Chapter 9

Differentiating Normal Cognitive Aging from Cognitive Impairment No Dementia: A Focus on Constructive and Visuospatial Abilities

Radka Ivanova Massaldjieva

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.73385

Abstract

Constructive and visuospatial abilities in normal and in pathological aging (cognitive impairment, no dementia, CIND) are investigated. The sample includes 188 participants over 60 years of age, divided in 2 groups: healthy subjects (MMSE ≥28), without cognitive complaints, and individuals with CIND (MMSE between 24 and 27 and subjective cognitive complains). Drawing of cube and drawing of house, Benton Visual Retention Test (BVRT), and Block design are used to test the hypothesis that short visuoconstructive and visuospatial tests can distinguish normal from pathological cognitive aging in its very early stages. Results proved the discriminative sensitivity of BVRT general assessment criteria and of omissions and distortions in CIND. The diagnostic sensitivity of a modification of Moore and Wike [1984] scoring system for house and cube drawing tasks was confirmed as well. Drawing of cube and house could be used for quick screening of CIND in subjects over 60. Principal component analysis with oblimin rotation was performed to explore the different dimensions in the visuospatial and visuoconstructive abilities in old age. A four-factor structure was established, all four factors explaining 71% of the variance.

Keywords: constructive ability, visuospatial ability, cognitive impairment, no dementia (CIND), old age, house and cube drawing, BVRT

1. Introduction

1.1. Mild cognitive impairment and cognitive impairment, no dementia

Age-related cognitive changes are widely discussed by the researchers, and rich evidences about them are reported in the literature [1]. The decline in cognitive functioning has long

been traditionally considered a consequence of normal aging [2], and since dementia caused by neurodegenerative diseases has a long preclinical stage [3–7], it may not be recognized for months or even years [8, 9]. Early differentiation of normal aging from neurodegenerative pathology is of great importance in terms of timely adequate treatment helping to postpone further cognitive decline [9–14]. A better understanding of normal aging itself is also extremely important because of the increase in life expectancy and, respectively, of elderly people. This necessitates the implementation of effective measures for successful and active aging, and they require more clarity about the cognitive aging dimensions.

Research related to the early diagnosis of dementia in Alzheimer's disease (AD) and vascular dementia brought about the differentiation of many terms indicating boundary or intermediate conditions of cognitive changes without dementia [3, 5–7, 11, 15–20]. The variety of such terms created over the years and their content are widely discussed in the literature and will not be analyzed here.

The most frequently used term—mild cognitive impairment (MCI)—is defined as an early stage of neurodegenerative pathology, a transient phase between normal aging and dementia. It is a syndrome characterized by a cognitive decline, sufficiently serious to be considered a result of normal aging, but not reaching the criteria for dementia syndrome [6] and associated with an increased risk of developing dementia, most commonly Alzheimer's disease [5, 13, 18]. Criteria for diagnosis of preclinical forms of vascular dementia—mild cognitive impairment of vascular type (MCI-V) and vascular cognitive impairment, no dementia—have been also developed [21, 22].

The definition of MCI syndrome, made by Petersen et al. [23], comprises subjective complaints of memory impairment, normal daily activity, normal cognitive functioning, memory impairment (1–2 standard deviations below the norms), and absence of dementia. This definition is later amplified with impairments of other areas of cognition [24] like naming, abstract thinking, spatial localization, and ability to communicate. The relations between the states of memory decline and conditions of cognitive impairments without significant memory changes are still unclear [11].

Another widely used term for milder impairment of cognition, situated between normal aging and dementia, is "cognitive impairment, no dementia, CIND," characterized by impairment in any objectively tested cognitive area. CIND does not require the determination of the degree or the specific cause of the cognitive decline [24]. It is a condition with similar criteria such as for mild cognitive impairment that could be applied when there is impaired performance of cognitive tests or cognitive complains [25, 26].

As a result of the Third Canadian Consensus conference on the diagnosis and treatment of dementia, Chertkow et al. [4] discuss important recommendations for family physicians in the efforts at providing "practical guidance on definition, diagnosis and treatment of mild cognitive impairment and cognitive impairment, no dementia." They consider it necessary for the general practitioner to know CIND as a condition with an increased risk of dementia and to monitor the patients with this condition.

1.2. Normative (non-pathological) and pathological cognitive aging

It is difficult to establish to what extent the cognitive changes, accompanying aging, are due to the increase in chronological age and to what extent they are associated with illness or lifestyle [27]. Intensive studies of the impact of age and different diseases on biological, mental, and cognitive changes have not validated sufficiently reliable markers that allow the differentiation of the normal (physiological aging) from pathological aging. The very term "normal" in relation to different characteristics of people in the old age has not enough clear boundaries [21, 28].

For the cognitive changes in elderly, a continuum is used at one end of which is cognitive functioning allowing active and independent life (normal aging) and at the other end significant cognitive impairments typical of dementia. Cognitive aging in late adulthood is one of the most important issues in aging processes research, because of its wide influence on all other aspects of older population life. Taking into account that cognitive aging is too complex to be described briefly, the Committee on the Public Health Dimensions of Cognitive Aging defines it as a lifelong process of change in cognitive functioning. At the same time, the necessity of operational definition is emphasized [29]. Approaching a fuller description and understanding of cognitive changes in later life require responses to different questions of great significance and among them: Are these changes in the elderly global or partial, affecting certain functions earlier? Which components of the cognitive system are the most vulnerable to impairments as a result of aging? How do these components change? How do the changes affect the performance of cognitive tasks, the everyday and social functioning? Are they significantly different patterns of cognitive change allowing accurate and reliable differentiation of normal (normative) from pathological cognitive aging, etc.?

