

A study on visuo - spatial dysfunction in TBI: Any correlation with cognitive profile of Degenerative Memory Disorders?

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Abstract

Visuo spatial functional impairments affect a person's ability to perceive and interact with their environment, leading to challenges with navigation, spatial memory, visual attention, and balance. It has an important role in maintaining quality of life of an individual. Recent research shows that cells in frontal and temporal lobes responds to the subjects' navigational goals and to conjunctions of place, goal and view. Visuospatial function is an adaptive response to spatial changes. Traumatic Brain Injury has a role in the impairment of visuo spatial function including visual attention, spatial learning, and working memory. Deficits are often worse in moderate-to-severe injuries and can be persistent, though some improvement is seen with time. Research also indicates TBI affects visuomotor scanning, and information processing speed. Deficits in visuo spatial and visual attentional test indicates advancement in visuospatial dysfunction in memory disorders and TBI. The nature of visuo spatial deficits in TBI and memory related disorders is comparable. The visuo spatial impairment is rapid in TBI while slowly progressive in Degenerative Memory Disorders. TBI is caused by a traumatic event leading to localized or diffuse brain damage, but neuronal degeneration is causing degenerative memory disorders. Visuo spatial functions early and progressively affect during the course of the disease.

Ninety participants were recruited and divided into three groups: TBI (n = 30), Degenerative Memory Disorders (n = 30), and healthy controls (n = 30). Participants underwent a comprehensive neuropsychological battery assessing global cognition, working memory, visual memory, executive functions, visuospatial perception, and spatial orientation. Group comparisons and correlation analyses were conducted using parametric and non-parametric statistics.

This study hypothesised that: (1) visuo spatial impairments in TBI is severe than that in Degenerative Memory Disorders (2) processing speed, verbal visual memory, executive functions, face recognition, are worse in Degenerative Memory Disorders than in TBI. (3) Composite cognitive scores are high in TBI than in Degenerative Memory Disorders

The results of this study indicated significant group differences across all cognitive domains. Controls performed best, followed by the TBI group, while Degenerative Memory Disorders patients showed the greatest impairment. Executive dysfunction and mental shifting errors were more pronounced in DMD, whereas visuospatial profiles differed qualitatively between TBI and DMD. Complex executive functions were inversely related to errors on Trial Making Test-B. Space perception was relatively preserved in TBI, while line orientation was severely impaired in DMD.

These findings highlight distinct patterns of visuospatial and cognitive dysfunction in TBI and DMD, with implications for differential diagnosis and targeted cognitive rehabilitation

Conclusion: Complex frontal executive functions are inversely related to errors in Trial Making test B. Space perception is better in TBI but line orientation is worse in DMD.

Keywords: TBI, DMD, Visuo spatial Dysfunction, Cognitive Impairment

Introduction

Visuo spatial dysfunction is a common impairment both in TBI and degenerative memory disorders. TBI (Traumatic Brain Injury) is the damage to the brain from external forces like blow, jolt, penetration which are causing temporary or permanent issues with thinking, moving, sensing, and emotions, while Degenerative Memory Disorders (DMD) are progressive type neurodegenerative disorders manifested by memory loss and cognitive decline.

Various physical, cognitive, emotional and behavioural consequences are frequently observed after TBI, as are functional difficulties and have significant social repercussions (Rabinowitz, 2014, Thomas et al. 2008).

Visuo spatial dysfunction is common impairment in TBI and DMD but the nature of impairment varies. The visuo spatial dysfunction cannot be considered as a crucial diagnostic indicator for any of the disease. The current article discusses the nature of cognitive impairment in TBI and Degenerative highlighting the variable visuo spatial dysfunction.

Review of Literature

Visuo spatial dysfunction is a common after effect of Traumatic Brain Injury. This can manifest as difficulties with spatial orientation, navigation, object recognition, and visual attention. In DMD there is a reduction in parietal lobe volume and there is synaptic loss which affects connectivity and neuronal circuits through degeneration (Padula, 2017). TBI causes dysfunction of visual processing affecting binocularity, spatial orientation, posture and balance (Padula, et al., 2017). Visuo spatial impairment, noise sensitivity, visuo spatial dysfunction, vestibular dysfunction etc are included in TBI (Landen, 2012). There is cueing deficit as an impact of TBI and hence chance of visuo spatial dysfunction is high in TBI (Mohammed et al., 2024). Neuroimaging studies have revealed that some metabolic and perfusion impairments along with a reduction of the white and grey matter could take place in the parietal lobe during DMD. TBI may cause lesions in the occipital or parietal lobe that leave the TBI patient with incomplete homonymous hemianopia (Rauchman, 2022).

