



# Special tests in cognition for Neurodegenerative dementia

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# Introduction

- The “cognition” word came from the Latin word *cognoscere*, which equals “to know”.
- There are six key domains of cognitive functions as per DSM-5 definition namely –

Memory

Perceptual-  
motor

Complex  
attention

Executive  
functioning

Language

Social- cognition

- Impairment of these cognitive functions causes **dementia**
- It is characterized as a clinical syndrome of sufficiently severe cognitive decline which hampers with occupational or social operations

# Auditory cognition

The process by which individual process perceptual information of auditory component in the CNS : auditory pattern recognition; localization of sound and its lateralization; audition with its temporal aspects(distribution, ordering, masking, integration)

Auditory cognition non-verbal is divided into two major headings-

-Auditory inputs

-Auditory outputs

- An exploratory model of non-verbal auditory processing includes

-Processing of basic property in the brainstem

-Conversion of the sound signal into neural signals

-Perceptual property processing

-Semantic processing (associative processing) i.e., Association of meaning with object representations

# Visuospatial Cognition

- The process by which individual plans, decides and maintains a trajectory between two points in the surrounding space or environment to perform navigation is called spatial navigation.
- The spatial navigation depends on two different, but symbiotic strategies called allocentric and egocentric navigation strategies
  - **The egocentric or self-centric** strategies depends on the individual's relation with the landmarks. This strategy is useful when an individual is navigating the same route repeatedly
  - **The allocentric or world-centric** strategies depends on the individual's navigation by assessing the position of a landmark with other landmarks in the environment and uses these relations to navigate in the space

# Need of the study

- Impairment in terms of processing of central auditory function and visuospatial skills deficit is well known symptom in neurodegenerative dementia
- Visuospatial navigation skill play an important role to locate an individual in their environment and establish spatial relationship between them
- Non-verbal sounds is the principle for a relevant social interaction and judgment and play an important factor to be aware of the environment in which an individual live
- These impairments can have explicit effects on the support and care of dementia patients, and such studies hold great importance and urgent necessity but few studies are done so far

# In the present study, we aimed to evaluate

- **Environmental sounds** recognition, emotions and hedonics in different types of dementia and to relate the degree of deficit in its recognition with different types and stages of dementia
- Visuospatial navigation skills with the 2 novel visuospatial navigation skill tests -**the 4 mountain test and the statue test** in different types of dementia and to relate the degree of visuospatial navigation skill deficit with different types of dementia

# Materials and methods

- Type of study- Analytical case control study
- Place of Study- Cognitive disorders clinic, NIMHANS, Bengaluru
- Participants
  - For Auditory cognition- 73  
Control- 27 subjects, AD- 22 subjects and FTD-24(Behaviour Variant FTD- 13, language variant FTD- 11
  - For Visuospatial navigation skills-61  
Control-20 subjects, AD- 15 subjects, FTD- 15 subjects, PCA-11 subjects
- All patients underwent a detailed demographic, clinical, cognitive, imaging and laboratory investigations

- **Addenbrooke's Cognitive Examination-III (ACE-III)** adapted for Indian languages was used as a cognitive screening instrument in all cases
- The severity of dementia was assessed using the **Clinical Dementia Rating (CDR) Scale**
- Visuospatial working memory was assessed using **Spatial span**
- Visuospatial traditional tests used were- **Modified Taylor's Complex Figure Test (MTCF)** / Illiterates were tested using **Stick figure test** developed for use in the Indian context



## For non verbal auditory cognition



## Environmental sound tests

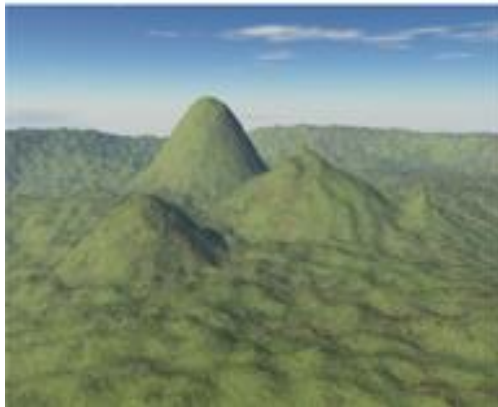
- 16 most appropriate environmental sounds were taken for the study were administered the test in sound free room in the hospital in the same sequence
- Bansuri playing, phone ringtone, cooker whistling, tabla playing, traffic, train, ambulance, clapping, dog barking, baby crying, birds chirping, cock, dog barking, forest, laughing, crow, dripping water
- The sounds were divided into following headings
  - Simple sounds and complex sounds
  - Natural sounds and man made sounds
  - Harmonic and non-harmonic sounds



