everyday problems, dealing with them adaptively, and solving them constructively. There are various cognitive capacities, the strength or harmony of which contributes to the adaptive functioning of humans and their flexibility in the surrounding complex world [1]. Various cognitive capabilities such as intelligence, verbal and nonverbal memory, language, attention, and executive functions have been considered to explain typical or atypical functioning. Neuropsychology is a basic and clinical science that tries to explain human cognitive abilities by relating brain and behavior functions, and in other words, by examining the behavioral and psychological manifestations of normal and abnormal brain conditions [2]. Indeed, neuropsychological assessment is considered one of the most important scientific fields with advanced methods which is expected to be effective in measuring and making decisions about goals such as determination of diagnosis, rehabilitation/treatment planning, forensic determination, educational planning, baseline of function for subsequent testing, capacity for independent living, pre- and post-medical intervention, and localization of lesion [3].

Visual-related abilities such as visual memory and visuo-constructional skills are among the cognitive abilities that are one of the components of comprehensive neuropsychological assessment (batteries) or are measured independently or along with some other functions [4]. These abilities are of fundamental importance for normal cognitive function, and their impairment is manifested in many neurological and psychiatric disorders [5]. One of the reasons for the popularity and importance of visuospatial tests in neurodegenerative disorders is that visuospatial impairments are among the first symptoms of these diseases [6]. So far, several tests have been designed and standardized to measure these abilities [4]. The Rey-Osterrieth Complex Figure Test (ROCFT) is one of the most widely used neuropsychological tests to measure visuospatial abilities and visual memory. Since reproducing the figure in the ROCFT is a complex cognitive task that requires organizing the figure into a meaningful perceptual unit, this test is also used as a useful tool to evaluate the executive functions of the frontal lobe.

The ROCFT was developed by Andre Rey in 1941 in brain-damaged patients and the first normative data on 230 children and 60 adults was published by Osterrieth in 1944 [6]. Based on a survey conducted by the National Academy of Neuropsychology and the International Neuropsychological Society, the ROCFT is the eighth most widely used neuropsychological test, the third most widely used test for measuring memory, the ninth most widely used test for measuring executive functions, and the first widely used test for measuring visuospatial /visuoconstructional abilities [3]. Due to the high popularity of the ROCFT in research and clinical settings, extensive research has been conducted to collect its normative data in healthy populations in various countries – for example, the United States [7, 8], Italy [9], Spain [10, 11], Canada [12], Latin America [13], Greece [14] and Portugal [15]. In addition, this test has been repeatedly studied on different age groups – children [16], adults [17], and elderly [18]. Also, ROCFT, in addition to being used for a better and more accurate understanding of visuospatial abilities and visual memory, is widely used to measure these abilities in clinical conditions, especially neurodegenerative diseases such as dementia, Parkinson, and aphasia [5] and psychiatric disorders [19].

So far, several versions and scoring methods of the ROCFT have been introduced. The Benson Complex Figure Test (BCFT) is a simplified version of the ROCFT that was developed by Frank Benson [5, 6], and was used in many researches, especially on patients with neurodegenerative disorders. Compared to the ROCFT, the BCFT is less affected by executive functions and can provide a purer evaluation of visual-spatial features [5]. The BCFT consists of three trials: copy (in which the figure has to be copied from a geometric figure), recall (in which the figure has to be recalled after a 10–15 min interval), and recognition (in which the target figure has to be recognized amongst three other figures) [6, 20]. The BCFT, like its predecessor the ROCFT, allows the measurement of multiple mechanisms of cognitive impairment, and for this reason, it is a good candidate for measuring visuo-spatial abilities, visual memory, and to some extent other functions such as including attention and concentration, fine-motor coordination, visuospatial perception, planning and organization, and spatial orientation [20]. Among the advantages of this test, we can point out the ease of implementation, the subjects' comfort with it, and its low influence on language and culture [5, 20].

The BCFT has been used repeatedly in examining the cognitive impairments of older adults [21, 22] and patients with mild cognitive impairment [23], Parkinson's disease [24], primary progressive aphasia [25], and dementia [6, 26]. Specifically, most studies using the BCFT have looked at differences between patients with behavioral variants of frontotemporal dementia (bvFTD), patients with Alzheimer's disease, and healthy controls [20]. It is worth noting that to measure visuo-constructional functions and visual memory in cognitive aging and dementia, the BCFT has been included in three batteries of neuropsychological tests: UDSNB 3.0 (Neuropsychological Battery of the Uniform Data Set, National Alzheimer's Coordinating Center (NACC)) [27], GENFI (the Genetic Frontotemporal dementia Initiative) [20], and TAS (Online Tasmanian Tests battery) [28]. In addition, the age-, sex- and education-related normative data of the BCFT has been collected in three studies [20, 27, 29].

Although some tests, including measures of visuospatial skills and visual memory, are less dependent on language and culture compared to other tests, nevertheless, for a better understanding and measurement of the possible deficit, the collection of normative data based on demographic variables is necessary [2, 4]. To the best of our knowledge, in Iran, clinicians show great interest in neuropsychological tests, and every year many articles are published by Iranian researchers about or using these tests. In Iran, the normative data have also been provided for some widely used neuropsychological measures including the Color Trials Test (CTT) [30], the phonemic and semantic verbal fluency test (VFT) [31], the Rey auditory verbal learning test (RAVLT) [32], and the Stroop test [33]. However, many well-known neuropsychological measures still lack Iranian population normative data, and in some cases, clinicians may have to refer to published normative data from other countries to make clinical decisions. As such, there is a high need for normative data for each one of the neuropsychological instruments. Such norms will enable the clinicians and researchers to compare individual’s cognitive performances with available norms, and this may eventually result in increased diagnostic value of the cognitive measures.