The optic nerve and tracts can be damaged from transmitted forces during TBI. With regard to the allocation of visuo spatial attention, patients with TBI have more difficulty than healthy. (Rauchman, 2022) The neurodegenerative disease syndromes like Alzheimer's impact the brain in characteristic topographic patterns of neuropathology. Recent electrophysiological studies have linked spatial memory deficits to difficulties in spatial information encoding.

Spatial orientation is a complex process involving vestibular sensory input and possibly cognitive ability. (Anson et al., 2021). The Alzheimer's patients have difficulty in visual modality tasks. Temporal order significantly affected visuo spatial functions in DMD.

The long-term effects of mild head injury on short-term memory for visual form, spatial location, and their conjunction in well-functioning university students is worse compared to controls. (Y M Lisa Chuah, 2021). These observations suggest that spatial navigation skills may be impaired early in the course of brain diseases such as DMD, and could be a marker of future clinical progression of dementias. On a neurocognitive level, impairments in various cognitive processes can contribute to DMD patients going

missing including topographical memory, object recognition, as well as the modulation of visuospatial processing by working memory and executive functions.

visuospatial function is impaired in the early stages of DMD. The VOSP battery is a sensitive battery test for visuospatial deficits which is popularly used to assess visuo spatial perception. (Natalia Bazzera, 2013)

The regions of the brain associated with the orienting and executive components of visuospatial attention may be most susceptible to neural damage resulting from mTBI.

TBI may have an enduring effect on the orienting system at both neural and behavioural levels. Alteration of spatial attention can be a major cause of disability; present findings suggest that m/sTBI survivors exhibit this loss of normal upward attentional bias.

For wayfinding, there were age effects in recalling landmarks, and recognizing environmental scenes. In the route learning condition, older adults evidenced difficulty with the location, temporal order and directional information of landmarks. In both conditions, there was evidence of age-related differences in the acquisition of configural knowledge. Wayfinding was associated with the hippocampus whereas route learning was associated with the caudate nucleus. (Natalia Bazzera, 2013)

Patients with AD with vestibular impairment show more visual-spatial cognitive impairment.

Research progress on vestibular dysfunction and visual-spatial cognition in patients with Alzheimer's disease. (Joyce Bosman 2024) Visuospatial function is a critical aspect of cognitive abilities, encompassing visual perception, attention, memory, and adaptive responses to spatial changes. In the VOSP, the AD patients performed more poorly in all subtests examining object perception and in two subtests examining space perception (Number Location and Cube Analysis.

(Natalia Bazzera, 2013)

Impaired patients evidenced memory and visuospatial deficits after TBI.

The most common impairments in the TBI sample were unilateral neglect and impairments of body scheme and constructional skills. Significantly higher incidences of agnosia, apraxia, unilateral neglect and impairments in body scheme and constructional skills were found in the TBI sample compared to the normative sample (Calzolari, 2020). The incidence of visual perceptual impairment in patients with severe traumatic brain injury is high. (Calzolari, 2020)

The regions of the brain associated with the orienting and executive components of visuospatial attention may be most susceptible to neural damage resulting from mTBI

Methodology

1. Participants

The patients were collected from a community camp run by Christian missionaries as a part of community charitable work. All are residents of Kerala. They belonged to an age group of 30-70, from middle socio-economic status. Gender, Employment, Marital Status, position in family and education are not considering as influential variables but diagnosis related functional disability has given major considerations in this study.

To balance the results and for proper comparison, 90 samples were recruited to this study. 30 from Traumatic Brain Injury, 30 from Degenerative Memory Disorders, and 30 normals. Since it is a comparative study among the groups and within the groups, the rational number 90 had been selected as average size of sample. The participants were recruited on the basis of inclusion and exclusion criteria

Inclusion Criteria

1. Patients with a diagnosis of Traumatic Brain Injury

3. Patients with a diagnosis of Degenerative Memory Disorders

4. People who are normal healthy.

No exclusion on the basis of caste, class, race.

Apart from these patients with psychosis, intellectual disability, visual field deficits were excluded from the study.

2. Procedure

The selected participants were given consent to undergo neuropsychological testing to quantify the variables of verbal working memory, visual memory (immediate and delayed), visual recognition of faces, errors in mental shift, impairment in executive function and visuo spatial dysfunction.