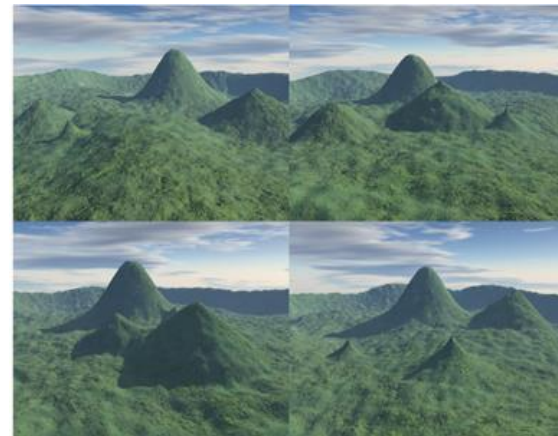
## For visuospatial navigation cognition

The Four Mountains Test. ( 4MT )-

- The four mountain test is a test for allocentric navigation strategy.
- The test consists of a computer-generated landscape of 4 mountains where the landscape's shape and features can be varied.
- The test consists of two trials and fifteen items for the actual test. Each of the items consists of five images.



**4MT target image**

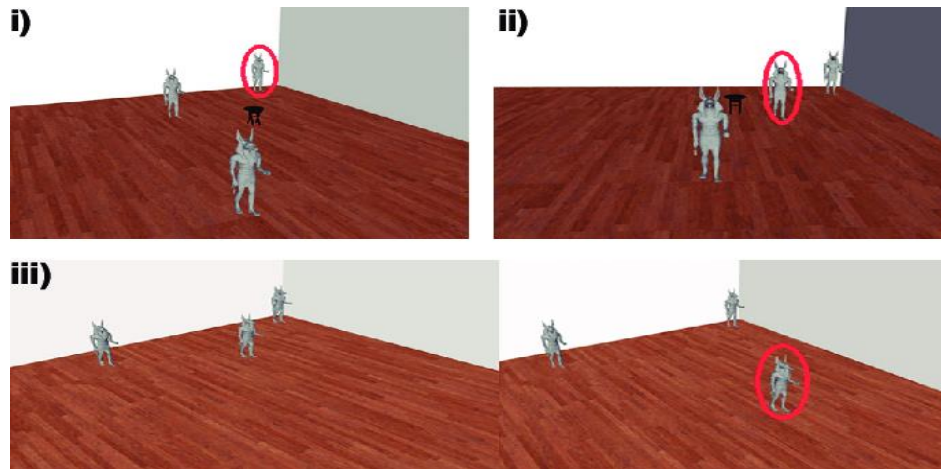


**4MT target image with 3 foils**

# For visuospatial navigation cognition

## The Statue Test –

- The statue test is a test for allocentric and egocentric navigation strategy



- The Statue test sample image (i) Statue closest to the wall. (ii) Statue closest to the stool. ( iii ) Statue's position has changed.

# Statistical analysis

- Data analysis was performed using the Statistical Package for Social Sciences (SPSS) 16.0 software.
- The demographic variables were analysed from a descriptive viewpoint.
- Nonparametric tests were used to compare environmental sounds result variables and non-continuous variables (Mann–Whitney and Kruskal–Wallis test). The chosen significance level was 5% ( $P < .05$ )
- Ethics approval was provided by the NIMHANS Institutional Ethics Committee

# Results

# Demographic profile

- For both “non verbal auditory cognition” and “visuospatial skill test”, participants with dementia were age, sex, years of education and community matched controls
- **For environmental sound test**
- Mean ages in years were 59.07 for Controls, 59.9 for dementia subgroups
- Controls have 55.6% male and the male accounted 48.9% for dementia subgroups
- **For Visuospatial skill test**
- Mean age in years for controls was 59.1 and 60.2 for dementia subgroups
- Controls have 55.1% male and the male accounted 59.6% for dementia subgroups