The complexity of the topic has led to a wide variety of approaches and hypotheses. One of the most commonly used ways of thinking is based on Cattell subdivision of cognitive capacities of fluid and crystallized intelligence [30]. The first concept comprises the independent of social experience abilities involved in the processing of new information and problem solving. The second signifies the acquired (learned) cumulative knowledge, e.g., the vocabulary [1, 30, 31]. Results from multiple studies of age-related cognitive changes lead to the development of the so-called classic model of cognitive aging: the crystallized abilities show little or no decline up to 60 years of age or later, whereas fluid abilities decline steadily from age 20 to 80 [31–34]. A recent study exploring cognitive functioning in a representative sample of about 40,000 subjects from the UK, aged 16 to 100, confirmed that the processing effectiveness decreases earlier than the knowledge-based abilities that begin to decline from age 60 [35].

Fluid intelligence is considered connected with Spearman's g (general intelligence—a broad mental capacity underlying specific mental abilities) [see [36]]. Duncan et al. [37] have found that "g" reflects the brain frontal area functions. These findings relate the classic model of cognitive aging with another model, based on the brain localization of cognitive functions and postulating that executive functions, highly related to the frontal lobe, decline earlier than these dependent on the temporal cortex, hippocampus, and limbic system (e.g., memory) [36].

The decline of fluid abilities during the life span find different explanations in two groups of theories: The first group seeks a common factor that influences the worsening of the performance of various cognitive tasks. The age-related slowing of speed of cognitive performance or processing speed is frequently used to explain elders' worse results in neuropsychological testing, compared with younger individuals [1, 34]. The second group relies on diversity—the change of different processes at different speed during adult life [38].

The multifactor intelligence theories differentiate specific capabilities that are equally important for cognitive functioning. According to these theories, there is no common factor of the intelligence. Authors list different numbers of individual abilities from seven to 120 or more. Thurstone [38] distinguishes seven primary mental abilities: numerical, perceptual, verbal comprehension, word fluency, memory, spatial ability, and reasoning abilities [39, 40]. His conceptualization related to primary mental capabilities serves as a basis for H. Gardner's theory about the existence of multiple, relatively independent "intelligences" [41, 42]. Gardner [40] noticed that most intelligence tests measure mainly linguistic (verbal) and logical mathematical abilities, but not spatial, musical, bodily kinetic, and personal intelligence.

The doubts of some cognitive ability researchers, concerning the relevance of factor analysis to the effort to understand human intelligence, lead to the creation of the hierarchical theory of cognitive abilities, describing several general cognitive functions involved in the realization of a large part of the cognitive abilities and more specialized capacities placed higher in the hierarchy of the cognitive system [40]. It is not difficult to see the connection between this hierarchical model and the two-factor theory, according to which the results from each intelligence test depend on the Spearman's common intelligence and on the specific abilities necessary for the performance of each separate test task.

1.3. Constructive and visuospatial abilities and their later life changes

In Mapou's [43] hierarchical model of cognitive abilities, higher level skills depend on the capabilities of the lower levels. The visuospatial functions are modal specific and depend on global functioning (the intelligence) and on basic abilities like attention, sensory and motor functions, executive functions, and problem solving. R. Mapou divides the visual-spatial functions into perceptual abilities, constructive abilities, and spatial awareness. Perceptual abilities are related to the initial processing of the spatial information, which takes place after the sensory basic level and regardless of the motor response. These abilities are responsible for the acquisition of visual information. Constructive abilities include organizational and planning faculties realized through basic visual and motor functions. Spatial awareness involves the ability to orientate in the outer space as well as the awareness of the interior space.

The visuospatial abilities are very important for human everyday functioning, because they are an essential part of the save movement in the environment, that is not possible without a correct estimation of direction, distance, and spatial relationships between objects and places [29, 44]. Different authors depict a different structure of these abilities and propose

specific tasks for their assessment [45]. De Bruin et al. [44] present them as composed by spatial visualization, spatial perception, and mental rotation. The definition of Blazer et al. [[29], p. 40], "maintenance and manipulation of visual images," includes producing figures and matching objects and pictures, creating relationships between locations and recognizing faces.

Constructive ability (visual constructive praxis) is also a broad term used for very different types of activities, a common feature of which is assembling, joining individual parts into a single structure—a whole unit. This term refers to combining or organizing behavior in which the relationships between the component parts of the whole object must be understood in order to obtain the desired synthesis between them [46]. The term "constructive apraxia" was introduced by Kleist [see [47]], who defined it in 1914–1918, as an impairment of capacity for spatial organization in assembly, construction, or drawing of a given model, while the motor function is not affected [48]. According to Kleist, constructive apraxia is an executive function deficit that affects also the spatial part of the performance. Bradshaw et al. [49] consider the impairment of the constructive strategy in copying complex figures as part of the so-called dorsolateral prefrontal syndrome that is manifested by executive deficiency. For Kleist, constructive apraxia is independent of both the visual-spatial deficit and the motor disorders. He describes it as impaired integration of these two abilities. Later investigators found that constructive disturbance was almost always associated with a wider visual perceptive or visuospatial impairment [47].