The Neuropsychological Tests used to elicit responses are: ACE (Addenbrookes Cognitive Examination Tests), RAVLT (Rey Auditory Verbal Learning Test), Wechsler -Visual Memory Tests (Immediate and Delayed), Trail Making Tests (Trail A and B), WCST (Wisconsin Card Sorting Test for assessing executive function tests), Visual Recognition of Faces (RMT-Faces), Visual Object Space Perception Test, Judgement of Line Orientation. The ACE score is used as a composite /collective score to keep baseline score for medical diagnosis.

The errors in mental shifts indicates the impairment in mentally shifting between tasks, the comparison of those scores give an idea of slowness in performing dual tasks, especially in connection to attention and higher order executive function. Impairment in verbal working memory gives a picture of impairment in executing plans. Recognition memory scores differentiate visual recognition impairment and visual memory impairment. Visual memory and visuo spatial functional impairment gives a demarcation between diagnosis of TBI and Degenerative Memory Disorders.

3. Results and Discussions

Data were analysed by computing the mean and standard deviation (SD) of scores for each group and comparing them using ANOVA. Comparisons for relationship analysis of diagnosis related impairment variables were done using Pearson's correlation. Given the small sample size, the analyses were repeated with median and range for each variable, and the p-values for comparing these were calculated using the Kruskal-Wallis test.

Similarly, the relationships were analysed using Spearman's correlation tests.

The study measures diagnosis related impairment in the variables, and for relationship analysis, Spearman's rho correlation tests were performed to examine associations between cognitive measures.

Demographic Details: Patients belonged to the age group of 30-70 in all the three groups and male female ratio was heterogeneous in the study groups. Patients belonged to middle socio-economic backgrounds with education of 10th std and above with heterogeneous occupations

Table 01. Statistical Differences among Variables

Variable	Summary	Group 1(TBI)	Group 2(AD)	Group 3 (Control)	p value
ACE Score	Mean (SD)	76.4 (19.6)	69.8 (17.6)	87.8 (1.2)	<0.001
	Median (Range)				
	80.5 (12-98)	71.5 (29-99)	88.0 (85-90)	<0.001*	
Verbal Working Memory	Mean (SD)	28.6 (14.2)	21.0 (13.1)	51.6 (7.7)	<0.001

	Median (Range)	26.0 (0-57)	21.0 (0-62)	54.0 (30-58)	<0.001*	
Visual Memory Immediate	Mean (SD)	17.1 (14.3)	14.6 (15.4)	36.9 (3.5)	<0.001	
	Median (Range)	15.5 (0-41)	7.5 (0-41)	37.5 (31-41)	<0.001*	
Visual Memory Delayed	Mean (SD)	12.1 (12.5)	6.4 (11.8)	35.6 (3.5)	<0.001	
	Median (Range)	10.0 (0-41)	0.0 (0-41)	35.0 (31-41)	<0.001*	
Trial Making Test A	Mean (SD)	3.4 (7.5)	3.0 (6.1)	0.0 (0-0)	0.042	
	Median (Range)	0.0 (0-23)	0.0 (0-27)	0.0 (0)	0.004*	
Trial Making Test B	Mean (SD)	9.2 (10.8)	15.3 (10.2)	0.0 (0)	<0.001	
	Median (Range)	2.5 (0-28)	18.0 (0-29)	0.0 (0)	<0.001*	
Executive Function Test	Mean (SD)	3.3 (2.4)	2.6 (2.2)	5.6 (1.5)	<0.001	
	Median (Range)	4.0 (0-6)	2.0 (0-6)	6.0 (0-6)	<0.001*	
Faces	Mean (SD)	14.0 (7.6)	13.0 (7.0)	24.2 (1.4)	<0.001	
	Median (Range)	15.5 (0-24)	14.5 (0-23)	25.0 (19-25)	<0.001*	
Visual Object Space Perception	Mean (SD)	6.4 (6.8)	6.0 (5.6)	15.3 (3.0)	<0.001	
	Median (Range)	7.0 (0-20)	6.5 (0-21)	15.5 (11-20)	<0.001*	
Judgement of Line Orientation	Mean (SD)	9.0 (10.4)	9.2 (9.2)	24.1 (4.0)	<0.001	
	Median (Range)	4.0 (0-30)	9.5 (0-30)	23.0 (13-30)	<0.001*	

*Kruskall Wallis test

The results are appropriate for measuring impairment on the basis of diagnosis -TBI, Neurodegenerative Dementia and the control group. There is significant difference in the composite score (ACE), between TBI, Degenerative Memory Disorders (DMD), and control group.