To the best of our knowledge, so far there hasn’t been any normative data reported for the BCFT in Iran. The BCFT is short and simple to perform, and it is increasingly used in the cognitive assessment of elderly people or patients with various types of neurodegenerative diseases. Considering the growing importance of neuropsychological assessments and the need to access regional normative data, the present study aimed to (a) collect the normative data appropriate to the Iranian population, (b) cover a longer age range (ages 20 to 70), and (c) have both genders equally present in the study sample. In addition to the above objectives, we sought to answer the question that, like some normative data in the populations of other countries [20, 27, 29], demographic variables of age, gender, and education have an effect on the cognitive functions of visuospatial abilities and visual memory in the Iranian population.

2. Materials and Methods

2.1. Data

The present study was conducted in 2017-2018 as part of the Iranian Brain Imaging Database (IBID) project in collaboration with and under the supervision of a group of international experts to prepare normative measures of normal brains for research and clinical purposes [34]. In this project, in addition to functional and structural imaging, in order to investigate the cognitive and psychological correlates of the structural and functional properties of the brain in the Iranian population, a series of well-known tests were performed by a trained cognitive psychologist with a master's degree in the same order for all participants and in one day. As a result, a considerable neural, cognitive, and psychological database was collected for further analyses. The BCFT was one of the cognitive tests that was performed to evaluate visual memory and visuospatial abilities. The study sample consisted of 300 normal individuals in the age range of 20 to 70 years, with an equal number of participants and an equal proportion of genders in each age decade (# 60). Independent and dependent variables, respectively, were age (classified by five decades including 20-30-year-olds, 31-40-year-olds, 41-50-year-olds, 51-60-year-olds, and 61-70-year-olds) and performance in the BCFT (defined in terms of 3 scores on a copy, recall, and recognition of the geometric figure and 2 scores on time of copy and recall).

2.2. Procedure

Participants were recruited by advertising the research project on online social networks such as Instagram and Telegram (For more and complementary information, see Batouli *et al*. [34] and Sisakhti *et al*. [35]. Since the present study was part of the IBID project and many issues had to be considered in relation to neuroimaging, several inclusion and exclusion criteria were used. The inclusion criteria were weight below 110 kg, age between 20 and 70 years, Iranian nationality, ability to read, and consent to participate in all steps of the study. The exclusion criteria were having cognitive, medical and mental health problems including using drugs and being addicted to alcohol (only based on the subjective report); any diagnosed internal or neurologic diseases, such as asthma, high blood pressure, diabetics, cardiovascular diseases, high cholesterol, migraine, head trauma, encephalitis, epilepsy, meningitis, multiple sclerosis, liver disease, hepatitis, HIV+, anemia, stroke, or cancer; current medications used for neurologic disorders; any history of chronic headache, tinnitus, dizziness, seizure, nausea, or memory impairments; family history of any disease; any surgery with anesthesia (with exceptions on tonsillectomy/adenoidectomy, pulling wisdom tooth, cesarean delivery, and vasectomy); a history of losing consciousness; any metal objects in the body, such as a pacemaker, dental brace, coronary stent, any type of implant, tattoo, etc.; being claustrophobic; and being pregnant or breastfeeding.

To exclude individuals with cognitive, medical, and mental health problems from the study, all participants were interviewed twice by a general practitioner and a trained cognitive psychologist. In addition, after entering participants in the study and gathering the data from them, if the obtained scores in cognitive and mental health tests were extreme outliers (> ±3.3 standard deviation) were excluded from the sample. After cognitive, medical, and mental health screening, eligible individuals were invited to participate in functional and structural imaging in the National Brain Mapping Laboratory (NBML) and comprehensive cognitive and psychological assessment. Part of the inclusion criteria were being in the age range of 20 to 70, fluent in Persian, and having the ability to read. Exclusion criteria were a history of neurological and/or psychiatric illness, a history of illicit drugs, a history of systemic disease, the current use of any medication that affects cognitive function, and visual or auditory impairments. Participation in the study was voluntary and written consent was received from the participants. The present study was approved by the ethics committee of the National Institute for Medical Research Development (NIMAD). (For more information on the IBID project, inclusion and exclusion criteria, and methods, see Batouli *et al.* [34]). It should be noted that due to (a) the existence of multiple tests in the IBID project and the impossibility of performing other visual memory and visuospatial skills tests to assess its convergent validity and (b) the impossibility of re-implementing the BCFT to measure the reliability of test-retest, in the present study, we decided not to take any other tests to re-evaluate its validity and reliability.

2.3. About the Benson Complex Figure Test

The BCFT is a simplified version of the Rey-Osterrieth Complex Figure Test that was first developed by Frank Benson [6] and since then, it has been used to evaluate visual memory and visuospatial skills in different populations, from healthy individuals to patients with various neurodegenerative diseases [20, 24]. The BCFT consists of three trials: In the first trial, which aims to assess the ability to reproduce and copy a geometric shape, the subject is asked to draw from the figure placed in front of her/him with a non-colored pen. The subject is told, "Please copy this figure as best you can." After completing the copy trial, the figure is placed in front of the subject for 5 seconds and she/he is told to be sure that she/he has remembered the figure because later she/he will be asked to draw it again from memory. In the second trial, which aims to assess the ability to recall from delayed memory, after a 10 to 15-minute delay the subject is asked to draw from memory the previously shown figure. Subjects should be given as much time as needed to complete the delay trial. Also, other figure-copy tests should not be administered during this trial. In the third trial, which aims to evaluate the second ability of memory, i.e. recognition, the subject is asked to distinguish the target figure from three other distracting geometric figures [20, 27]. The start and stop times of the BCFT are recorded by the examiner. Also, the ROCFT should not be administered on the same day before the BCFT.