# Cognitive profile

## For Environmental sound test-

- The average ACE score for control is 97.52 whereas average ACE III score for AD, Behavioural variant FTD and Language variant FTD are 62.68, 59.15 and 53.42 respectively
- CDR- Language variant FTD has 100% mild CDR, whereas Behavioural variant FTD has mild form as 92.3% and moderate form as 7.7% and AD had a mild form of CDR 95.5% and Moderate to be 4.5%

# Cognitive profile

## For Visuospatial skill tests-

- The average ACE score for control is 97.52 whereas average ACE III score for AD, Behavioural variant FTD and Language variant FTD are 62.68, 59.15 and 53.42 respectively

CDR- 10% controls had a mild CDR and rest were normal, all AD patients had a mild form , FTD had 93.3 % mild cases and 6.7 % moderate CDR cases and 90.9 % PCA has a mild form of CDR and 9.1 % has moderate CDR



- **Environmental sound tests among different cohorts**
- In this study, all the controls could recognize all the 17 environmental sounds however dementia group scored- AD- average 9.18, Behavioural variant- average- 10.31 and Language variant FTD scored average 8.67 respectively
- The P-value is significant when we compared healthy control subjects with dementia groups i.e,  $P < 0.001$
- No statistical difference between environmental sound recognition among different dementia subgroups
- Positive Correlation coefficient was found between Environmental sound recognition and ACE score among different subjects( 0.941, 0.874, 0.853 respectively)

- **Correlation of ace score and environmental sound subgroups recognition in dementia subjects**
- **Simple sound and complex sounds**
- There is good correlation in all dementia subgroups between simple sounds as well as complex sounds and ACE score
- **Non harmonic and harmonic sounds**
- There is good correlation in all dementia subtypes between non harmonic sounds and harmonic sounds with and ACE score
- **Natural and man made sounds**
- In the study, there is good correlation in AD and language variantFTD between natural and man-made sounds and ACE scores, and by FTD with man-made sounds.

- **Environmental sound tests among different cohorts**

## **Emotional association**

- All of the **control and AD** has **appropriate emotion** in relation to environmental sound being played
- In Behavioural variant FTD , 46.2% had inappropriate emotion to environmental sounds , equally for both always sad(i.e, 23.1% ) and always happy(i.e, 23.1% ) and Language variant FTD has inappropriate emotion accounting for 8.2% again equally for always sad(i.e, 4.1% ) and always happy(i.e, 4.1% )
- There is **difference in proportion of emotion among Bv FTD, AD and language variant FTD.**

- **Environmental sound tests among different cohorts**

## **Hedonic association**

- Impaired environmental sound hedonics is found in AD, Bv-FTD and language variant FTD in 9.1%, 30.8% and 25.0% respectively
- There is difference in proportion of environmental sound hedonic impairment among AD, Bv-FTD and Language variant FTD ( $\chi^2$  (3)-9.997,  $P < 0.0019$ )

Diagnosis	Environmental sounds recognition (n=16)Average	Emotion recognition			Enviromental sound hedonics	
		Always sad	Always happy	Approp riate	Impaired	Intact
Control(n=27)	17	0%	0%	100%	0(0%)	27(100%)
AD(n =22)	9.18	0%	0%	100%	2(9.1%)	20(90.9%)
Behavioural variant FTD(n=13)	10.31	23.1%	23.1%	53.8%	4(30.8%)	9(69.2%)
Lang variant FTD(n=12)	8.67	4.1%	4.1%	91.9%	3(25.0%)	9(75.0%)

