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Identification of Mild Cognitive Impairments in Elderly Indian Subjects

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ABSTRACT

Mild cognitive impairment (MCI) is a common condition in the elderly which is characterized by deterioration of memory, attention, and cognitive function that is beyond what is expected based on age and educational level. MCI does not interfere significantly with individuals' daily activities. It can act as a transitional level of evolving dementia with a range of conversion of 10%–15% per year. Thus, an early detection is crucial to protect older people against MCI and developing dementia. A cross-sectional study with 75 participants of geriatric population to study the effect of advancing age on cognitive function in geriatric subjects by a memory questionnaire and MIDLANDS application. The p value of more than 0.5 was seen in attention (0.1>0.05), language comprehension (0.406>0.05), and agnosia (0.7>0.05) domains whereas a significance was seen in domains of memory(0.001<0.05), praxis (0.085<0.05) and visuospatial tasks(0.001<0.05). Thus amongst the three age groups, a notable decrease in memory as well as the other domains like praxis, visuospatial tasks and executive functions was seen. The young old and mid old were comparatively affected at a milder rate compared to the old geriatric population. Whereas in domains like language and attention no considerable decrease was noticed. It was also seen that co-morbid factors do a play a significant role in decrease of cognition with increase in age.

Keywords: Mild cognitive impairment; Geriatric population; Midlands application; Memory questionnaire; Dementia

INTRODUCTION

Nowadays, cognitive impairment prevalence is increasing rapidly in the elderly population. Cognitive impairment is a term used for defining a boundary area between normal aging and dementia, especially Alzheimer's disease (AD). In follow-up studies, individuals with MCI were shown to convert to dementia at 5-20% per year[1]. The population of elder adults in India is growing rapidly and experiencing a fast demographic and epidemiologic transition. Age is a prominent risk factor for many medical conditions, including cognitive impairment and dementia. Aging leads to gradual decrease in physical and mental capacity which results in growing risk of diseases. These changes may differ from moderate to severe cases which tend to significantly interfere with your daily life and affect your day-to-day activities.

The spread of age-related health problem is becoming a major public health concern as proportions of older individuals in the population of worldwide is growing. Moreover, developing countries like India are more prone to be affected due to low literacy rates, poor lifestyle, and lack of awareness about situations like dementia or Alzheimer's. Dementia is one of the major causes of disability in the elderly. It is a complex syndrome characterized by global and irreversible cognitive relapse that is severe enough to debilitate daily functioning. MCI is regarded as a transitional state between normal aging and dementia. It may progress to dementia, remain same or revert back to normal.It is evident that the most prominent risk factor for mild cognitive impairment is increasing age. Other medical conditions linked to cognitive impairment is diabetes, high blood pressure, depression, lack of physical activities, anxiety etc. Cognitive impairment occurs when there are problems related to difficulty in remembering events, loss of reasoning etc. As your body grows older, mild cognitive problems tends to go beyond expected that may lead to severe ailments such as dementia, Parkinson's, Alzheimer's. Dementia is one

of the major causes of disability in the older population. However, people with mild cognitive impairment are not always at risk of developing dementia provided they do timely diagnosis followed by proper care. Although, some degrees of memory weakness come with old age, and the term dementia is used to denote memory relapse and forgetfulness among people of this age group. Researchers have found that condition like dementia and Alzheimer's disease is related to lifestyle habits also.

A study on subjects of cognitive impairment has shown that the people who have memory impairment as a prime feature in their cognitive profile have the highest probability of developing dementia in the future. However, many basic day-to-day activities may protect an individual against memory loss caused by Alzheimer's or dementia disease.

CONGNITION is referred to as the ability that we have to assimilate and process the information that we receive from different sources (perception, experience, beliefs, etc.) and convert them into knowledge[2].

The word Cognition comes from the Latin root cognoscere, which means "to know[3]. The most accepted cognition definition is the ability to process information through perception (stimuli that we receive through our different senses), knowledge acquired through experience, and our personal characteristics that allow us to integrate all of this information to evaluate and interpret our world. Cognition includes different cognitive processes, like learning, attention, memory, language, reasoning, decision-making, etc., which are part of our intellectual development and experience[2]. Cognition perception allows us to organize and understand the world through stimuli that we receive from our different senses. It is not only crucial to human thinking but also to conduct one's everyday activities and to plan and enact the course of one's occupational life.