Scoring follows the rules provided in UDSNB 3.0 (Neuropsychological Battery of the Uniform Data Set, National Alzheimer's Coordinating Center) [27]. Scoring is done based on two criteria of accuracy and placement and the eight elements are given points from 0 to 2.

For accuracy, the element drawn must be recognizable as the target element and meet the additional criteria listed below. Leniency is given for wavy lines (e.g., due to tremors). A protractor and ruler should be used for making angle and distance judgments. Extraneous lines are acceptable unless otherwise indicated in the scoring rules. For placement, the element need not be accurate, it must only bear some slight resemblance to the target element (with leniency), be placed correctly, and meet the additional placement criteria below. Major rotation of an element is not acceptable for placement credit. The maximum score of 2 is given when both the accuracy and placement of the copied or recalled figure are correct. As a result, the scores for both copy and recall trials range from 0 to 16. A bonus point – adding up to a maximum score of 17 – is given when the figure is well-drawn (i.e., each element must be accurately drawn, all elements must be properly placed, all elements must be drawn in proper proportions, all connections between elements must be clean, and no extraneous lines may be present) [20]. The subject's performance in the recognition trial is scored as 0 (incorrect) or 1 (correct).

2.4. Statistical Analysis

According to the common procedure in collecting normative data for cognitive tests, mean and standard deviation were used in the descriptive analysis of demographic data and the performance of participants in the BCFT. Pearson's and Spearman's correlation coefficients were used to investigate the association between demographic variables and the BCFT scores. One-way and three-way analysis of variance (ANOVA) were used to compare the genders in terms of age and education years and to evaluate the effect of each demographic factor on the BCFT scores, respectively. In addition, Tukey's post hoc test was used to examine whether different age groups differed significantly in the BCFT scores and education years. A p-value below 0.05 was considered statistically significant.

3. Results

The total number of participants was 300. The age range of the sample was 20–70 years, with 60 participants in each decade of age and an equal proportion of genders in each group. Most of the participants had a diploma and bachelor's or master's degree, and the frequency of participants with under-diploma or doctorate education was less. Therefore, according to many previous studies [36, 37], two levels of diploma/sub-diploma and higher diploma were used to investigate the effect of education level on the BCFT scores. One-way ANOVA showed that males and females were not significantly different in terms of age (F = 0/168, P < 0/682) and years of education (F = 2/06, P < 0/152). Table 1 shows the mean and standard deviations of age and education years of participants classified by five age groups.

Table 1. The means and standard deviations of age groups

Age groups (year olds)	Age		Years of education	
	Mean	Standard deviation	Mean	Standard deviation
20-30	25.26	2.9	16.98	1.87
31-40	35.35	3.12	16.41	4.15
41-50	45.64	3	14.69	3.22
51-60	54.67	2.95	14.12	3.74
61-70	66.03	4.06	12.95	3.39

Tukey's post hoc test was used to examine whether the different age groups differed significantly in terms of education years. Tukey's test showed that 20-30-year-olds differed significantly from other groups (P < 0.0001) and, on average, had a higher education than all other groups. 31-40-year-olds, in addition to 20-30-year-olds, differed only from 61-70-year-olds (P < 0.019) and had higher education on average. 41-50-year-olds and 51-60-year-olds differed only from 20-30-year-olds (P < 0.0001). In the end, 61-70-year-olds differed from 20-30-year-olds (P < 0.0001) and 31-40-year-olds (P < 0.019). In other words, the older the participants, the less their years of education.

As shown in Table 2, the correlation matrix between all our variables showed that age and education had a significant correlation with most of the BCFT scores, while gender only had a significant correlation with recognition score. Pearson's correlation coefficient was used to examine the association between age and the BCFT scores, and Spearman's correlation coefficient was used to examine the association between gender and education with age and the BCFT scores. As can be seen, age has a negative association with education and recognition score (P < 0.01) and a positive association with copy time and recall time (P < 0.05). This means that with increasing age, education years and recognition score decrease, and copy time and recall time increase. It can also be seen that gender has a positive association with recognition score (P < 0.05), which indicates the superiority of men in this measure. In addition, education

Table 2. Correlation matrix between demographic variables and the BCFT scores

	Age	Gender	Education	Copy	Copy Time	Recall	Recall Time	Recognition
Age	1							
Gender	-.055	1						
Education	-.326**	.016	1					
Copy	.082	-.058	.126*	1				
Copy Time	.120*	-.098	-.119	-.219**	1			
Recall	.001	-.065	.147*	.938**	-.181**	1		
Recall Time	.138*	-.081	-.195**	-.169**	.687**	-.15**	1	
Recognition	-.159**	.125*	.103	-.133*	-.075	-.068	-.112	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

has a positive correlation with copy ($P < 0.01$), recall ($P < 0.01$), and recall time ($P < 0.05$), which means an increase in copy and recall scores and recall time with increasing education. Overall, based on these findings, from the two memory abilities, i.e. recall and recognition, age shows a significant correlation with recognition and education with recall. Also, age showed a significant correlation with both recall time and copy time, while education showed this correlation only with recall time.