Studies of age influence on cognitive functioning found that the elderly examined showed a decline not only in short-term memory and psychomotor speed but also in constructional and visual-spatial praxis and visual perceptual functions [31, 45, 50]. Constructive impairments can be detected in the early stages of dementia and Alzheimer's disease (AD) [8, 51, 52], but they are better studied in focal brain lesions than in normal aging and dementia. Visuospatial ability's progressive decline is found in patients with dementia in Alzheimer's disease and vascular dementia [8, 47, 53, 54].

A fundamental question, according to A. Benton, is whether patients with general intellectual disabilities have constructive apraxia as well. The author found in a study of 1967 that intellectually impaired patients showed a high incidence of failures in performing constructive tasks, but at the same time, a large number of patients with intellectual disabilities did not have significant difficulties in the performance of such tasks. Therefore, the author concludes that the general intellectual decline is not necessarily related to constructive apraxia [55]. These findings correspond to the subgroup models of cognitive impairments in Alzheimer's disease, expecting decline in particular cognitive domains rather than simultaneous advancing global impairments in the early stages of the disease [see [56]]. Using Factor Analysis of the Severe Impairment Battery results, Pelissier et al. [57] establish relative independence of constructive praxis and visual perceptive function from other cognitive functions. All this is in favor of the need for a separate and specific study of constructional and spatial impairments in normal and pathological aging to allow their better understanding.

1.4. Early recognition of pathological cognitive decline by visuoconstructive and spatial tasks

Assessment of cognitive impairments in the elderly is an important task of modern cognitive neuropsychology. Neuropsychological evaluation can respond to the expectations of valid and reliable differentiation of pathological from normal aging if it is accomplished by sufficiently sensitive, specific, and standardized psychometric tools [14]. The use of such tools is a requirement of the diagnostic algorithm for early discrimination of dementia from normal aging [9, 58]. The widely applied strategy to administer global clinical scales for screening and quantifying the level of individual cognitive deficit has low specificity, particularly in subjects with high or very low level of premorbid cognitive functioning and in the early stages of impairments in elderly [5, 14]. Short tests, assessing specific cognitive dysfunctions, are more accurate than the global cognitive scales [14, 59].

In order to detect age-related visual-spatial and constructive decline early enough, specific neuropsychological techniques are required. Such measures could be efficient and helpful if they take into account the age-related and pathological cognitive changes and assure accuracy of the assessment. Many different neuropsychological instruments are used to test the spatial functions [45]. The visuoconstructive ability is traditionally assessed by drawing of two- or three-dimensional figures [51, 52, 54] and block-building tasks [55] of varying complexity. Drawing neuropsychological tasks can detect the deficits in reproducing shapes, following their relationships in space, but it is difficult to standardize them [51], and in most cases, subject drawings are assessed "intuitively" and very rarely through an objective assessment system [52].

Drawing as a cognitive ability is not well studied in late-life adults. It is a complex multicomponent ability that engages perception, representation, memory, attention, spatial thinking, planning, and motor functions. Better knowledge of the structure of drawing process in old adults as well as of its age-related impairments can contribute to a more successful study of visual constructive and visual-spatial functions and their disturbances in old age.

Our study tests the hypothesis that short and easy-to-use visuoconstructive and visuospatial tests can be used to distinguish normal from pathological cognitive aging in its very early stages if appropriate, accurate, and valid criteria are applied. We use drawing of cube and drawing of house, together with other traditionally used and well-proven neuropsychological instruments—Benton Visual Retention Test (BVRT) and Block design—assessing visual memory, perception, constructional, and spatial abilities.

1.5. Aims of the chapter

The aims of this chapter are to explore the visuoconstructive and visuospatial abilities in normal and in pathological aging (CIND) above 60 years of age and to analyze:

1. The discriminative capacities of a set of visuoconstructive and visuospatial neuropsychological tasks in the differentiation of pathological (CIND) from normal cognitive aging over 60 years of age.

2. The influence of age on the visuoconstructive and visuospatial abilities in healthy elderly and individuals with CIND.
3. The patterns of Benton Visual Retention Test (BVRT) performance in normal aging and in CIND.

2. Method and procedure

2.1. Subjects and recruitment

The participants in this study were individuals over 60 years of age with normal daily functioning and without self-reported history of psychiatric and neurological disorders, residents of Plovdiv region, living independently in the community. The sample was divided in two groups: healthy subjects (MMSE ≥28), without cognitive complaints, and individuals with CIND (MMSE between 24 and 27 and subjective cognitive complains). The decision to accept the diagnostic category CIND was substantiated by the design of the study, which did not include the possibility of conducting detailed clinical, laboratory, and neuroimaging studies. After testing, all the participants from CIND group were advised to seek consultation from a general practitioner or neurologist to accurately identify the cause of the condition and the need for treatment. A total of 216 subjects were recruited for this study with the help of clubs for the elderly; 28 of them dropped out due to age below 60 years, impairments in every day functioning, visual disturbances that hindered neuropsychological testing, data from the interview about mild mental retardation, and test data for severe cognitive deficits. Only participants defining themselves as right handers were included in the study. Basic demographic characteristics of the study groups are shown in **Table 1**.

Groups: **Partial testing**	**Age (years)**			**Gender**		**Education**		
	Mean	SD	max	Male	Female	1	2	3
				n %		**n %**		
Healthy	68.11	6.89	88	34	69	20	48	35
				33%	67%	19.4%	46.6%	34.0%
CIND	71.11	7.58	89	37	48	33	33	19
				43.5%	56.5%	38.8%	38.8%	22.3%
Complete testing								
Healthy	67.00	5.19	78	11	29	3	24	13
				27.5%	72.5%	7.5%	60.0%	32.5%
CIND	70.36	6.86	83	8	14	5	10	7
				36.4%	63.6%	22.7%	45.5%	31.8%

Note: 1, primary and secondary school; 2, high school; and 3, college/university.