Mild cognitive impairment is a stage of transition between 'normal' functional ability and a full-blown clinical picture of dementia[3]. The term MCI refers to some lowering of cognitive function, from a formerly normal level toward a mildly impaired level. It exists across a cognitive continuum with borders that are difficult to define precisely. Mild cognitive impairment may increase your risk of later developing dementia caused by Alzheimer's disease or other neurological conditions. But some people with mild cognitive impairment never get worse, and a few eventually get better.

THE DOMAINS OF COGNITION[4]

Attention/Concentration: This domain deals with the ability to focus awareness on a given stimulus or task, to concentrate on that stimulus or task long enough to accomplish a goal, and to shift awareness if appropriate.

Language: Language is a complex cognitive domain composed of both crystallized and fluid cognitive abilities. They are typically associated with the left (dominant) cerebral hemisphere. Both oral, written, they consist of one's abilities to comprehend repeat and express in these modes, in addition to finding words and names quickly by category or sound. Problems in this area can make communication difficult in therapy.

Visuospatial Skills: This group of cognitive functions involves the ability to understand space in two and three dimensions.Visual construction skills, which involves the ability to put together individual parts to make a coherent whole.

Motor Skills: Gross, manual fine-motor, and facial fine-motor abilities are covered here. Difficulties can make one's facial expressions or gestures difficult to read, or affect one's self-esteem.

Memory: Visual, verbal, and motor memory are the usual foci here, with olfactory and gustatory memory usually not having strong psychological implications (although they may be associated with dementia). Memory can be very brief, short-term, or long-term.

Executive functioning: This refers to capacities that allow a person to successfully engage in independent, appropriate, purposive, and self-serving behaviour. This includes a wide range of cognitive abilities such as the ability to self-monitor, plan, organize, reason, be mentally flexible, and problem-solve. largely concerned with the working of the frontal lobes.

The purpose of this study is as cognitive impairment is now a significant health concern as the individuals with cognitive impairments may experience loss of self-confidence and esteem and can increase dependence on family and may be left out of decision making in the family.

Hence punctual screening of cognitive impairment may be helpful in early detection and timely treatment. So that the quality of life can be improved as a future concern.

Thus, this study is being carried out to assess mild cognitive deficits in subjects in advancing age through an application as well as a questionnaire.

METHODOLOGY

A cross-sectional study, on 75 participants of geriatric population were chosen and divided into three age groups 60-69 = young old ,70-79= middle old, 80 plus very old. With the inclusion criteria being atleast 60 years of age and no known history of any kind of cognitive deficit with a MMSE score of minimum 23. For those who consented to devote uninterrupted 20 minutes for performing the test and exclusion criteria being a disturbance in intellectual functioning or any symptom that indicates the lack of understanding of the questions, having a verbal audio /visual impairment or any psychological issues.

With the aim being to study the effect of advancing age on cognitive function in geriatric subjects. The objective of this study is to assess mild cognitive deficit in older adults using pre validated questionnaires and android based assessment

application and to compare mild cognitive deficit in young old, mid old and old-old adults using above mentioned measures.

With an inclusion criteria of at least 60 years of age and no known history of any kind of cognitive deficit with a MMSE score of minimum 23 and those who consented to devote uninterrupted 20 minutes for performing the test, with the exclusion criteria being disturbance in intellectual functioning or any symptom that indicates the lack of understanding of the questions, having a verbal audio /visual impairment or any psychological issues.

The procedure is an interviewer-administered questionnaire was conducted to collect socio-demographic and health-related data including name, gender, age, education, dominance, height, weight, family type, current work status, and type of work involved. Self-reported medical conditions were recorded including diabetes, hypertension/hypotension, heart conditions, and thyroid respectively. Weight and height were measured and Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2); BMI <24 and $\geq$24 kg/m^2 were categorized as normal and overweight, respectively.