As shown in Table 3, multivariate analysis of variance (MANOVA) showed the effect of age ($F = 1.749$, $P < 0.013$), gender ($F = 2.482$, $P < 0.033$), and their interaction ($F = 2.285$, $P < 0.0001$) on scores, while education did not make a significant difference in the BCFT scores ($F = 1.195$, $P < 0.312$). Age had a significant effect on the copy ($F = 2.555$, $P < 0.028$) and recognition ($F = 3.001$, $P < 0.012$) scores. On the other hand, gender had a significant effect on recognition scores ($F = 9.088$, $P < 0.003$). The interaction of age and gender also had a significant effect on copy time ($F = 3.287$, $P < 0.007$), recall ($F = 2.470$, $P < 0.033$), and recall time ($F = 5.246$, $P < 0.0001$).

Tukey's post hoc test showed that the age groups of 51 to 60 and 61 to 70 have a significant difference in recall ($P < 0.048$), so that the 61 to 70 age group has a higher average and this indicates their better performance. Also, there is a significant difference between the age groups of 31 to 40 and 61 to 70 in recognition ($P < 0.049$), so that the group of 31 to 40 showed a better performance.

An independent t-test was used to study the difference between men and women in the BCFT scores (See Table 4). As can be seen, Levene's test showed that copy time ($F = 0.769$, $P < 0.381$) and recall time ($F = 3.165$, $P < 0.076$) had similar variances, while the variance of copy ($F = 6.084$, $P < 0.014$), recall ($F = 4.058$, $P < 0.045$), and recognition ($F = 18.874$, $P < 0.0001$) scores were heterogeneous. When the assumption of multivariate

Table 3. MANOVA between demographic variables and the BCFT scores

Source	Dependent Variable	df	Mean Square	F	Sig.	Partial Eta Squared
Age Category	Copy	5	6.663	.147	.981	.003
	Copy Time	5	2397.910	2.555	.028	.054
	Recall	5	18.840	.248	.941	.005
	Recall Time	5	1183.121	1.589	.164	.034
	Recognition	5	.183	3.001	.012	.062
Gender	Copy	1	8.776	.194	.660	.001
	Copy Time	1	1491.592	1.589	.209	.007
	Recall	1	7.480	.098	.754	.000
	Recall Time	1	2223.696	2.986	.085	.013
	Recognition	1	.555	9.088	.003	.039
Age Category * Gender	Copy	5	80.215	1.769	.120	.038
	Copy Time	5	3084.487	3.287	.007	.068
	Recall	5	187.862	2.470	.033	.052
	Recall Time	5	3906.537	5.246	.000	.104
	Recognition	5	.115	1.888	.097	.040

Table 4. Comparison of differences between two genders in the BCFT measures

Measures	Levene's test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	df	Sig. (2-tailed)
Copy	6.084	.014	1.699	154.181	.091
Copy Time	.769	.381	1.329	283	.185
Recall	4.058	.045	1.982	166.385	.049
Recall Time	3.165	.076	1.539	283	.125
Recognition	18.874	.000	-2.146	248.872	.033

normality is established, the relationships between the variables have similar variances. Therefore, equality of variances is strongly related to the assumption of normal distribution. Also, the t-test showed that there was a significant difference between men and women in recall ($t = 1.982$, $P < 0.49$) and recognition scores ($t = -2.145$, $P < 0.033$). This is while women obtained more scores in recall than men and men also showed more successful performance in recognition than women.

To provide normative data about the participants' performance in the BCFT, Table 5 presents the mean and standard deviation of the BCFT scores by five age groups. According to the significant association between the performance in the BCFT and the variables of gender and education in the present study, the mean and standard deviation of the scores of the BCFT are classified according to gender (Table 6) and education years (Table 7) in five age groups. Overall, it is evident from Table 5 that copy, copy time, and recall time increase with age, while the performance of recognition memory decreases. Also, the differences between the two genders and the two levels of education are evident in Tables 6 and 7.

4. Discussion

To the best of our knowledge, despite the increasing use of the BCFT in clinical and non-clinical studies and

Table 5. Means and standard deviations of Benson test performance classified by age group

Age Category	Copy		Copy Time		Recall		Recall Time		Recognition	
	M	SD	M	SD	M	SD	M	SD	No	Yes
20-30	16.69	.61	68.71	33.59	15.22	1.65	52.26	30.34	4	60
31-40	16.73	.71	66.03	34.68	14.85	2.26	49.88	28.75	1	66
41-50	16.59	.95	65.69	29.92	13.83	2.57	56.49	25.10	5	58
51-60	17.63	6.64	64.65	47.82	14.74	11.82	57.95	38.12	3	48
61-70	19.29	17.66	87.88	84.12	16.26	20.70	64.35	37.04	7	28

Table 6. Means and standard deviations of the BCFT performance classified by age group and gender

Age Category	Gender	Copy		Copy Time		Recall		Recall Time		Recognition	
		M	SD	M	SD	M	SD	M	SD	No	Yes
20-30	Female	16.82	.39	70.36	33.52	15.52	1.39	55.53	29.93	3	29
	Male	16.56	.76	67.00	34.12	14.91	1.86	48.89	30.87	1	31
31-40	Female	16.76	.50	61.26	27.87	14.85	2.19	44.33	18.57	1	33
	Male	16.70	.88	70.94	40.39	14.85	2.36	55.59	35.82	0	33
41-50	Female	16.61	1.08	71.22	27.61	13.61	2.86	60.43	23.86	4	31
	Male	16.57	.79	58.57	31.73	14.11	2.15	51.43	26.17	1	27
51-60	Female	18.63	8.81	70.63	60.20	17.07	15.44	65.54	46.41	1	26
	Male	16.37	.88	57.17	24.37	11.83	2.35	48.46	21.54	2	22
61-70	Female	22.11	23.87	100.26	108.43	20.00	27.79	69.42	47.16	6	13
	Male	15.94	1.18	73.19	38.82	11.81	2.43	58.34	19.23	1	15