The composite score ACE is lowest in DMD when comparing to TBI and control group (69.8(17.6)). Control group has the highest composite score ACE (87.8 (1.2)) when compared to the other two groups. Verbal working memory has lowest score with DMD (21.0 (13.1)), and has the greatest score with control (51.6,7.7) with a significant p value of 0.001. The impairment in verbal working memory is more in DMD when compared to TBI and control. Delayed visual memory has more impairments in AD (6.4(11.8)) than immediate visual memory (14.6,15.4). But the difference is not statistically significant. The nature of impairment in visual memory in DMD is similar to that in TBI. In TBI delayed visual memory is (12.1,12.5) is more impaired than immediate visual memory (17.1,14.3) and the difference is statistically significant with p value 0.001

Errors in complex task shift/mental shift is high in DMD (15.3,10.2), than in TBI (9.2,10.8), shows executive function impairment is high in DMD than in TBI

The nature of impairment in executive function is more similar to impairment in simple task shift/Mental shift in all the three groups and the difference is statistically significant with a P value of (P 0.001). The impairment in mental shift is related to executive function in such a way that less errors, more success in executive function

Face recognition is more impaired in DMD than in TBI. DMD patient had more impairment in space perception than in space orientation. But TBI patient has more impairment in space orientation than in space perception. And the mean difference is statistically significant with a p value (p value 0.001).

Correlation Values

In TBI, verbal working memory has significant and strong correlation with immediate visual memory ($r=0.483$, $P=.007$) and with delayed visual memory ($r=0.660$, $P=0.000$).

Between this more positive strong correlation with delayed visual memory. Delayed visual memory has a strong correlation with recognition memory of faces ($r=0.536$, $P=0.002$). Space perception has direct correlation with line orientation in TBI. ($r=0.508$, $P=.004$)

The variables mental shift, and executive function has no direct correlation with other variables. The cognitive profile in TBI has not a common pattern in cognitive impairment.

In degenerative memory disorders variables verbal working memory has a very strong correlation between immediate visual memory ($r=0.654$, $P=.000$) and delayed visual memory ($r=0.595$, $P=0.001$)

Inverse correlation with mental shift in complex task ($r=0.367$, $p=-.046$), positive relation with executive function ($r=0.586$, $P=.000$ and recognition memory of faces ($r=0.586$, $P=.000$) and has a very strong significant correlation with space orientation ($r=0.501$, $P=.005$).

The variables visual memory, Mental shift (simple task) has no direct correlation with space perception and line orientation.

When comparing the cognitive profile of TBI with DMD certain points to be highlighted:

In TBI space perception and line orientation has no direct relationship with other variables. In DMD, the variables verbal memory, visual memory immediate, visual memory delayed, executive function, mental shift, space perception, line orientation are positively correlated.

Variables are equally distributed among the control. There is no strong direct/inverse relationship among the variables in control

Table 02 DMD

Table 03. Control Group

Discussion

This study measures the visuospatial dysfunction in TBI and neurodegenerative dementia. The unbiased cognitive profile reveals distinctive features in the tested variables. Controls perform best in all cognitive domains.

DMD shows the poorest performance, especially in executive functions, mental shifting (TMT-B), verbal working memory, and visual memory, visual recognition of faces, visual space perception and line orientation. And this affects in planning, doing complex tasks, and higher order mental functioning. There are alterations in the hippocampus and the temporal lobe which are well documented in DMD, while the alterations of the parietal lobe have been less thoroughly explored¹

Parietal lobe which is responsible for visuo spatial execution undergoing different neuronal plasticity changes plays an important role in the diagnosis of DMD. In DMD there is a reduction in parietal lobe volume and there is synaptic loss which affects connectivity and neuronal circuits. Long term potentiation impaired in DMD including parietal lobe. TBI causes dysfunction of visual processing affecting binocularity, spatial orientation, posture and balance²