Cognitive function was examined by using a validated memory questionnaire and MIDLAND'S application. The assessments were conducted strictly following the guidelines and protocols of the application and the questionnaire.

The memory questionnaire comprises 20 questions that help to analyse the memory related to daily life activities. The total scoring of it is 100, where scores lying between 0-40 are considered to be of (most concern),40-80 (moderate concern, and 80-100 (low concern). Face-to-face interviews and cognitive assessments were both performed on the same day.

MIDLAND'S APPLICATION

The assessments were conducted strictly following the guidelines and protocols of the application and the questionnaire.

Unfortunately, midland application hasn't been used in any researches. Although it has been validated by a neurosurgeon and a neurophysician. The midlands app consists of a test called Mica which consists of a variety of cognitive tests under the main domains of cognition which are language, attention and concentration, memory, praxis, gnosis and executive functions respectively. Each domain has different tests the tests and scoring as follows: The scoring is divided into normal, equivocal and impaired respectively.

Face-to-face interview and cognitive assessment were both performed on the same day.

The ethics approval for research was taken from institutional ethics committee after submitting a detailed synopsis and methodology of the study. Written informed consent was taken from all study subjects.

TASKS	Normal (N)	Equivocal (E)	Impaired (I)
Language Comprehension: 3 Stage Command (LC)	no errors	some difficulty	1 or more errors
Working Memory Verbal Trial 1: Ten Word Recall (MVT1)	>6	5 or 6	<6
Short-term Memory Verbal Trial 2: Ten Word Recall (MVT2)	>6	5 or 6	<6
Short-term Memory Verbal Trial 3: Ten Word Recall (MVT3)	>7	5 to 7	<5
Visuospatial & Praxis: Line Drawing Copy(V&P)	>6	6	<6
Attention: Vigilance Test	no mistakes	one mistake	> 1 mistake
Executive1: Animal Naming Task	>12	12 to 14	<12
Executive2: Luria Alternating Hand Movements	3 cycles without mistakes	able to do 1 - 2 cycles	unable to complete task
Executive3: Serial Order Reversal Task	all correct	1 error	> 1 error
Short-Term Memory Verbal Recall: Orientation (MVR)	5	4	<4
Praxis: Finger-hand Dexterity: Right	no errors	some difficulty	clear difficulty
Praxis: Finger-hand Dexterity: Left	no errors	some difficulty	clear difficulty
Short-Term Memory Verbal1: Delayed Recall Of 10 Words	>5	5	<5
Short-Term Memory Verbal2: Recognition: Total Score	>10	=10	<10
Short-Term Memory Visual3: Line Drawing Recall	>5	5	<5
Anomia: Naming Line Drawings	all correct	1 error	> 1 error
Agnosia: Recognition of Line Drawings	all correct	1 error	> 1 error
Executive: Design Fluency	N > 7 drawings	E = 5 - 7 drawings	I < 5 drawings
Spoken Language (SL)	Normal	Equivocal	Definite Impairment

The Midland cognitive application and the memory questionnaire was validated by two experts in the field since no evidence is present in of these questions being used in any published literature.

RESULTS

The software used in this study were Microsoft Word, Power-point and Excel. The data was analysed through Microsoft Excel and the results were expressed in mean and percentage.

Table 1: Demographic characteristics of the study groups

Demographics	Group 1, (60 -69) young old	Group 2, (70-79)	Group 3, 80 and above
Number of subjects	25	25	25
Average age (M+SD) Standard deviation	65+2.77 2.77	74+2.23 2.23	82+ 2.21 2.21
Work involving cognition (economically productive job)	56%	44%	48%
Employment current status CURRENTLY WORKING	40%	28%	12%
Retired (current status)	36%	44%	52%
Housewives	24%	28%	36%
Type of family	44%-joint 56%-nuclear	44%-joint 56%-nuclear	28%-joint 72%-nuclear
BMI (Average BMI and % of overweight) M+SD	26.4 + 4.02	26.9 + 3.53	26.4 + 2.72
Co morbid factors (HTN, Diabetes, thyroid, cardiac issues)	72 %	80%	72%