Table 7. Means and standard deviations of the BCFT performance classified by age group and education

Age	Education	Copy		Copy Time		Recall		Recall Time		Recognition	
		M	SD	M	SD	M	SD	M	SD	No	Yes
19-28	<=12	17.00	.00	54.25	22.23	15.25	1.71	34.75	11.18	0	4
	>12	16.67	.63	69.66	34.12	15.21	1.66	53.41	30.89	4	56
29-38	<=12	16.50	1.03	67.06	21.11	15.06	2.05	52.59	15.18	0	16
	>12	16.77	.61	66.07	39.94	14.67	2.47	49.03	33.27	1	42
39-48	<=12	16.42	1.27	71.00	28.33	13.77	2.60	62.40	26.53	3	22
	>12	16.78	.48	59.92	28.23	13.92	2.60	51.16	22.52	2	35
49-58	<=12	18.29	8.69	60.25	25.55	15.17	12.77	57.47	28.74	3	19
	>12	17.36	4.52	56.36	23.38	14.68	11.52	50.96	32.41	0	27
59-68	<=12	21.79	25.45	95.21	56.14	17.93	28.85	75.71	41.03	3	11
	>12	18.30	9.85	61.80	22.49	15.65	13.73	51.57	23.33	3	17

the collection of its normative data in three studies, this test has not been used in Iranian studies, nor has normative data been collected for it. As far as we know based on an extensive search in scientific databases, the results presented in this article are the first normative data of the BCFT in the Iranian population. The correlation matrix among the variables showed that age and education have a significant correlation with most of the BCFT scores, while gender only has a significant correlation with recognition score. More specifically, with increasing age, recognition score decreases and copy time and recall time increase, and with increasing education, copy and recall scores and recall time increase. In addition, the t-test showed a significant difference between men and women in recall and recognition, so women and men showed a better performance in recall and recognition, respectively. Taken together, these results suggest that the above-mentioned demographic variables affect visual memory and visuospatial abilities and that it is essential to generate normative data for clinical or research use.

Our finding showed that most BCFT scores are negatively associated with age. In other words, participants' performance on many BCFT scores worsened with age. Evidence regarding the association between age and episodic memory performance (verbal and non-verbal) has been repeatedly reported in the studies [38-40] and meta-analysis [41]. For example, many studies on the most widely used version of the complex form test, the ROCFT, have shown that most scores worsen with age [12, 14, 15]. This finding also applies to the three studies on the BCFT normative data collection [20, 27, 29]. In Weintraub *et al.*'s study, increasing age was associated with worse scores [27]. The same finding was repeated in the study of Sachs *et al.* [29] and Jiskoot *et al.* [20].

According to our finding, which represents a clear inconsistency with the literature,among the two BCFT visual memory scores, i.e. recall and recognition, only recognition showed a correlation (negative) with age. In the study of Jiskoot *et al.* [20], although no significant association was observed between copy in the BCFT and age, there was a significant correlation between increasing age and decreasing recall memory both in this study and in two other studies [27, 29]. A recent meta-analysis found that although there are age-related memory deficits in recall tasks, there is clear evidence of comparable deficits in recognition memory [42]. Another meta-analysis recently reported that, according to some studies, there are comparable age differences in recall and recognition performance, Although age differences appear to be greater in recall than recognition [41]. Given that in the literature, some issues such as cohort, sample size, or racial differences have been mentioned as factors influencing the results of studies, especially in memory [43], perhaps the difference observed in the present study with the other three studies related to BCFT can be attributed factors like them.

Another finding indicated that there are significant differences between the two genders in memory performance: women and men showed better performance in recall and recognition, respectively. In the study of Tsatali *et al.* [14], gender was the only predictor of recognition score among the ROCFT scores. In the study of Jiskoot *et al.* [20], women obtained a higher score in a copy of complex figures, but no significant difference was observed between women and men in recall and recognition. On the other hand, in the study of Weintraub *et al.* [27], women performed worse than men in the recall of complex figures, but there was no significant difference in copy. Much evidence in favor of female advantage in recall performance has already been reported in the literature [43]. However, this female advantage is often attributed to their better performance in verbal episodic memory [44, 45]. In fact, many findings have been reported showing that men outperform women in tasks that require visuospatial processing [43, 46].

Some biological explanations have been proposed to explain the causes of these gender differences [47]. In particular, pre- and postnatal hormone exposures have been proposed as possible reasons for gender differences [43]. It has been shown that prenatal androgen exposure early in gestation in girls with Congenital Adrenal Hyperplasia (CAH) influences their spatial performance [48]. Also, some studies have shown that the early postnatal testosterone surge in infants may have a negative correlation with subsequent verbal performance in both boys and girls [49, 50]. In addition, it has been shown that women with complete androgen insensitivity syndrome (CAIS) perform on par with control women on an episodic memory task, suggesting a negative effect of prenatal androgens on episodic memory performance [51].

