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Original Research Article

Examining the Impact of Learning Disability on Development of Working Memory

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ABSTRACT

Present study aimed to examine the effect of socioeconomic status (SES), age and learning disability on the development of working memory. A 3X3X2 factorial design with three level of Socio-Economic Status (High, Middle and Low) X three age groups i.e. (Children, 7-10yrs., Pre-Adolescents, 11-13yrs. and Adolescents 14-16yrs) X two levels of Learning Ability (Learning Disabled and Non-Disabled) was used and a total of 240 students participated in the present study. Raven's Standard Progressive Matrices (SPM) and Diagnostic Test of Learning Disability (DTLD) were applied to identify the learning disability in participants. Further, a set of three Working Memory Tasks were used to assess three components of working memory i.e. phonological loop, Visuo-Spatial Sketch-Pad and Central Executive. Data analysis was done using Univariate analysis.
Results revealed significant effects of socioeconomic status, age and learning disability on working memory. Specifically, participants with high SES were found superior on working memory and its components as compared to middle and low SES group. Further, adolescents performed far better on working memory and its components in comparison to neo-adolescents and children respectively. However, learning disabled (LD) participants performed very poor on each components of working memory and overall WM than their Non-LD counterparts. Findings are discussed.

Key Words: central executive, learning disability, phonological working memory, socioeconomic status, visuo-spatial sketch-pad.

INTRODUCTION

A person has capacity for retaining information on a temporary basis, and for manipulating, transforming and reinterpreting that information during the performance of a wide range of everyday task and this range of abilities has been referred to as working memory. The term working memory is known as the ability to hold and manipulate information in the mind for a short period of time. It has often been described as a flexible mental workspace in which one can store important information in the course of complex mental activities. Working memory plays a pervasive role in learning; it is where knowledge is constructed and modified and where information is processed for semantic encoding. Nearly all of what must be learned and remembered must pass through working memory. Out of several cognitive processes, working memory has been found to be strongly related to reading, [1-2] writing, [3] and arithmetic [4] skills. Studies reported that students with different types of learning disabilities, struggle in the classroom because they are unable to hold in mind sufficient information to allow them to complete the task. Research has also provided numerous indications that learning disability are associated with impairments in working memory. [5] Thus, researchers believe that impairments in working memory have been described as one of the major defining characteristics of learning disability, and memory difficulties will have a significant impact on a learning disabled individual throughout life. [6] Therefore, the study of working memory in relation to learning disability has been the central focus of research in developmental psychology.

After the dissatisfaction of the single storage model of memory, [7] the multiple component model of Baddeley captures the idea that working memory is more than just a single short term store. Baddeley and Hitch (1974) [8] proposed a working memory model which comprised of three components i.e. Phonological Loop, Visuospatial Sketchpad and Central Executive. Baddeley (2003) further modified his model and added a fourth component i.e., Episodic Buffer. The articulatory loop or Phonological loop, stores a limited number of sounds, and memory trace decays within 2 seconds unless material is rehearsed. The visuo-spatial sketch-pad is considered to be responsible for the temporary storage and manipulation of visual and spatial information – much like a paper to work out a problem in geometry. The central executive integrates information from Visuo-spatial sketch-pad and Phonological loop as well as from LTM. Central executive also plays a major role in attention, in planning and controlling behavior. Episodic Buffer is thought to be another temporary storage system, but one that interacts with both the phonological loop and the visuo-spatial sketch pad, as well as with LTM. It is also controlled by the central executive, and is used to integrate information across different modalities and to facilitate the transfer of information into and from LTM.

Working memory capacity develops with increasing age. It develops steeply up to eight years of age thereafter shows more gradual improvement. [9] The development pattern with increasing age is found in entire components of working memory. One year old children typically have small capacities that increase gradually until the teenage years, when adult capacities are reached that are more than double that of 4 year old children.

The neural processes sub-serving working memory and brain structures underlying this system continue to develop during childhood. The prefrontal cortex is one of the last brain regions to mature and it has been suggested that developmental changes in this brain area parallel the cognitive development during childhood. [10] Researchers evinced that the development of working memory process is tied to the maturation of the frontal lobes in childhood years. Developmental studies conducted with the n-back task have shown that visuo-spatial working memory (VSWM) performance improves throughout childhood and adolescence into young adulthood. [11]

In spite of age working memory is also influenced by other demographic variables such as gender and socioeconomic status. Socioeconomic status (SES) refers to an individual’s place in society and it strongly influences the individual experiences since childhood and during adult life. [12-13] SES is usually assessed through indicators such as education, occupation and family income or a combination thereof. [14]

Studies indicate that family socioeconomic status (SES), especially during early childhood, seem to affect performance in some neuropsychological systems more than in others, particularly memory (episodic, working and semantic), oral and written language and executive functions. [11] Such influence is more prominent at younger ages, [15] until about ten years old, [16] probably due to their complexity and prolonged development. [17] In the first years of childhood, the socioeconomic status is very important for development, since it may limit the conditions for stimulation, access to materials and activities that favor cognitive development. [18]

The education level of parents, especially the mother, [19] is associated with a higher cognitive performance, which was observed in North American, [20-21] Finnish, [22] British [19] and Latin-American [23] families. In a bulk of studies, researchers have found associations between parental education and the performance of children and adolescents (aged 3–13 years) in tasks of attention and verbal and visual memory, [24] executive functions [23&25] and written language. [26] Studies [27] denoted that the children with lower SES had lower performance regarding IQ, verbal episodic and semantic memory, working memory, written language, visuo-verbal memory and inhibitory control tasks than those with higher SES.