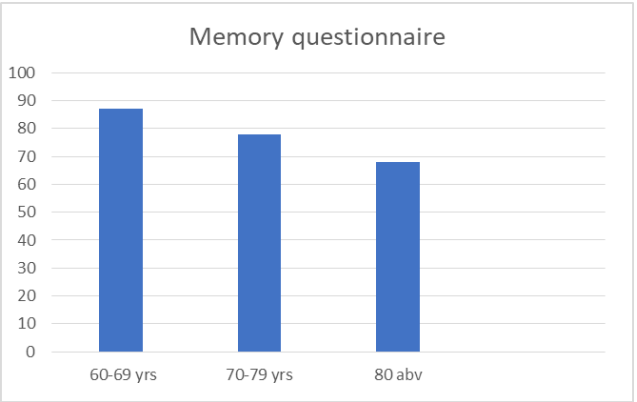


Fig. 1: Comparison of Memory Questionnaire across geriatric age groups

Data analysis according to the midland application:
N - Normal
E - Equivocal
I – Impaired

Table 3: Midlands analysis after performing chi square and spearman's correlation test

Domain	P value
Attention	0.1
Language comprehension	0.406
Anomia	0.754
Spoken language	0.406
Mvt2	.000*
Mvt3	.001*
STMVDR	.000*
STMVR	0.105
STMVR-orientation	0.111
Line drawing	.003*
Praxis FHD -R FHD -L	0.085 0.138
V&P(LDC)	.003*
Agnosia	0.71
Visuospatial & praxis	.001*
Executive functions ANT DF LURIA	0.965 0.038* .026*

According to the results of Table 2 the domain of attention and concentration dint have any severe impairment but a mild impairment of 8 % was seen in 60-69yrs (group 1), 4% in 70-79 yrs. (group 2) with mildly increasing to 16% in 80 yrs. and above (group 3). The language domain consists of three tests which are language comprehension, anomia and spoken language. The language domain is comparatively less affected than other domains. With increasing age also language is not much affected according to the results collected. Anomia, this test consists of tasks where some pictures had to be identified and named correctly a significant increase in the impairment was seen with aging in 60 -69 yr. (group 1) – 4% of mild impairment was noticed progressing to 8%, in 70-79 yrs. (group 2) - where as in the (group 3)-80 years and above the impairment was observed to increase, ranging from moderate to severe where 20% was moderately affected and 8 % was severely affected. Spoken language in this particular test no significant decrease or impairment was noticed with aging.

VERBAL WORKING MEMORY

In this following test 10 words are given and the subject has to recall as many as possible. There are 3 trials later followed by a delayed recall. The results based on trial 1 are, where moderate impairment of 44% was seen in group 1 (60-69), 48% in group 2(70-79) and 12% in group 3 (80 yrs and above) followed by severe impairment of 20% in group 1, 48 % in group 2 and 84% in group 3. The results of trial 2 show a moderate impairment of 44% in group 1

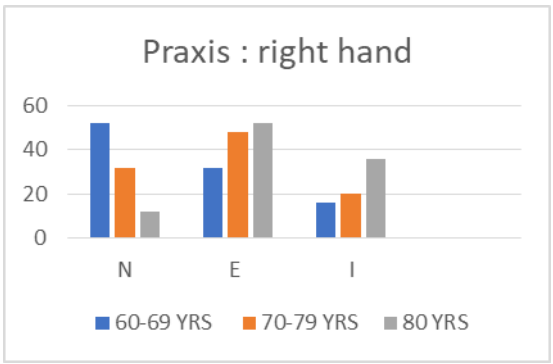
Table 2: Data based on midland s analysis