Another finding of the current study was that education has a significant correlation with most BCFT scores and with increasing education, recall and copying scores also increase. Consistent with this study, in the study of Sachs *et al.* [29], education was the strongest predictor of most UDSNB 3.0 measures (more than age and gender) and a significant difference was observed between less-educated and more-educated participants. This finding is also repeated in the study of Weintraub *et al.* [27]. However, in the study of Jiskoot *et al.* [20], although a significant association was observed between education and recall, the correlation between education and recognition in the BCFT was weak. Overall, there is a lot of evidence in the literature in favor of the association between years of education and episodic memory performance, including the BCFT and the ROCFT [10, 13, 29].

One obvious benefit of providing normative data of this type is that it can be used to interpret individual scores. Since most neuropsychological tests are standardized on normal populations, reporting the mean and standard deviation of the normative sample often allows comparisons to be made between individual scores and normative scores. According to the commonly recommended rule in interpreting neuropsychological tests, 1.5 standard deviations below the normative mean indicate that a person's performance was worse than approximately 93.3% of the normative sample. According to this rule, -1.5, -1.7, -2.0, -2.5, and -3.0 standard deviations below the normative mean will indicate mild, mild to moderate, moderate, severe, and very severe levels of impairment, respectively [52].

4.1. Limitations and Future Research

The first limitation of our study was that the participants were on average highly educated, and this may reduce the generalizability of its findings. It is recommended that in the following studies, participants who are in the lower range of education be selected. The second limitation relates to not differentiating the participants based on ethnicity, race, socioeconomic status, and cultural factors. Considering the variables of ethnicity, race, socioeconomic status, and cultural factors may be important to collect normative data. In one of three studies of collecting the normative data for the UDSNB 3.0 (including the BCFT) [27], it was found that African-Americans overall performed lower than whites on the examined tests. It is recommended that in future studies, participants are also classified by ethnicity or race to determine its possible effect on BCFT performance. The third limitation relates to the possible bias in sampling or self-reports of the memory abilities. In future studies, it is recommended to use randomized samples or behavioral and objective tasks to measure memory performance. The fourth limitation was that the present research is a cross-sectional study. The importance of research design in memory research is because according to the research literature, episodic memory decline is reported in cross-sectional studies more than in longitudinal studies [35]. Therefore, it is recommended to conduct longitudinal studies on the effect of age on memory performance, especially using the BCFT test. Another limitation of the study is its relatively small sample (300 participants). This sample size may not be enough to generalize the results to the healthy Iranian population. It is recommended to use a larger sample in future studies to collect normative data in the Iranian population.

5. Conclusion

Our research aimed to generate normative data for a well-known simplified version of the ROCFT in Iran and to assess the effect of demographic variables of age, gender, and education on its various measures. Generally, our findings indicate that with increasing age, recognition score decreases and copy time and recall time increase; women outperform men in recall and men outperform women in recognition; and with increasing education, copy and recall scores and recall time increase. These findings emphasize the importance of using demographic-related normative data in research and clinical settings.

References

1- Muriel Deutsch Lezak, Diane B Howieson, David W Loring, and Jill S Fischer, Neuropsychological assessment. *Oxford University Press, USA*, (2004).

2- Cecil R Reynolds, Robert A Altmann, and Daniel N Allen, "Neuropsychological Testing." in *Mastering Modern Psychological Testing: Theory and Methods*: *Springer*, (2021), pp. 499-541.

3- Laura A Rabin, Emily Paolillo, and William B Barr, "Stability in test-usage practices of clinical neuropsychologists in the United States and Canada over a 10-year period: A follow-up survey of INS and NAN members." *Archives of Clinical Neuropsychology,* Vol. 31 (No. 3), pp. 206-30, (2016).

4- Esther Strauss, Elisabeth MS Sherman, and Otfried Spreen, A compendium of neuropsychological tests: Administration, norms, and commentary. *American chemical society*, (2006).

5- Xiaonan Zhang, Liangliang Lv, Guowen Min, Qiuyan Wang, Yarong Zhao, and Yang Li, "Overview of the complex figure test and its clinical application in neuropsychiatric disorders, including copying and recall." *Frontiers in Neurology,* p. 1304, (2021).

6- Katherine L Possin, Victor R Laluz, Oscar Z Alcantar, Bruce L Miller, and Joel H Kramer, "Distinct neuroanatomical substrates and cognitive mechanisms of figure copy performance in Alzheimer's disease and behavioral variant frontotemporal dementia." *Neuropsychologia,* Vol. 49 (No. 1), pp. 43-48, (2011).

7- Philip S Fastenau, Natalie L Denburg, and Bradley J Hufford, "Adult norms for the Rey-Osterrieth Complex Figure Test and for supplemental recognition and matching trials from the Extended Complex Figure Test." *The Clinical Neuropsychologist,* Vol. 13 (No. 1), pp. 30-47, (1999).

8- MM Machulda *et al.*, "Mayo's older Americans normative studies: Visual form discrimination and copy trial of the Rey–Osterrieth complex figure." *Journal of clinical and experimental neuropsychology,* Vol. 29 (No. 4), pp. 377-84, (2007).

9- P Caffarra, G Vezzadini, F Dieci, F Zonato, and A Venneri, "Rey-Osterrieth complex figure: normative values in an Italian population sample." *Neurological sciences,* Vol. 22pp. 443-47, (2002).

10- Jordi Peña-Casanova *et al.*, "Spanish multicenter normative studies (NEURONORMA Project): Norms for the Rey–Osterrieth complex figure (copy and memory), and free and cued selective reminding test." *Archives of Clinical Neuropsychology,* Vol. 24 (No. 4), pp. 371-93, (2009).