Table 1. Subject basic demographics.

2.2. Instruments

Assessment of correspondence to the inclusion criteria (administered to all subjects):

1. Mini-Mental State Examination (MMSE) [60], Bulgarian translation [61]—a short global scale for cognitive functioning, with subtests for spatial and temporal orientation, concentration, memory, aphasia, agnosia, and apraxia [8, 62]. The scale is the most widely used screening tool for cognitive impairments in late life in Bulgaria.
2. Semi-structured interview, collecting basic demographic information, and data on neuropsychiatric history and cognitive complains.
3. The Social and Occupational Functioning Assessment Scale—SOFAS (DSM-IV) [3, 63].

Neuropsychological assessment:

1. Benton Visual Retention Test (BVRT), form C, administration "A"—a well-known test of short-term visual memory, visual perception, and constructive ability. The "C" form is considered the easiest BVRT task that makes it appropriate for old adults [64].
2. Raven's Standard Progressive Matrices (RSPM)—a language and culture-free measure of fluid intelligence. The task comprises five sets of 12 black and white matrices, presenting pattern matching tasks with increasing difficulty, used as a test of general intelligence and nonverbal reasoning [65, 66]. The raw score is used in the analyses because of the lack of studies in Bulgaria on late-life RSPM performance.
3. Free drawing of a house and of a cube.
4. Block design—a subtest from Hamburg-Wechsler Intelligence Test, Bulgarian adaptation [67]; the task requires construction of observed patterns—two, four, nine, and 16 elemental figures—from the same multicolored cubes, with standard instruction. The time for task completion is not assessed. The score used in this study is the number of correctly reproduced patterns (accuracy of performance).

2.3. Procedures

The demographic and neuropsychiatric interviewing and the testing were conducted by a licensed clinical psychologist with experience in psychiatric disorder assessment (the chapter author). All the tests were administered individually on 2 separate days. To those who agreed to participate in the full 2-day testing (N = 62), all the study instruments were applied. The other participants (126) were tested with BVRT and RSPM. Subjects were assessed at the elderly club premises in prearranged days and hours.

BVRT cards were reproduced after a 10-s exposition (immediate recall trial) with the standard instruction and assessment: The subject was given 10 white sheets for the reproduction of the 10 test cards and pencil with rubber. Assessment took into account: (1) number of correct reproductions—each card reproduction is judged correct or wrong, and every correct card

reproduction received one point— and (2) specific types of errors (quality assessment). Types of errors for which points were awarded were as follows: (a) omissions, (b) distortions, (c) perseverations, (d) rotations, (e) misplacements, and (e) size errors.

Subjects received two white sheets of paper (15 × 21 cm) for the free drawings of cube and house and black pencil with rubber. The drawings were assessed following a modification of the scoring system of Moore and Wyke [52] developed by the author: One point was given for each line drawn from the front, top, and side walls of the cube (maximum nine points). Orientation of the cube was not evaluated. For the additional qualitative criteria of Moore and Wake, quantitative assessment (maximum of four points) was used. One point was given for three-dimensional representation, for the presence of additional elements (interior walls), for the cohesion of the figure, and for lack of spatial distortion (parallelism of the sides and accuracy of the corners).

Written informed consent was obtained from all participants. The study design and procedure were approved by the ethics committee of Medical University in Plovdiv, Bulgaria.

2.4. Data analysis

In order to achieve the study objectives, it was necessary to analyze the differences in test performance between (1) "normal" subjects and subjects with CIND and (2) participants up to and above 70 years of age. Descriptive statistic (frequencies, percents, means, standard deviations) was used to describe the sample as well as for the analysis of results regarding general scoring criteria and error types in study groups; comparison of test performance in different subgroups was made by t-test and Mann-Whitney test; RSPM performance was additionally described using Z-scores and chi-square test. The relationships between study variables were studied with Pearson and Spearman correlations and multiple regression analysis. We performed a principal component analysis to explore the structure of visuoconstructive and visuospatial abilities, involved in the study tests.

3. Results and interpretation

3.1. Performance in the diagnostic groups

Significant differences in BVRT total scores—mean total number of correct reproductions and mean total number of errors—were found when the normal subjects, and the subjects with CIND were compared ($p < .001$) (**Table 2**). (We use the term "normal" and "healthy" subjects to distinguish between normal and pathological aging, taking into account the conditionality of its use.) There were significantly more omissions and distortions (BVRT) in CIND group than in the normal group ($p < .001$). These differences can also be seen in the BVRT frequency distribution data—50% of the healthy participants had between three and six correct reproductions and made between seven and 12 errors; 50% of participants with CIND reproduced correctly between two and four cards and made between 10 and 14 errors. As for the different types of

Criteria	Diagnostic group	Mean score	SD	t	p
Total correct	Healthy	4.62	1.805	6.16	< .001
	CIND	3.21	1.328		
Total errors	Healthy	8.91	3.697	-6.23	< .001
	CIND	12.08	3.178		
Omissions	Healthy	1.74	1.925	−3.95	< .001
	CIND	3.14	2.765		
Distortions	Healthy	2.78	1.715	−5.22	< .001
	CIND	4.28	2.153		
Perseverations	Healthy	1.02	1.093	0.93	0.35
	CIND	0.87	1.100		
Rotations	Healthy	1.18	1.135	−2.41	0.17
	CIND	1.58	1.073		
Misplacements	Healthy	1.74	1.335	0.59	0.55
	CIND	1.62	1.291		
Size errors	Healthy	0.46	0.764	−0.98	0.33
	CIND	0.58	0.918		

Note: results from partial testing group.