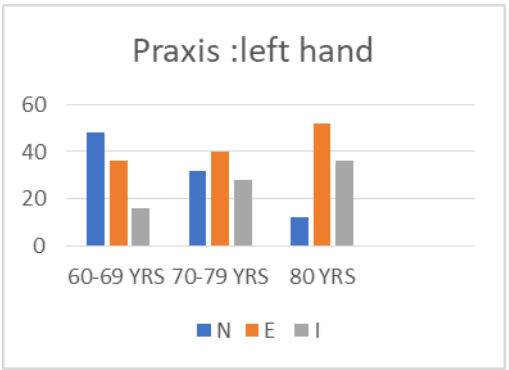
Sr no	Tasks	60-69 YEARS	70-79 YEARS	80 YEARS and above
1	Attention and concentration: Attention vigilance test	N-92% E-8% I-0%	N-96% E-4% I-0	N-84% E-16% I-0
2	Language Language comprehension :3 stage command Anomia: naming pictures Spoken Language	N-96% E-4% I -0% N-96% E-4% I-0 N-96% E-4% I-0	N-100% E-0 I-0 N-92% E-8% I-0 N-100% E-0 E-0	N-100% E-0 I-0 N-72% E-20% I-8% N-100% E-0 I-0
3	Verbal working memory Working memory verbal trial 1: 10-word recall	N-36% E-44% I -20%	N-4% E-48% I-48%	N-4% E-12% I-84%
4	Verbal short term memory Short term memory verbal trial 2: 10-word recall Short term memory verbal trial 3: 10 words recall delayed recall: Short-term memory verbal recognition: total score Short term memory verbal recall: orientation	N-36% E-44 % I-20 % N-20 % E-56% I- 24% N- 52% E -20% I- 2 8% N- 96% E -0 I- 4% N-84% E -4% I -12%	N-4% E-48% I-48% N- 4% E-56% I-40% N- 4% E- 40% I -56% N -92% E- 4% I -4% N- 100% E- 0 I -0	N-4% E-12% I-84% N- O% E- 16% I- 84% N- 0% E -12% I -88% N -72% E-12% I -12% N- 100% E- 0 I- 0
5 6	Visual short-term memory Short term memory visual: (line drawing recall) Praxis Praxis: finger hand dexterity right Praxis: finger hand dexterity left Visuospatial and praxis: line drawing copy	N- 64% E -12% I -24% N- 52% E -32% I -16% N-48% E-36% I-16% N-60% E-16% I-24%	N- 52% E-4% I-44% N -32% E-48% I -20% N -32% E-40% I -28% N -36% E-36% I-28%	N- 8% E -12% I -80% N -12% E-52% I -36% N -12% E -52% I-36% N- 12% E-16% I -72%
7	Gnosis: Agnosia: recognition of pictures Visuospatial and praxis: line drawing copy	N-84% E-8% I-8% N-64% E -12% I -24%	N -92% E-8% I-0 N-36% E-36% I -28%	N- 76% E -20% I-4 % N- 12% E -16% I -72%
8	Executive functions: Executive: animal naming task Executive: design fluency Executive: serial order reversal Executive: Luria alternating hand movements	N -68% E-20% I-12% N-12% E-56% I-32% N-100% E-0 I-0 N -72% E -28% I -0	N -56% E -36% I -8% N -12% E-44% I-44% N- 100% E-0 I-0 N -88% E -12% I-0	N -56% E -36% I -8% N- 0 E -16% I -84% N -100% E-0 I-0 N- 56% E -36% I -8%

(60-69) yrs, 48% in group 2(70-79) and 12% in group 3 (80 yrs and above) followed by a severe impairment of 20% in group 1 (60-69yrs),48%in group 2 (70-79yrs) progressing to 84 % in group 3 (80 yrs and above). The results of trial 3 shows a moderate impairment of 56% in group 1 (60-69yrs),56% in group 2(70-79 yrs) and 16% in group 3 (80 yrs and above) followed by a severe impairment of 24% in group 1, 40%in group 2 progressing to 84%in group 3. Results based on delayed recall showed that a moderate impairment of 20% was seen in group 1 (60-69yrs), 40%in group 2(70-79yrs) and 12% in group 3 (80 yrs and above) with a severe impairment of 8% seen in group 1 followed by 56%in group 2 with a progression of 88 % in group 3. In Short term memory verbal recognition in group 1 (60-69yrs) only 4% was severely affected ,whereas in group 2(70-79 yrs) a moderate impairment was seen in 4% and also 4% of severe impairment was noticed followed by a moderate to severe impairment of 24 % was seen. Thus this domain was comparatively mildly affected. In brief this domain was affected moderate-severely.