11- R Palomo *et al.*, "Spanish normative studies in young adults (NEURONORMA young adults project): Norms for the Rey–Osterrieth Complex Figure (copy and memory) and Free and Cued Selective Reminding Test." *Neurología (English Edition),* Vol. 28 (No. 4), pp. 226-35, (2013).

12- Marie-Pier Tremblay *et al.*, "Normative data for the Rey–Osterrieth and the Taylor complex figure tests in Quebec-French people." *Archives of Clinical Neuropsychology,* Vol. 30 (No. 1), pp. 78-87, (2015).

13- D Rivera *et al.*, "Rey–Osterrieth Complex Figure–copy and immediate recall: Normative data for the Latin American Spanish speaking adult population." *NeuroRehabilitation,* Vol. 37 (No. 4), pp. 677-98, (2015).

14- Marianna Tsatali *et al.*, "Rey complex figure test (RCFT): Norms for the Greek older adult population." *Applied Neuropsychology: Adult,* Vol. 29 (No. 5), pp. 958-66, (2022).

15- Selene G Vicente *et al.*, "Regression-based norms for the hopkins verbal learning test-revised and the rey–osterrieth complex figure in a portuguese adult population." *Archives of Clinical Neuropsychology,* Vol. 36 (No. 4), pp. 587-96, (2021).

16- D Rocha-Amador *et al.*, "Use of the Rey-Osterrieth Complex Figure Test for neurotoxicity evaluation of mixtures in children." *Neurotoxicology,* Vol. 30 (No. 6), pp. 1149-54, (2009).

17- Simona Luzzi *et al.*, "Non-verbal memory measured by Rey–Osterrieth Complex Figure B: normative data." *Neurological sciences,* Vol. 32pp. 1081-89, (2011).

18- Anita M Hubley, "Using the Rey–Osterrieth and Modified Taylor Complex Figures with older adults: A preliminary examination of accuracy score comparability." *Archives of Clinical Neuropsychology,* Vol. 25 (No. 3), pp. 197-203, (2010).

19- Bern G Lee, Julie-Ann Kent, Bernice A Marcopulos, Beth C Arredondo, and Monique Wilson, "Rey–Osterrieth complex figure normative data for the psychiatric population." *The Clinical Neuropsychologist,* Vol. 36 (No. 7), pp. 1653-78, (2022).

20- Lize C Jiskoot *et al.*, "The Benson Complex Figure Test detects deficits in visuoconstruction and visual memory in symptomatic familial frontotemporal dementia: A GENFI study." *Journal of the Neurological Sciences,* Vol. 446p. 120590, (2023).

21- Karolina M Lempert *et al.*, "Neural and behavioral correlates of episodic memory are associated with temporal discounting in older adults." *Neuropsychologia,* Vol. 146p. 107549, (2020).

22- Lok-Kin Yeung *et al.*, "Anterolateral entorhinal cortex volume is associated with memory retention in clinically unimpaired older adults." *Neurobiology of aging,* Vol. 98pp. 134-45, (2021).

23- Tau Ming Liew, "Developing a brief neuropsychological battery for early diagnosis of cognitive impairment." *Journal of the American Medical Directors Association,* Vol. 20 (No. 8), pp. 1054. e11-54. e20, (2019).

24- Jihye Ryu, Joe Vero, Roseanne D Dobkin, and Elizabeth B Torres, "Dynamic digital biomarkers of motor and cognitive function in Parkinson's disease." *JoVE (Journal of Visualized Experiments),* (No. 149), p. e59827, (2019).

25- Donna C Tippett *et al.*, "Visuomotor figure construction and visual figure delayed recall and recognition in primary progressive aphasia." *Aphasiology,* Vol. 34 (No. 12), pp. 1456-70, (2020).

26- Megan S Barker *et al.*, "Proposed research criteria for prodromal behavioural variant frontotemporal dementia." *Brain,* Vol. 145 (No. 3), pp. 1079-97, (2022).

27- Sandra Weintraub *et al.*, "Version 3 of the Alzheimer Disease Centers' neuropsychological test battery in the Uniform Data Set (UDS)." *Alzheimer disease and associated disorders,* Vol. 32 (No. 1), p. 10, (2018).

28- Jane Alty *et al.*, "The TAS Test project: a prospective longitudinal validation of new online motor-cognitive tests to detect preclinical Alzheimer's disease and estimate 5-year risks of cognitive decline and dementia." *BMC neurology,* Vol. 22 (No. 1), pp. 1-13, (2022).

29- Bonnie C Sachs *et al.*, "Expanded demographic norms for version 3 of the Alzheimer disease centers' neuropsychological test battery in the uniform data set." *Alzheimer disease and associated disorders,* Vol. 34 (No. 3), p. 191, (2020).

30- Mahgol Tavakoli, Majid Barekatain, and Golita Emsaki, "An Iranian normative sample of the Color Trails Test." *Psychology & Neuroscience,* Vol. 8 (No. 1), p. 75, (2015).

31- Ensiyeh Ghasemian-Shirvan, Saba Molavi Shirazi, Masoume Aminikhoo, Mostafa Zareaan, and Hamed Ekhtiari, "Preliminary normative data of Persian phonemic and semantic verbal fluency test." *Iranian journal of psychiatry,* Vol. 13 (No. 4), p. 288, (2018).