Table 2. BVRT mean score comparison in the diagnostic groups (t-test).

errors that showed significant differences, 50% of normal subjects made zero to two omissions (one to five in CIND subjects) and, respectively, two to four distortions (2.50 to six in CIND).

Table 3 shows RSPM performance of the participants from both diagnostic groups (percentiles, means, and z-scores). Healthy subjects gave more correct answers than subjects with CIND (p<.001).

Performance of the house and cube drawing, as well as of the Block design tasks, was also significantly worse in the CIND group (Mann-Whitney test, $p < .01$) (**Table 4**). **Figures 1** and **2** present cube and house drawings in the diagnostic groups.

3.2. Performance in the age groups

When the healthy and CIND study participants were subdivided in age groups, healthy elders up to 70 years of age (N = 70) showed more BVRT correct reproductions and RSPM correct answers (p<.001); they made significantly fewer errors (total errors), as well as fewer omissions and distortions, than the oldest subjects from the same diagnostic group. Younger subjects with CIND (N = 48) made significantly fewer number of errors, as well as fewer omissions (BVRT). They also showed significantly better result in RSPM performance than the subjects over 70 years of age (**Table 5**).

Healthy	**RSPM total correct**	**Mean (SD)**	**Z score**
Minimum	12		−1.505
Maximum	53		2.003
Percentiles			
25	19.00	29.58	
50	28.00	(11.69)	
75	40.00		
CIND			
Minimum	5		−1.716
Maximum	55		4.430
Percentiles			
25	14.00	17.87	
50	16.00	(7.08)	
75	20.00		
		t = 8.462	Chi-square = 1.880
		P < .001	P < .001

Table 3. RSPM results in the diagnostic groups.

No significant differences were found between the age groups with respect to house and cube drawing tasks, as well as to Block design subtest both for healthy and CIND participants (Mann-Whitney test, p >.05).

In the healthy group with partial testing (N = 103), age correlated positively and significantly with BVRT total errors, as well as with omissions, distortion, and rotation scores

Test variables **Diagnostic group**	**Mean rank**	**Mann-Whitney U**	**Sig. (Two-tailed)**
Total house score	37.04	218.5	P = .001
Healthy	21.43		
CIND			
Total cube score	35.86	265.5	P = .009
Healthy	23.57		
CIND			
Block design score	37.16	213.5	P = .001
Healthy	21.20		
CIND			

Table 4. Mean comparison for cube and house drawing and block design.

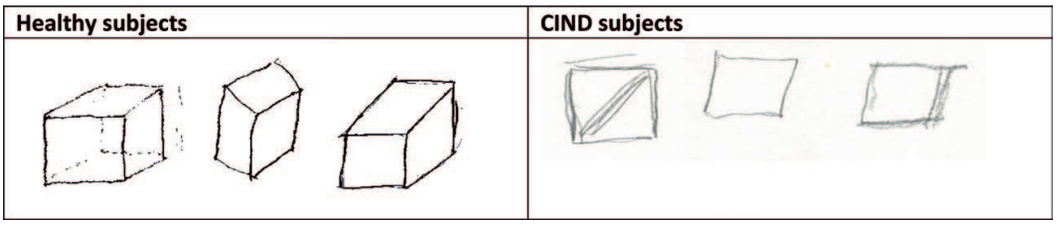

Figure 1. Examples of cube drawings in the diagnostic groups.

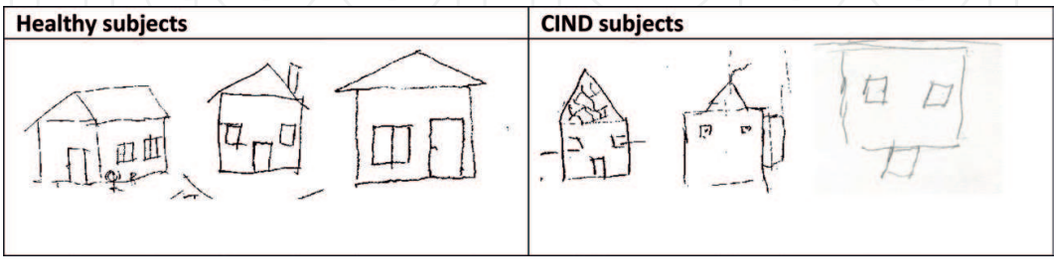

Figure 2. Examples of house drawings in the diagnostic groups.

(r between .213 and .520, $p < .05$). As expected the relation between age and BVRT total correct score was negative ($r = -.397$, $p < .001$).

In the CIND group, age correlated positively and significantly only with BVRT omissions ($r = .359$, $p = .001$). The relation between age and size errors score did not reach acceptable significance ($r = -.202$, $p = .064$). Negative moderate significant correlation existed between MMSE (r CIND = −.257 and r healthy = −.385) and RSPM total score (r CIND = −.340 and r healthy = −.535) on the one hand and the age, on the other, in both diagnostic groups.

In the group with complete testing, age correlated only with RSPM score, both in the whole group (Pearson correlation), N = 62, and in the diagnostic groups (Spearman correlation)—moderate significant negative correlation ($p < .001$ and $p < .05$, respectively).