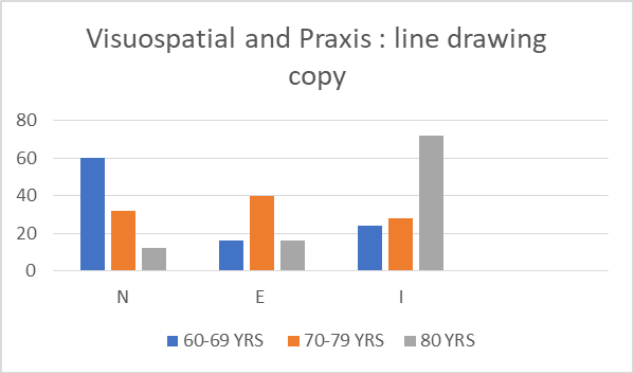
In short term memory drawing recall, a mild impairment was seen in 12% population in group 1 (60-69 yrs), 4% in group 2 (70-79yrs) and 12%in group 3 (80 yrs and above) followed by a moderate impairment of 24%in group 1, 44% in group 2 and 80 % in group 3. This suggests that there is mild to moderate impairment seen as a whole.

In the praxis domain there was a moderate to severe impairment observed as shown in the graphs.





In visuospatial and praxis there was an in increase in the severity of the impairment seen as shown in the graph where the severity increased from 12 %in group 1 to 16%in group 2 progressing to 72%in group 3.



The tasks of line drawings were impaired from a range of moderate to severe as shown in the graph above where a moderate impairment of 12 % in group 1, 36%in group 2 and 16 % in group 3 progressing to a severe impairment of 24 % in group 1, 28 % in group 2 and 72 % in group 3.

In design fluency task there was a severe impairment seen as age increases in group 1 the impairment was 32 %, 44% in group 2 progressing to 84 % in group 3 respectively.

DISCUSSION

The goal of the current study was to identify Mild cognitive deficits in elderly population. According to the demographic data collected in our study subjects the working population was 40% in group 1(60-69 yrs.),28%in group 2 (70-79yrs) and 12%in group 3(80yrs and above) as observed on the basis of the study the working population had a better memory than the retired population. As seen with increase in age the working population decreases and also a notable decrease in their memory is observed. Several experimental studies carried out by AndelR, FinkelD, Pederseren NL -Effects of preretirement work complexity[5] Dingemans, Henkens K-Involuntary retirement a longitudinal investigation and several other studies stated that lack of activity in old age may have negative consequences on health status and on personal well-being[6]. The cognitive decline seen more in retired population is because cognitive aging is defined by a progressive reduction in brains weight and volume this loss is not homogenous indeed it is greater in temporal lobes hence memory is affected. Thus, there is a notable decrease in memory in the retired population.

The existence of co morbid factors (hypertension, diabetes, and obesity) in our study subjects were seen in 72%in group 1 (60-69 yrs.), 80%in group 2(70-79 yrs.) and 72% in group 3 (80 yrs. and above) these factors are found to have a significant role in decrease in the cognitive factors too. A study by Roland Devere, MD – the cognitive consequences of obesity[7], stated that obesity had increased the concentration of hippocampal markers associated with Alzheimer's disease and decreased hippocampal volume. BMI Alone is a predictor of atrophy and there is evidence that obesity increases the risk of mild cognitive impairment[7]. Using diffusion tensor imaging to measure Gray and white matter volume of elderly subjects with normal cognition showed that those with increased BMI, hyperinsulinemia, and type 2 diabetes had more atrophy in the frontal, temporal and subcortical brain regions, areas that are known to be involved in learning and memory[8].

Our study unravelled subtle impairments in Geriatric age group. These included in domains of memory, attention, praxis, gnosis and other executive tasks.

As observed in our study subjects the average memory score was 87/100 in the age of 60-69 yrs where as in the age group of 70-79 and 80 yrs and above it was 78 and 68 respectively, there are several theories about what's behind this deterioration, but according to Michael E Hasselmo s study -The role of Acetylcholine in learning and memory stated that aging causes major cell loss in a tiny region in the front of the brain that leads to a drop in the production of a neurotransmitter called acetylcholine[9]. Acetylcholine is vital to learning and memory[10]. In addition, some parts of the brain that are essential to memory are highly vulnerable to aging.[10]

Also according to a study by Richard c Mos it was seen that, The hippocampal area, loses 5 percent of its nerve cells with each passing decade for a total loss of 20 percent by the time the person reaches 80s[11]. In addition, the brain itself shrinks and becomes less efficient as you age. Thus, a decrease in memory is seen with increase in age.