Correlations

Group 1 TBI		ACE score	verbal working memory	Visual Memory immediate	Visual Memory Delayed	Trail Making Test A	Trail Making Test B	Executive Function Test	Face	Visual Object Space Perception	Judgment of Line Orientation
1 Spearman's rho	ACE score	Correlation Coefficient Sig. (2-tailed) N	1.000 .567** 30	.449* .013 30	.682** .000 30	-.291 .119 30	-.390* .033 30	.475** .008 30	.438* .016 30	-.010 .960 30	.247 .188 30
	verbal working memory	Correlation Coefficient Sig. (2-tailed) N	.567* .001 30	1.000 .007 30	.483** .000 30	-.088 .643 30	-.165 .383 30	.283 .129 30	.201 .286 30	.223 .235 30	.201 .287 30
	Visual Memory immediate	Correlation Coefficient Sig. (2-tailed) N	.449* .013 30	.483** .007 30	1.000 .000 30	-.367* .046 30	-.353 .056 30	.326 .079 30	.380* .038 30	.335 .070 30	.040 .836 30
	Visual Memory Delayed	Correlation Coefficient Sig. (2-tailed) N	.682* .000 30	.660** .000 30	.754** .000 30	1.000 .049 30	-.362* .022 30	-.415* .016 30	.437* .002 30	.536** .436 30	.148 .951 30
	Trail Making Test A	Correlation Coefficient Sig. (2-tailed)	-.291 .119	-.088 .643	-.367* .046	-.362* .049	1.000 .003	.524** .080	-.325 .086	-.319 .959	-.010 .709
	Trail Making Test B	Correlation Coefficient Sig. (2-tailed)	-.390* .033	-.165 .383	-.088 .643	-.362* .049	1.000 .003	.524** .080	-.325 .086	-.319 .959	-.010 .709

	N	30	30	30	30	30	30	30	30	30	30
Trail Making Test B	Correlation Coefficient	-.390*	-.165	-.353	-.415*	.524**	1.000	-.122	-.351	.126	.206
	Sig. (2-tailed)	.033	.383	.056	.022	.003	.	.520	.057	.507	.275
	N	30	30	30	30	30	30	30	30	30	30
Executive Function Test	Correlation Coefficient	.475*	.283	.326	.437*	-.325	-.122	1.000	.267	.191	.289
	Sig. (2-tailed)	.008	.129	.079	.016	.080	.520	.	.154	.312	.121
	N	30	30	30	30	30	30	30	30	30	30
RFaces	Correlation Coefficient	.438*	.201	.380*	.536**	-.319	-.351	.267	1.000	-.178	-.100
	Sig. (2-tailed)	.016	.286	.038	.002	.086	.057	.154	.	.346	.599
	N	30	30	30	30	30	30	30	30	30	30
Visual Object Space Perception	Correlation Coefficient	-.010	.223	.335	.148	-.010	.126	.191	-.178	1.000	.508**
	Sig. (2-tailed)	.960	.235	.070	.436	.959	.507	.312	.346	.	.004
	N	30	30	30	30	30	30	30	30	30	30
Judgment of Line Orientation	Correlation Coefficient	.247	.201	.040	.012	-.071	.206	.289	-.100	.508**	1.000
	Sig. (2-tailed)	.188	.287	.836	.951	.709	.275	.121	.599	.004	.
	N	30	30	30	30	30	30	30	30	30	30

TBI group has middle line performance on various neuropsychological tests worse than controls but better than Alzheimer's patients. Patients with diagnosis of TBI performed poorer than controls on target detection and discriminations and were slower to respond. With regard to the allocation of attention, patients with TBI have less sensitivity to the type of cues given from the environment ³.