3.3. Relationships between test measures

3.3.1. Correlation

Most of the measures assessing the performance of the drawing tasks correlate moderately and significantly (Pearson correlation), except for cube total score and BVRT correct and error scores (**Table 6**). As expected Block design and RSPM measures are in a significant relation with all other variables (r between .326 and .591) as well as between them ($p < .001$). Further analyses (Spearman correlations) were accomplished for the same variables in each diagnostic group separately. In the group of healthy participants, the cube total score correlates only with the house total score ($r = .345$, $p = .029$). BVRT total correct and total errors correlate highly between them ($r = -.886$, $p < .001$) and moderately with RSPM ($p < .001$). There is a significant correlation between BVRT total errors and Block design score ($r = -.318$, $p = .046$).

Healthy	BVRT total correct	BVRT total errors	BVRT O	BVRT D	BVRT P	BVRT R	BVRT M	BVRT SE	RSPM total correct
60-70 years									
N=70									
Mean	5.01	8.04	1.40	2.34	1.04	1.06	1.74	0.46	32.97
SD	1.77	3.56	1.61	1.63	1.03	1.13	1.29	0.77	11.53
>70 years									
N=33									
Mean	3.79	10.76	2.45	3.70	0.97	1.45	1.73	0.45	22.39
SD	1.60	3.37	2.33	1.53	1.24	1.12	1.44	0.75	8.37
T-test	**3.378**	**−3.686**	**−2.347**	**−4.007**	.315	−1.672	.055	.016	**5.273**
	P=.001	**P<.001**	**P=.023**	**P<.001**	P=.753	P=.098	P=.956	P=.987	**P<.001**
CIND									
60-70 years									
N=48									
Mean	3.40	11.44	2.33	4.21	0.98	1.54	1.67	0.69	20.04
SD	1.45	3.32	2.36	2.15	1.10	1.09	1.21	1.05	8.06
>70 years									
N=37									
Mean	2.97	12.92	4.19	4.38	0.73	1.62	1.57	0.43	15.05
SD	1.12	2.81	2.92	2.18	1.10	1.06	1.40	0.69	4.21
T-test	1.515	**−2.178**	**−3.236**	**−.**359	1.037	**−.**339	.349	1.275	**3.684**
	P=.133	**P=.032**	**P=.002**	P=.720	P=.303	P=.736	P=.728	P=.206	**P<.001**

Note: O. omissions; D. distortions; P. perseverations; R. rotations; M. misplacements; SE. size errors.

Table 5. Mean comparison for BVRT and RSPM results in the age groups for healthy subjects and CIND.

In the CIND group, results showed a different picture, probably affected by the heterogeneity of cognitive impairments, which is characteristic of this early stage of pathological decline [56, 68]. BVRT total correct and total errors correlate moderately between them (r = −.447, p = .037), and there is no significant correlation between them and RSPM. The cube total score correlates only with the Block design score (r = .470, p = .027). The house total score also correlates with Block design score and with Benton total errors(r = −.644, p = .001). Benton total errors correlate with Block design score as well (r = −.607, p = .003).

Moderate significant correlation was found between BVRT omissions and the cube drawing score (r = −.378, p = .016) and between BVRT distortions and the Block design score (r = −.485, p = .002), as well as the RSPM score (r = −.480, p = .002), in healthy participants. In CIND group the scores for the different types of errors did not correlate with the outcome measures from other tests.

Variables	Age	Block design	Cube score	House score	RSPM	BVRT correct	BVRT errors
Age							
Coefficient r	1	−.071	−.124	−.035	**−.437**	−.113	.130
Sig.		−.071	.335	.788	**.000**	.382	.315
Block design							
Coefficient r	−.071	1	**.400**	**.448**	**.505**	**.352**	**−.529**
Sig.	.586		**.001**	**.000**	**.000**	**.005**	**.000**
Cube score							
Coefficient r	−.124	**.400**	1	**.437**	**.326**	.213	−.204
Sig.	.335	**.001**		**.000**	**.010**	.097	.112
House score							
Coefficient r	−.035	**.448**	**.437**	1	**.332**	**.400**	**.420**
Sig.	.788	**.000**	**.000**		**.008**	**.001**	**.001**
RSPM							
Coefficient r	**−.437**	**.505**	**.326**	**.332**	1	**.573**	**−.591**
Sig.	**.000**	**.000**	**.010**	**.008**		**.000**	**.000**
BVRT correct							
Coefficient r	−.113	**.352**	.213	**.400**	**.573**	1	**−.864**
Sig.	.382	**.005**	.097	**.001**	**.000**		**.000**
BVRT errors							
Coefficient r	.130	**−.529**	−.204	**−.420**	**−.591**	**−.864**	1
Sig.	.315	**.000**	.112	**.001**	**.000**	**.000**	

Table 6. Intercorrelations between age and visuospatial/visuoconstructive test scores.

In the group with partial testing, we found high significant negative correlation between BVRT total correct and total errors both for healthy and for CIND participants. As for the types of errors, (1) in the group of healthy subjects, the total number correct and total errors correlated moderately and significantly with all types of errors. (2) In CIND group BVRT total correct score correlated moderately and significantly only with the number of omissions and distortions (p=.001) and BVRT total errors—with omissions and distortions (p<.001) as well as with misplacement (p = .016).