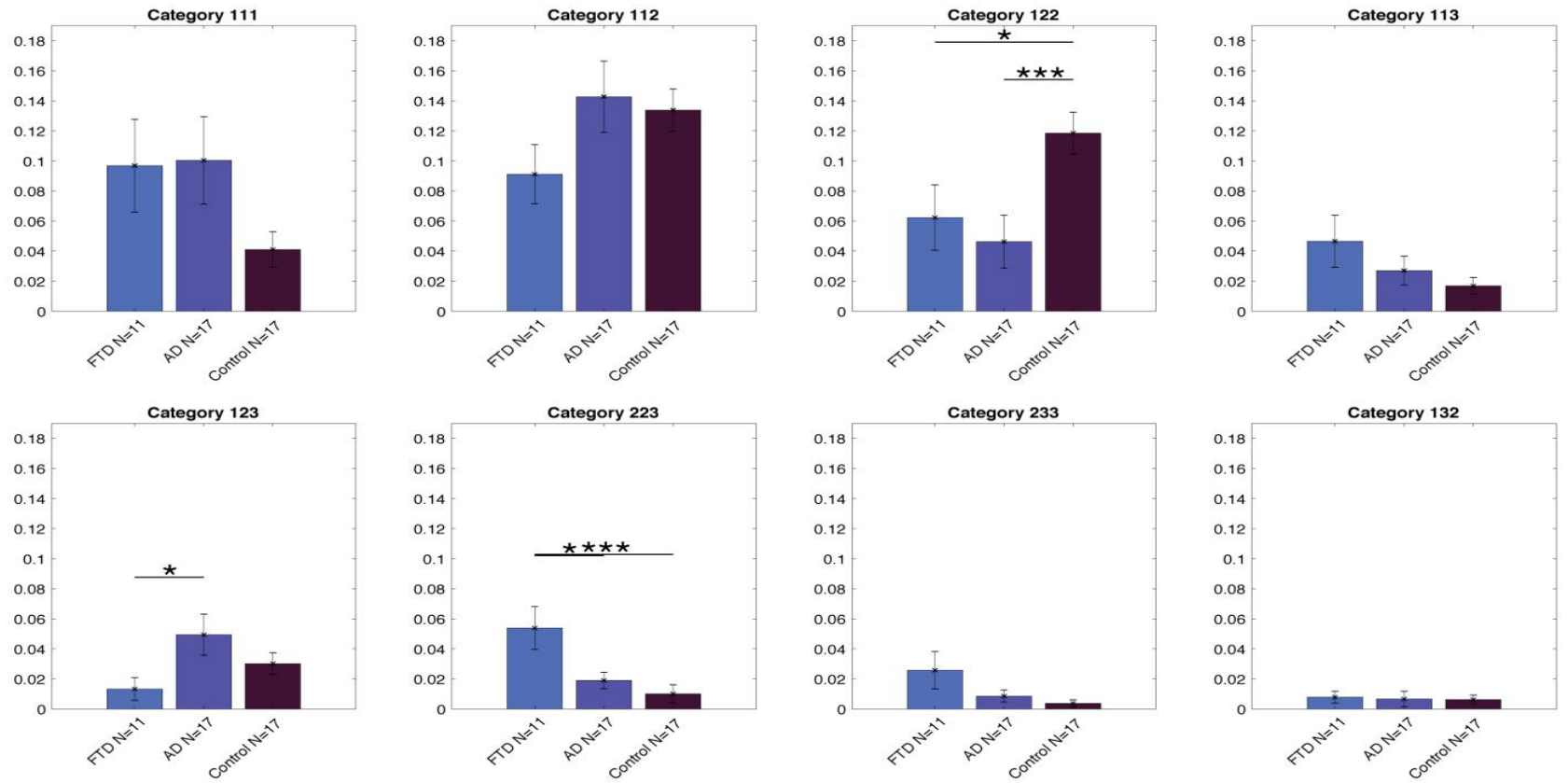
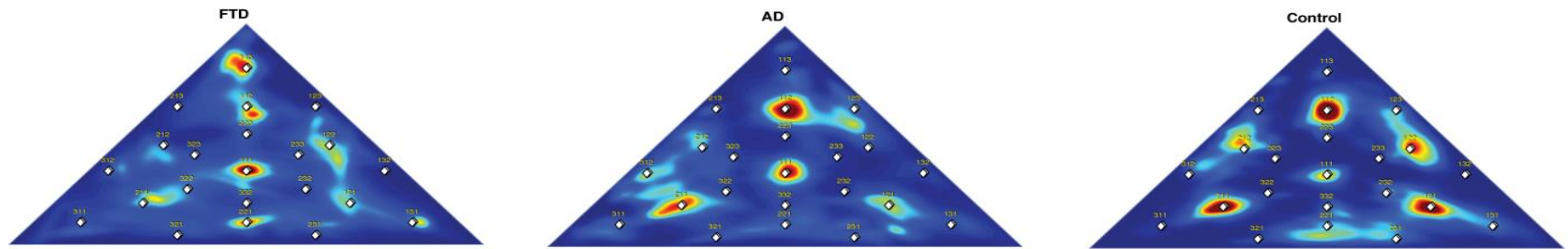
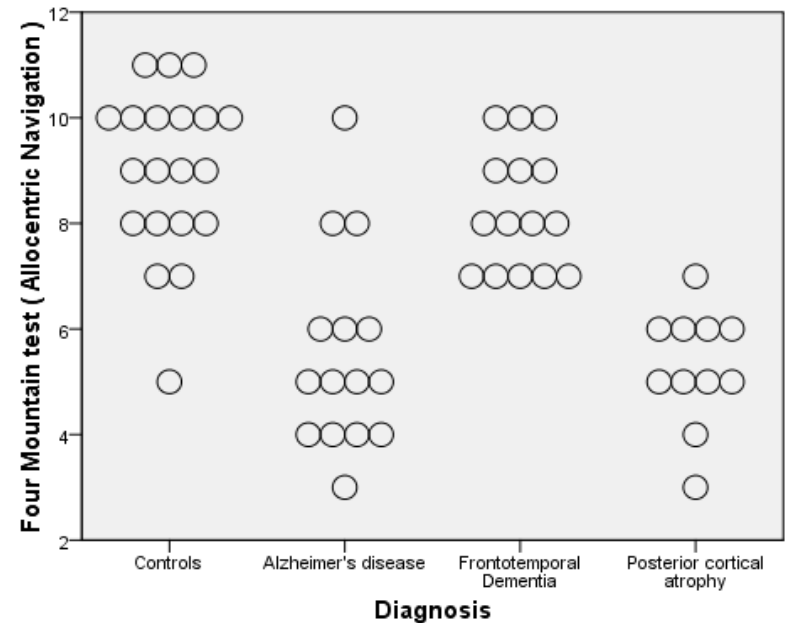