Spearman's rho	ACE score	Correlation Coefficient	1.000	.855**	.693**	.767**	-.460*	-.395*	.621**	.743**	.457*	.181
		Sig. (2-tailed)	.	.000	.000	.000	.011	.031	.000	.000	.011	.338
		N	30	30	30	30	30	30	30	30	30	30
	verbal working memory	Correlation Coefficient	.855**	1.000	.654**	.595**	-.347	-.367*	.680**	.586**	.501**	.073
		Sig. (2-tailed)	.000	.	.000	.001	.060	.046	.000	.001	.005	.702
		N	30	30	30	30	30	30	30	30	30	30
	Visual Memory immediate	Correlation Coefficient	.693**	.654**	1.000	.717**	-.332	-.394*	.508**	.623**	.434*	.356
		Sig. (2-tailed)	.000	.000	.	.000	.073	.031	.004	.000	.017	.053
		N	30	30	30	30	30	30	30	30	30	30
	Visual Memory Delayed	Correlation Coefficient	.767**	.595**	.717**	1.000	-.470**	-.563**	.516**	.650**	.314	.187
		Sig. (2-tailed)	.000	.001	.000	.	.009	.001	.004	.000	.092	.323
		N	30	30	30	30	30	30	30	30	30	30
Spearman's rho	Trail Making Test A	Correlation Coefficient	-.460*	-.347	-.332	-.470**	1.000	.580**	-.494**	-.467**	-.185	-.204
		Sig. (2-tailed)	.011	.060	.073	.009	.	.001	.006	.009	.327	.279
		N	30	30	30	30	30	30	30	30	30	30
	Trail Making Test B	Correlation Coefficient	-.395*	-.367*	-.394*	-.563**	.580**	1.000	-.609**	-.540**	-.075	-.034
		Sig. (2-tailed)	.031	.046	.031	.001	.001	.	.000	.002	.694	.857
		N	30	30	30	30	30	30	30	30	30	30
	Executive Function Test	Correlation Coefficient	.621**	.680**	.508**	.516**	-.494**	-.609**	1.000	.473**	.277	.198
		Sig. (2-tailed)	.000	.000	.004	.004	.006	.000	.	.008	.139	.295
		N	30	30	30	30	30	30	30	30	30	30
	Faces	Correlation Coefficient	.743**	.586**	.623**	.650**	-.467**	-.540**	.473**	1.000	.376*	.123
		Sig. (2-tailed)	.000	.001	.000	.000	.009	.002	.008	.	.040	.518
		N	30	30	30	30	30	30	30	30	30	30
Spearman's rho	Visual Object	Correlation Coefficient	.457*	.501**	.434*	.314	-.185	-.075	.277	.376*	1.000	.475**
		Sig. (2-tailed)	.011	.005	.017	.323	.009	.001	.006	.009	.	.000
		N	30	30	30	30	30	30	30	30	30	30

Space Perception	Sig. (2-tailed)	.011	.005	.017	.092	.327	.694	.139	.040	.	.008
N		30	30	30	30	30	30	30	30	30	30
Judgement of Orientation	Correlation Coefficient	.181	.073	.356	.187	-.204	-.034	.198	.123	.475**	1.000
LineSig. (2-tailed)		.338	.702	.053	.323	.279	.857	.295	.518	.008	.
N		30	30	30	30	30	30	30	30	30	30

Current research on spatial orientation primarily emphasizes navigational performance with limited attention given to the relationship between navigation and visuospatial abilities. Visuospatial impairments may disrupt the accurate processing of spatial cues, consequently impairing navigation performance. However, few experimental designs explicitly control for visuospatial factors as potential confounders. Moreover, although numerous studies focus on navigation strategies, some infer strategy selection merely based on the presence of landmarks, neglecting scenarios in which landmarks are available but not consciously utilized by participants¹³ ACE is a neuropsychological tool with proper diagnostic validity which can be used as a composite score for arriving at the level of neuropsychological diagnostic tool.

All differences are highly statistically significant among the groups showing that the groups are truly different in cognitive functioning. No meaningful relationship between executive function, working memory, or visuospatial scores in TBI suggests that variables are not strongly linked in TBI group.

In DMD, there is a strong positive correlation between Executive Function and Verbal Working Memory ($r = 0.687$, $p < 0.001$). (Better working memory strongly relates to better executive functioning.).

Visuospatial performance has strong positive correlation with visual memory (both immediate and delayed, delayed greater than immediate) in DMD. The variable mental shift is tightly linked to performance in executive and visuo spatial functions. The DMD patients were significantly impaired on original learning and reversal learning in the visual modality. On the spatial tasks, the DMDs were impaired on reversal learning. The profile of deficits on the visual tasks may reflect selective orbito frontal system lesions in the former⁴

In TBI, visual memory has a weak and non-significant correlation with visuo spatial functions. In DMD, recognition memory strongly correlates with visuo spatial functions of space perception and line orientation. In TBI recognition memory is independent of space perception and line orientation.

In control group, variables are independent of each other. All correlations are weak and non-significant, some negative (an increase in errors in executive function has a negative correlation with space perception and line orientation. It suggests that in a cognitively strong group, these domains operate more independently). Results revealed that the temporal order significantly affected spatial judgments in eAD patients but not in NC participants⁵

recent studies indicate that spatial memory loss that is known as an early clinical sign of AD is due to synaptic dysfunction rather than neuronal death⁶

Patients with dementias such as Alzheimer's disease (AD) frequently lose their way in familiar as well as unfamiliar surroundings. Spatial navigational difficulties are seen in early clinical stages of AD, and are even reported in pre-dementia syndromes such as Mild Cognitive Impairment syndrome (MCI). Navigational impairments, especially those involving exocentric navigation, have a similar pattern in patients with MCI and AD.