3.3.2. Multiple regression analysis

Multiple regression analyses were performed to determine if age continued to predict BVRT score, when education and RSPM (fluid intelligence) score were taken into account. Gender was added as a possible predictor only for BVRT distortions (in healthy group) and for BVRT omissions in CIND group. These were the only variables that correlated with the gender of participants (low negative correlation for distortions, which means more errors in male subjects, and

low positive correlation for omissions—more errors, made by females). Dependent variables were the outcome measures that correlated with age in both diagnostic groups. As it could be seen from **Table 7**, age predicted significantly the variance in BVRT omissions, together with fluid intelligence for healthy participants and together with education and fluid intelligence for the participants with CIND. For the other BVRT outcome measures, age is no more significant performance predictor when other demographic variables and fluid intelligence are included in the analyses.

Fluid intelligence contributed to the variance in all the variables analyzed, except for BVRT rotation in the healthy group. Education was a significant predictor only for the total errors, made by healthy participants and for the number of omissions in CIND subjects.

Diagnostic group	Dependent	Predictor	F	B	Beta	t	R^2
Healthy	Total correct	Age	11.848***	−.025	−.097	−.967	.264
		Education		.110	.163	1.738	
		RSPM		.057	.372	**3.479****	
	Total errors	Age	24.401***	.087	.162	1.839	.425
		Education		−.250	−.180	**−2.170***	
		RSPM		−.146	−.463	**−4.896*****	
	Omissions	Age	11.954***	.092	.329	**3.302****	.266
		Education		.020	.028	.297	
		RSPM		−.045	−.274	**−2.564***	
	Distortions	Age	10.529***	.025	.102	1.036	.301
		Education		−.109	−.170	−1.848	
		RSPM		−.052	−.354	**−3.379****	
		Gender		−.790	−.218	**−2.556***	
	Rotations	Age	3.973*	.003	.020	.183	.107
		Education		−.080	−.189	−1.826	
		RSPM		−.019	−.193	−1.640	
CIND	Omissions	Age	9.353***	.075	.206	**2.001***	.319
		Education		−.337	−.330	**−.3.059****	
		RSPM		−.082	−.211	**−.2.077***	
		Gender		−.007	−.014	−.138	

Note:
*p<.05;
**p<.01;
***p < .001.

Table 7. Multiple regression analyses of demographic factors and fluid intelligence contributing to BVRT results.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Block design	.324	.439	.435	.070
House score	.170	.405	.463	−.229
Cube score	.097	.787	.059	−.033
BVRT correct	.840	−.082	.182	−.107
BVRT errors	−.896	.097	−.241	.058
BVRT omissions	−.482	−.404	.572	.305
BVRT distortions	−.050	.021	−.915	.000
BVRT perseverations	−.386	−.079	−.086	−.830
BVRT rotations	−.788	.037	.206	−.208
BVRT misplacements	−.371	.838	−.127	.119
BVRT size errors	−.208	.012	−.035	.664
RSPM total correct	.535	.237	.188	−.186

Table 8. Principal component pattern matrix for the sample with complete testing.

3.4. Principal component analysis

To explore the different dimensions in the visuospatial and visuoconstructive abilities in old age, a principal component analysis was performed with oblimin rotation, because of the comparatively small data set (N = 62) and the postulated interrelations between variables used. A four-factor structure, with eigenvalues bigger than 1, was established, all four factors explaining around 71% of the variance. Item loading above 0.3 on each factor is taken into consideration (**Table 8**). Most of the variables load high on the first factor, which could mean that the same kind of abilities is included in the tasks measured by many of our variables. That is why my suggestion for the name of this factor is "general cognitive ability." I would name the second factor extracted "executive functioning" (planning and executing visuoconstructive and visuospatial tasks). This factor is strongly associated with cube and house drawing, Block design performance, and planning and organization of the BVRT figures on the sheet of paper. It is the second factor on which RSPM score loads (coefficient = .237), and RSPM is proven as an executive test. Factor 3 includes BVRT omissions and distortions, together with house drawing and Block design scores and could be named "visuospatial memory." The characteristics of item loading on factor 4 give reason to label it "visuospatial analysis and visual perception."

4. Discussion

Constructive and visuospatial abilities are complex fluid functions that decline with advancing age [31, 45, 50, 54]. Their impairments are proven characteristics of the pathological aging related to different types of dementia [8, 47, 53], and they are not enough studied in the boundary states, posing a risk for the development of dementia. According to Guerin [69] and

Grossi [51], specific studies are needed to reveal the relations between visuospatial disorders and constructional apraxia.

We found that the global BVRT outcome measures (numbers of correct reproductions and number of errors) can significantly differentiate normal from pathological aging. Our work regarding the qualitative characteristics of BVRT performance is consistent with the view that it is necessary to study the specific patterns of this test results in different diagnostic groups [70, 71]. Most existing studies with BVRT analyze only the number of correct reproductions [71, 72] or the total number of errors [73]. The data about the profiles of errors in different groups, including geriatric, are scarce [74], and as far as they exist, they do not refer to CIND. We can assume that the types of errors that differ significantly in the two studied diagnostic groups—omissions and distortions—reflect the cognitive decline profile in CIND.

House and cube drawing tasks, as well as Block design subtest, also showed good discriminant capacity for differentiation of normal elders from persons with CIND. We compare the results reported here with studies of healthy individuals and dementia, as we were unable to find data on the use of these tests in subjects with cognitive impairment, no dementia. The house drawing test results are consistent with those obtained in Moore and Wyke [52] study, which found a statistically significant difference between the score from house drawing of patients with dementia and control group of healthy subjects. Similar results are reported by Gragnaniello et al. [53], who found mainly omissions of elements and simplification of the drawings of a house by persons with Alzheimer's dementia. Assessment criteria used in our study take into consideration omissions of elements, three-dimensionality, distortion, and cohesion of the figures.