Fig- 3 way comparison study between normal and dementia subgroups for perceptual prior rhythms perception study

- **Four mountain test ( allocentric cognition ) among different cohorts**

- In this study, the mean score of four mountain test ( out of 15 ) for control was 9.0 whereas mean score for AD, FTD and PCA were 5.53, 8.27 and 5.27 respectively



- A statistically significant difference was found to be present between controls and AD, PCA patients, with controls performing better than AD and PCA patients.

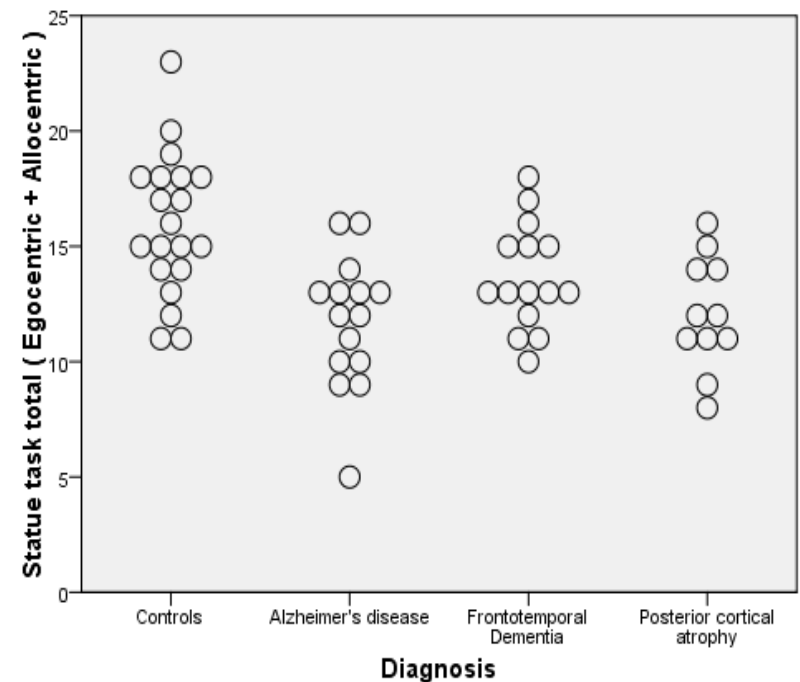
- **No statistically significant difference** was found to be present between **controls and FTD patients**