Spearman's 3rho	ACE score	Correlation Coefficient	1.000	.076	-.067	.157	.	.	.100	-.077	-.288	-.228
		Sig. (2-tailed)	.	.689	.726	.408	.	.	.600	.684	.122	.226
		N	30	30	30	30	30	30	30	30	30	30
	verbal working memory	Correlation Coefficient	.076	1.000	.072	.120	.	.	-.070	-.048	.212	.190
		Sig. (2-tailed)	.689	.	.705	.527	.	.	.713	.800	.262	.314
		N	30	30	30	30	30	30	30	30	30	30
	Visual Memory immediate	Correlation Coefficient	-.067	.072	1.000	.673**	.	.	-.070	-.295	-.024	.017
		Sig. (2-tailed)	.726	.705	.	.000	.	.	.711	.114	.899	.928
		N	30	30	30	30	30	30	30	30	30	30
	Visual Memory Delayed	Correlation Coefficient	.157	.120	.673**	1.000	.	.	-.124	-.124	-.041	.170
		Sig. (2-tailed)	.408	.527	.000	.	.	.	.513	.513	.829	.370
		N	30	30	30	30	30	30	30	30	30	30
	Trail Making Test A	Correlation Coefficient	.	.	.	.	.	.	.	.	.	.
		Sig. (2-tailed)	.	.	.	.	.	.	.	.	.	.
		N	30	30	30	30	30	30	30	30	30	30
	Trail Making Test B	Correlation Coefficient	.	.	.	.	.	.	.	.	.	.
		Sig. (2-tailed)	.	.	.	.	.	.	.	.	.	.
		N	30	30	30	30	30	30	30	30	30	30
	Executive Function Test	Correlation Coefficient	.100	-.070	-.070	-.124	.	.	1.000	.410*	-.342	-.336
		Sig. (2-tailed)	.600	.713	.711	.513	.	.	.	.024	.065	.070
		N	30	30	30	30	30	30	30	30	30	30
	Faces	Correlation Coefficient	-.077	-.048	-.295	-.124	.	.	.410*	1.000	-.245	-.010
		Sig. (2-tailed)	.684	.800	.114	.513	.	.	.024	.	.192	.956
		N	30	30	30	30	30	30	30	30	30	30

Visual Object Space Perception	Correlation Coefficient	-.288	.212	-.024	-.041	.	.	-.342	-.245	1.000	.357
	Sig. (2- tailed)	.122	.262	.899	.829	.	.	.065	.192	.	.053
	N	30	30	30	30	30	30	30	30	30	30
Judgement of Line Orientation	Correlation Coefficient	-.228	.190	.017	.170	.	.	-.336	-.010	.357	1.000
	Sig. (2- tailed)	.226	.314	.928	.370	.	.	.070	.956	.053	.
	N	30	30	30	30	30	30	30	30	30	30

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

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

These observations suggest that spatial navigation skills may be impaired early in the course of brain diseases such as AD, and could be a marker of future clinical progression of dementias. Spatial disorientation is one of the earliest symptoms in Alzheimer's disease (AD) (Coughlan et al., 2018,) and has been increasingly measured using novel virtual reality .

On a neurocognitive level, impairments in various cognitive processes can contribute to DMD patients going missing including topographical memory, object recognition, as well as the modulation of visuospatial processing by working memory and executive functions ⁸). For spatial navigation measures, to our knowledge only questionnaire-based information has been used to predict the incidence of getting lost for patients ⁹While younger age was reported as being a predictor of getting lost, the presence of a safety range (i.e., restricting navigation to very familiar places) was found to be a protector for getting lost recurrence in patients ¹⁰

Posterior parietal cortex plays an important role in visuo spatial functioning. Awareness of spatial geometry is crucial in visuo spatial navigation.¹¹

(2023 Mar 13,Elife) the parahippocampal cortex, retrosplenial cortex, dorsal striatum, and the posterior parietal cortex provide important complementary functions, and ultimately form part of a functional network that regulates successful way-finding behavior.¹²

.Current research on spatial navigation primarily emphasizes navigational performance itself, with limited attention given to the relationship between navigation and visuospatial abilities. Visuospatial impairments may disrupt the accurate processing of spatial cues, consequently impairing navigation performance. However, few experimental designs explicitly control for visuospatial factors as potential confounders.