Our results confirm the classic model of cognitive aging, showing a significant decline in fluid intelligence, measured by RSPM, with age, in both diagnostic groups. Concerning the other tests used in this study:

1. Healthy participants up to 70 years of age showed more accurate BVRT reproductions than these over 70 (number correct, number errors, omissions, and distortions). When the education, fluid intelligence, and gender (where correlated with our variables) were included in the model, age was a significant predictor only for BVRT omissions. In age groups over 70, Coman et al. [70] found the greatest decline in mean total number corrects. The error profile was not analyzed in their study. In another study of normal non-demented subjects from 20 to 102 years of age, significant age-related changes in omissions, distortions, and rotations for both genders were found. This made the authors suppose different brain regions involved in the different types of BVRT errors. When longitudinal analyses were performed, authors found more rapid increase of omissions and distortions for the oldest age groups [74].

2. Number of omissions was the only variable upon which age showed a significant effect in subjects with CIND before and after taking into account the other demographic features and RSPM scores. In normals with memory concerns, a negative correlation between age and BVTR total correct was reported [70].

We can conclude that age is a significant predictor of visuospatial memory decline. Accordingly Rabbit et al. [36] reported that age predicted the results from Spatial Working Memory test.

The two age groups did not differ significantly in the performance of house and cube drawing and of Block design task. Data exist about worse perception and presentation of three-dimensionality in cube drawing task by elders [29], but we could not find studies of house and cube drawing in different late-life groups. It could be supposed that the interindividual variability, characteristic of old age in this comparatively small sample, influenced our results. The size of the sample has also prevented the use of a more detailed statistical analysis of the performance of these three tests.

A possible explanation of the results concerning the cube drawing task score and BVTR total outcome measures could be the complexity of the tasks and in particular the three-dimensionality, as a mandatory feature of the cube drawing. These results could be partially explained as well by the structure of the BVRT task, which involves reproduction of geometric shapes by memory. The task of drawing a cube and a house also requires reproduction, but long-term memory is involved here, while Benton test assesses short-term memory. Another difference between Benton test and the drawing of cube and house is related to BVRT patterns themselves—part of them are new, unknown spatial models, and the other part are well-known figures (triangle, square, circle, trapezoid) engaging long-term representations. A comprehensive cognitive model of adults' drawing ability has not yet been developed. What is well known is its "multicomponential nature" [[51], p. 117] confirmed in this study by a principal component analysis of the results from testing healthy adults and individuals with CIND over 60 years of age (four factors extracted).

The global functioning or the intelligence together with attention, sensory, motor, and executive functions is fundamental for the visuospatial and visuoconstructive abilities, following R. Mapou's [43] hierarchical model. The correlations found reflect the relationship between these basic functions and the capabilities required for specific (constructional and spatial) cognitive functions. This explanation is supported by the principal component analysis, according to the results of which global and executive functioning are required for the performance, assessed by a large number of study variables. Interpretation of principal component analysis reveals at the same time the specificity of constructive and spatial functions, based on visuospatial analysis and perception.

As elements of the multiple regression model, education of participants predicted the total number of errors in the group of healthy subjects and the number of omissions in CIND group. In another study without consideration of type of errors, the level of performance of normal older adults aged 61–97 showed dependence on education. In the same paper, in the group of normals with memory concerns from 64 to 74, less educated had worse performance, the difference found not reaching significance over 75. As for the gender effects on BVRT performance, there are no evidences about significant differences between men and women, from most research results available [70]. Resnick et al. [74] reported sex differences for omissions and rotations in subjects from 20 to 102, but they account for very low percentage of the variance (1%). Our multiple regression results gave a gender effect only on distortions, made by healthy subjects.

5. Conclusions

The basic objective of this paper was to analyze the performance of constructive and visuospatial tasks in healthy and in CIND subjects.

The results confirm our hypothesis about significant differences in the level of performance in drawing and construction between persons with CIND and normally aging individuals over 60 years.

We found a prevalence of omissions and distortions in the error profile of CIND and significant difference between CIND and normal aging regarding these two types of errors.

In both diagnostic groups, age of participants showed a significant effect on BVRT omissions, when fluid intelligence, education, and gender were also considered.

Results proved discriminative sensitivity of BVRT general scoring criteria and the separate error types (omissions and distortions) in the preclinical stages of dementia.

We tested a modification of Moore and Wike [52] scoring system for house and cube drawing task in elders, and this study confirmed its diagnostic sensitivity. Drawing of cube and house could be used for quick screening of CIND in subjects over 60.

Results from the principal component analysis (oblimin rotation) reaffirmed the multicomponent structure of the visuospatial and constructive abilities in old age.

The main limitation of this study is the small number of participants with complete neuropsychological testing and the lack of detailed clinical and neuroimaging examination. For the future, it might be interesting to carry out a similar analysis using more detailed description of subjects, including neuroimaging with functional MRT that could give the possibility to conclude about brain structures involved in different task performance.

Author details

Radka Ivanova Massaldjieva

Address all correspondence to: rapsy_99@yahoo.com

Health Care Management Department, Centre for Translational Neuroscience,
Medical University, Plovdiv, Bulgaria

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