- The ACE III score had a positive correlation with the performance on 4MT. The correlation factor was 0.55 with a p-value of < 0.001





- **The Statue test ( allocentric + egocentric cognition component )among different cohorts**
- In this study, the mean score of Statue test ( out of 27 ) for control was 15.95 whereas mean score for AD, FTD and PCA were 11.73, 13.67 and 12.09 respectively.
- A statistically significant difference was present between controls and AD, FTD and PCA patients, with controls performing better than AD patients. ( p-value < 0.001 )
- The ACE III score had a positive correlation with the performance on statue test. The correlation factor was 0.60 with a p-value of < 0.001



- **Allocentric navigation tests ( 4MT + allocentric cognition component of the statue test ) among different cohorts**
- The mean score of allocentric navigation tests ( four mountain test + allocentric part of statue test ) ( out of 24 ) for control was 14.95 whereas mean score for AD, FTD and PCA were 9.67, 12.93 and 11.27 respectively.
- A statistically significant difference was present between **controls and AD, PCA patients**, with controls performing better than AD and PCA patients. ( p-value < 0.001 ).
- **No significant difference** was present between **controls and FTD patients**.( p-value > 0.05 )
- The ACE III score had a positive correlation with the performance on allocentric tests ( 4MT + allocentric component of statue test). The correlation factor was 0.58 with a p-value of < 0.001

# Discussion

- Environmental sound recognition is impaired in dementia, and in both AD and FTD
- Environmental sound recognition deficit increases as the degree of cognitive impairment increases, as measured by ACE III
- The deficit in different types of environmental sound recognition like harmonic and non-harmonic, man-made and natural sounds, simple and complex sounds were equally impaired and decreased proportionately with degree of cognitive impairment
- The performance of environmental sound recognition among dementia subgroups correlate with ACE III score, which suggests as cognitive impairment increases, the performance in environmental sound recognition decreases

# Discussion

- The four mountain test and the statue test are novel visuospatial tests used for testing allocentric and egocentric spatial cognition
- The 4MT scores and Statue test scores differed significantly in AD and FTD patients who were otherwise matched in terms of demographics, global cognition and general neuropsychological tests
- Exploring allocentric navigation strategies in dementia showed that FTD, AD and PCA patients had poor performance on allocentric tests than controls
- In the egocentric navigation test, the AD and PCA had poor performance compared to controls. In contrast, FTD had a comparable performance as the parietal cortex is relatively preserved in FTD patients

# Discussion

- Impaired visuospatial cognition will affect poor day-to-day functioning and the safety of patients in a world where visuospatial cognition plays an important role in daily functioning and performing activities of daily living
- The performance of visuospatial navigation tests among dementia subgroups correlate with ACE III score, which suggests as cognitive impairment increases, the performance in visuospatial navigation test decreases
- This has implications for the inclusion of visuospatial cognition tests like four mountain test and statue test in diagnostic cognitive assessment for dementia, to assist in the daily functioning of patients with dementia.

# Limitations

- Small sample size
- Clinically probable cases were used based on the standard criteria for diagnosing various dementia subtypes
- Histopathological or CSF bio-marker evidence is not available
- Detailed anatomical and neural correlation is not done

# Conclusion

- Neurodegenerative dementia is associated with impairment of not only the classical domains but also has an association with auditory cognitive deficit and visuospatial skill deficits
- Environmental sounds test and visuospatial navigation tests can be used as a cognitive marker in early dementia as it is found to be impaired in mild to moderate dementia in the study
- Auditory cognition can be considered to be included among the main domains of cognition as its deficit play a major in the living of patient with dementia.

**Thank You**



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