Moreover, although numerous studies focus on navigation strategies, some infer strategy selection merely based on the presence of landmarks, neglecting scenarios in which landmarks are available but not consciously utilized by participants. (Traumatic Brain injury and risk of neurodegenerative disorder)

The navigation disability in Alzheimer disease and mild cognitive impairment (MCI) involves a selective impairment of spatial cognition and is associated with atrophy of the right-

lateralized navigation network. Extensive spatial impairments in MCI suggest that navigation tests may provide early markers of cognitive and neural damage. spatial navigation impairment occurs early in the development of DMD and can be used for monitoring of the disease progression or for evaluation of presymptomatic DMD.

Highlights of the study

This study delineates distinct patterns of visuospatial and associated cognitive dysfunction in traumatic brain injury (TBI) and Degenerative Memory Disorders (DMD). Consistent with the results, healthy controls demonstrated intact and largely independent cognitive functioning, whereas both clinical groups showed significant impairment, with DMD exhibiting the most severe and interconnected deficits.

1. Visuospatial Dysfunction across diagnostic groups

Visuospatial impairment was evident in both TBI and DMD, but its qualitative expression differed. In DMD, deficits in space perception and line orientation were pronounced and closely linked with impairments in memory and executive functioning. This convergence suggests a network-level degeneration involving temporoparietal and hippocampal systems that support spatial cognition, visual memory, and higher-order control processes. The strong correlations observed among visuospatial measures, memory, and executive function in DMD are consistent with progressive synaptic dysfunction and reduced network segregation characteristic of neurodegeneration.

In contrast, individuals with TBI demonstrated relatively preserved space perception alongside deficits in spatial orientation, particularly on tasks requiring angular discrimination. The weak associations between visuospatial measures and executive functions in TBI indicate a heterogeneous profile, likely reflecting variable lesion distribution, diffuse axonal injury, and compensatory mechanisms rather than a uniform degenerative process.

2. Memory and Executive Function Profiles

Memory performance differentiated the two clinical groups. DMD was characterized by marked impairment in both immediate and delayed visual memory, with delayed recall showing greater vulnerability, consistent with hippocampal and medial temporal lobe involvement. In TBI, delayed visual memory was more impaired than immediate recall, suggesting disruption of consolidation or retrieval processes rather than primary encoding deficits.

Executive dysfunction, particularly impaired mental shifting as indexed by Trail Making Test–B, was significantly more severe in DMD than in TBI. The inverse relationship between executive performance and mental shifting errors in DMD underscores the central role of executive control in coordinating complex cognitive operations. In TBI, executive deficits were present but showed limited coupling with other cognitive domains, reinforcing the notion of task-specific rather than global executive breakdown.

3. Integrated Cognitive Decline in DMD

A key finding of this study is the tightly coupled pattern of cognitive decline in DMD. Strong intercorrelations among verbal working memory, visual memory, executive functioning, face recognition, and visuospatial orientation suggest that DMD affects multiple cognitive systems simultaneously. This integrated decline contrasts sharply with the more fragmented cognitive profile observed in TBI and aligns with contemporary models of DMD as a disorder of large-scale network disintegration rather than isolated regional damage.

Clinical Implications

These findings have important clinical implications. Detailed visuospatial assessment, when combined with memory and executive measures, may enhance differential diagnosis between TBI-related cognitive impairment and early to moderate DMD. Preservation of certain visuospatial perceptual abilities alongside impaired orientation may favour a diagnosis of TBI, whereas pervasive visuospatial deficits tightly linked to memory and executive dysfunction are more characteristic of DMD. Such distinctions are relevant for

prognosis, rehabilitation planning, and monitoring disease progression. And a much noticeable underlying finding is that visuo spatial disorientation or visuo spatial dysfunction is an early indicator of frontal lobe functional impairment, at a higher degree than memory impairment.

Limitations of the study

1. TBI location and lesion site couldn't be specified in this study due to resistance to MRI and lack of neuroimaging availability.
2. Sample size is less, which limited the generatability of the results.
3. Future studies with more samples are suggested.
4. Future studies integrating structural and functional neuroimaging with longitudinal cognitive assessment would help clarify the neural substrates underlying the distinct visuospatial profiles observed in TBI and DMD. and visuo spatial dysfunction can be a predictable factor in frontal lobe impairment .

Conclusion

Visuospatial dysfunction in TBI and DMD reflects different underlying mechanisms. Alzheimer's disease is characterized by pervasive and interrelated cognitive deficits, while TBI shows selective and variable impairments. Understanding these distinct profiles has important implications for diagnosis, prognosis, and cognitive rehabilitation

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