32- Mehrnaz Rezvanfard, Hamed Ekhtiari, Alireza Rezvanifar, Maryam Noroozian, Reza Nilipour, and Gelavizh Karimi Javan, "The Rey Auditory Verbal Learning Test: alternate forms equivalency and reliability for the Iranian adult population (Persian version)." *Archives of Iranian medicine,* Vol. 14 (No. 2), pp. 0-0, (2011).

33- Ayyoub Malek, Issa Hekmati, Shahrokh Amiri, Jaber Pirzadeh, and Hossein Gholizadeh, "The standardization of Victoria Stroop color-word test among Iranian bilingual adolescents." *Archives of Iranian medicine*, Vol. 16 (No. 7), pp. 0-0, (2013).

34- Seyed Amir Hossein Batouli *et al.*, "Iranian brain imaging database: a neuropsychiatric database of healthy brain." *Basic and Clinical Neuroscience,* Vol. 12 (No. 1), p. 115, (2021).

35- Minoo Sisakhti, Seyed Amir Hossein Batouli, and Hassan Farrahi. "The Rey Auditory Verbal Learning Test: Age-, Gender- and Education-Related Normative Data for The Iranian Healthy Population." *Frontiers Biomed Technol*;Vol. 10 (No.3):p. 308-320, (2023).

36- Sara Cavaco *et al.*, "Auditory verbal learning test in a large nonclinical Portuguese population." *Applied Neuropsychology: Adult,* Vol. 22 (No. 5), pp. 321-31, (2015).

37- Ondrej Bezdicek *et al.*, "Czech version of Rey Auditory Verbal Learning test: normative data." *Aging, Neuropsychology, and Cognition,* Vol. 21 (No. 6), pp. 693-721, (2014).

38- Elvira Lara *et al.*, "Episodic memory and verbal fluency tasks: normative data from nine nationally representative samples." *Journal of the International Neuropsychological Society,* Vol. 27 (No. 1), pp. 89-98, (2021).

39- Michael Rönnlund, Lars Nyberg, Lars Bäckman, and Lars-Göran Nilsson, "Stability, growth, and decline in adult life span development of declarative memory: cross-sectional and longitudinal data from a population-based study." *Psychology and aging,* Vol. 20 (No. 1), p. 3, (2005).

40- Stacey L Danckert and Fergus IM Craik, "Does aging affect recall more than recognition memory?" *Psychology and aging,* Vol. 28 (No. 4), p. 902, (2013).

41- Stephen Rhodes, Nathaniel R Greene, and Moshe Naveh-Benjamin, "Age-related differences in recall and recognition: A meta-analysis." *Psychonomic Bulletin & Review,* Vol. 26pp. 1529-47, (2019).

42- Scott H Fraundorf, Kathleen L Hourihan, Rachel A Peters, and Aaron S Benjamin, "Aging and recognition memory: A meta-analysis." *Psychological bulletin,* Vol. 145 (No. 4), p. 339, (2019).

43- Martin Asperholm, Nadja Högman, Jonas Rafi, and Agneta Herlitz, "What did you do yesterday? A meta-analysis of sex differences in episodic memory." *Psychological bulletin,* Vol. 145 (No. 8), p. 785, (2019).

44- Joel H Kramer, Kristine Yaffe, Jeanne Lengenfelder, and Dean C Delis, "Age and gender interactions on verbal memory performance." *Journal of the International*

Neuropsychological Society, Vol. 9 (No. 1), pp. 97-102, (2003).

45- Agneta Herlitz, Lars-Göran Nilsson, and Lars Bäckman, "Gender differences in episodic memory." *Memory & cognition*, Vol. 25 (No. 6), pp. 801-11, (1997).

46- Laura Tascón, Joaquín Castillo, and José Manuel Cimadevilla, "Age-related differences in the elderly in a spatial recognition task." *Memory*, Vol. 27 (No. 10), pp. 1415-22, (2019).

47- Agneta Herlitz, Lena Reuterskiöld, Johanna Lovén, Petra P Thilers, and Jenny Rehnman, "Cognitive sex differences are not magnified as a function of age, sex hormones, or puberty development during early adolescence." *Developmental neuropsychology*, Vol. 38 (No. 3), pp. 167-79, (2013).

48- David A Puts, Michael A McDaniel, Cynthia L Jordan, and S Marc Breedlove, "Spatial ability and prenatal androgens: meta-analyses of congenital adrenal hyperplasia and digit ratio (2D: 4D) studies." *Archives of sexual behavior*, Vol. 37pp. 100-11, (2008).

49- Karson TF Kung, Wendy V Browne, Mihaela Constantinescu, Rebecca M Noorderhaven, and Melissa Hines, "Early postnatal testosterone predicts sex-related differences in early expressive vocabulary." *Psychoneuroendocrinology*, Vol. 68pp. 111-16, (2016).

50- Gesa Schaadt, Volker Hesse, and Angela D Friederici, "Sex hormones in early infancy seem to predict aspects of later language development." *Brain and language*, Vol. 141pp. 70-76, (2015).

51- Anna Strandqvist *et al.*, "Cognitive abilities in women with complete androgen insensitivity syndrome and women with gonadal dysgenesis." *Psychoneuroendocrinology*, Vol. 98pp. 233-41, (2018).

52- Ronald C Petersen, Glenn E Smith, Stephen C Waring, Robert J Ivnik, Eric G Tangalos, and Emre Kokmen, "Mild cognitive impairment: clinical characterization and outcome." *Archives of neurology*, Vol. 56 (No. 3), pp. 303-08, (1999).