Language comprehension and spoken language in our study had a positive finding of 96-100% in the study subjects. This particular domain of cognition is seen to be affected in western population but in our study was found to be intact with advancing age[12]. Is because India is a diverse country in terms or languages and its varied culture. more than 21 languages are present in our country apart from them English is the main language used in schools and colleges. Thus, almost every Indian is familiar with more than one language. A study called -How aging and bilingualism influence language processing, carried out by Eleonora Rossi stated that Bilingualism has a huge influence on language processing[13].As bilinguals would exhibit greater volume of the frontal lobe and temporal lobe (grey and white matter), given the importance of these regions in executive and language functions, respectively[13].

According to another study carried by Lily Tao, Gongting Wang and Qing Cai on Bilingualism and domain-general cognitive functions from a neural perspective: A systematic review, stated that functional and structural neuroplasticity associated with bilingualism will contribute to some neural

reserves which helps to have a better language comprehension[14].

In our study subjects the working verbal memory was affected with about 20%impairment in group 1 (60-69 yrs), with a significant increase seen in group 2(70-79yrs) of about 48% and 84%in group 3(80 yrs and above. Along with working verbal memory there was significant decrease in short term as well. On the basis of the neuroanatomical changes, it is stated that although the hippocampus undergoes structural and biochemical changes with normal aging process, these changes may represent an important component of age-related deterioration in hippocampus-dependent cognition. The effects are regionally distributed in the brain especially in the regions of the neocortex and the hippocampal dentate gyrus. Due to this decline is further observed. Another theory by Ebere C. Anyanwu on Neurochemical Changes in the Aging Process: Implications in Medication in the Elderly stated that short term memory and working verbal memory is the decline of neurotransmitter production[15]. Neurotransmitters are the brain chemicals that allows brain cells to communicate and perform their various functions. As one ages the problem can be twofold. The first being that one can produce less of these chemicals with increase in age and the second being the body's natural process of breaking down excess neurotransmitters which begin to malfunction and work to excess causing a lack of supply for the brain[16]. Without proper supply of these chemicals the brain cannot perform correctly. Hence a decrease is seen as the person ages.

In our study the praxis domain was affected severely in about 16%in group 1(60-69yrs) with an increase of about 20%in group 2 (70-79yrs) increasing to 36% in group 3. A person's ability to copy a simple figure declines with age. On standard iq measures such as block design and object assembly much of declines with age are due to time but some researches show decline in when the time is factored out researches state that ageing produces loss of photoreceptor, bipolar or ganglion cells and changes in their connections that could account for visual acuity loses[17] also memory has to be intact to complete such tasks as we have seen in the above results that memory decreases with increase in age thus that also results in difficulty in performing visuospatial tasks.

There are age related declines in aspects of constructional praxis were Visual recognition of objects, shapes, gestures and conventional signs remain stable into advanced age according to the researches. As observed in our results also the tasks where they had to identify objects a positive result was found[18].

On the basis of our study the executive functions were found to be normal in various aspects but moderate to severe impairment was observed in the design fluency activities with an impairment of 32 % seen in group 1(60-69 yrs), 44%in group 2 and 84%in group 3 respectively. The neuroanatomical changes like the frontal-striatal systems are preferentially vulnerable to white matter change, atrophy, and certain forms of neurotransmitter depletion. Frontal-striatal change may underlie mild executive functions difficulties in aging that are most apparent on tasks demanding high levels of controlled processing. The change in the frontal striatal circuits is the most likely significant cause of reduced executive function in non-demented older adults.A research called White and Gray matter contributions to executive functions by Irene Cristofori and Jordan stated that have shown that damage of white matter results in considerable loss of the executive functions as it detoriates signal transmission between cortical areas within a functional network.

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