Learning new material requires manipulation of information, interaction with long-term memory, and simultaneous storage and processing of information. It also integrates new knowledge with prior existing information in long term memory (LTM). Individuals with learning disabilities are likely to have a deficiency in one or more cognitive processes, [28] including phonological processing, long term retrieval, attention, short term memory, and working memory. Out of several cognitive processes working memory has been found to be strongly related to learning ability. Children with learning disability may have poor working memory capacity consequently they have low academic performance in relation to their peers. These children are at risk for dropping out of school prematurely and failing to achieve their potential in life. Several studies have reported a strong relationship between working memory performance, reading skills, [29-30] written expression, [31] and mathematics performance. [32] In a study, Kibby et al. [33] declared that children with reading disability have difficulty with visuospatial working memory; they also have difficulty in reading and following maps, or coping items down from the board. A bunch of studies [34-35] determined that students with mathematical learning disability have deficiency in memory functions like; long term memory, memory for faces, memory for names, phonological working memory and visuospatial working memory. Bull and Scerif [36] found that low working memory scores are closely related to poor performance on arithmetic, word problems and poor computational skills. A close perusal of review of above studies denotes that there is a close association between learning disability and different types of memory processes. However the role of learning disability in the development of working memory is less investigated issue and more studies in this area is needed in Indian context. Therefore, the current study was planned to investigate the impact of learning disability on working memory.

Objectives

Present piece of work was conducted with following specific objectives:

- To examine the role of socioeconomic status (SES) and age in the development of working memory.
- To examine the effect of learning disability on working memory.

Hypotheses

On the basis of above objectives, following hypotheses were created for investigation. It was hypothesized that;

- The level of working memory would vary according to the socioeconomic status (SES) of participants.
- A developmental pattern in working memory would be found with increasing age. More specifically, adolescents would perform superior on different components of working memory as compared to pre-adolescents and children. and,
- Working memory would be adversely influenced by learning disability (LD). More specifically, learning disabled participants would perform inferior on working memory and its domains as compared to their non-disabled counterparts.

METHOD

Design

Present study is based on a 3X3X2 factorial design with three level of Socio-Economic Status (High, Middle and Low) X three age groups i.e. (Children, 7-10, Pre-Adolescents, 11-13 and Adolescents 14-16) X Level of Learning Ability (Learning Disabled and Non-Disabled).

Participants

A total of 240 children, age ranged 8-16 years, grade 3rd to 12th standard, enrolled in different schools of Gorakhpur city, participated in the present study. Purposive sampling technique was used for sample selection. On the basis of median score (mdn=42), obtained on Diagnostic Test of Learning Disability (DTLD), participants were divided into learning disabled (LD) and non-disabled groups (Non-LD). LD and Non-LD group were matched on the basis of age, grade and family's socio-economic status.

MATERIALS

(1) Socioeconomic Status Scale

This scale was developed and standardized by Pandey and Tripathi (2016) to determine the participant's social and economical condition. Initially this scale contained 10 items related to education level, occupation and income of the family. Participants had to respond on a five point scale, given in front of the each items. Thus, on this scale participants could get maximum 50 marks and minimum 10 marks. The scoring was done following 5,4,3,2 and 1 order and total summated scores indicated level of socioeconomic status of participants.

(2) Raven's Standard Progressive Matrices (SPM): Raven's Standard Progressive Matrices (Raven, Court and Raven) were used for the assessment of abstract reasoning and intelligence level of participants. The scale consists of 60 problems divided into five sets (A,B,C,D & E) of 12 matrices. Each item contains a figure with a missing piece and participant tries to see the relation between the matrices and by doing so, develops a systematic method of reasoning. The test was used to identify a pure group of learning-disabled children excluding those with sub-average intelligence.

(3) Diagnostic Test of Learning Disability (DTLD): This diagnostic test is developed and standardized by Swarup and Mehta (1991). The DTLD is a tool constructed to identify those children, who experience learning problems because of learning disability (LD). This test consists of 100 items which diagnoses learning disability in ten areas i.e.; (i) Eye-hand Co-ordination (EHC), (ii) Figure Ground Perception (FG), (iii) Figure Constancy (FC), (iv) Position-in-Space (PS), (v) Spatial Relations (SR), (vi) Auditory Perception (AP), (vii) Memory (M), (viii) Cognitive Abilities (CA), (ix) Receptive Language (RL), (x) Expressive Language (EL).

(4) Working Memory Task: Three sets of working memory tasks were devised by Pandey and Tamta (2007). These tasks were used to assess the level and form of working memory.

a) **Reading Span Task (RSPAN):** Reading span task contains 30 sentences each one written on a separate card. These cards were categorized under five sets based on increasing the number of sentences. The length of each sentence given in card is 8 to 12 words. Every card is presented for 0.5 second. Respondent read each sentences aloud and determined whether it made sense or not, and at the same time remembering the Red word (as one word was written with red color) of that sentence. After the presentation of each set, respondents were asked to recall the red word in correct order. Aggregate of correctly recalled items denoted the level of memory span (RSPAN) in adolescents.

b) **Visual Pattern Recall (VSPAN):** The Visual Pattern Recall Task includes 25 Geometric designs. The participant was instructed to look carefully at the pattern and try to remember where the blank parts were. The design was presented on the card and there was a half second delay before presentation of an empty geometric design of the same size of recall. The participants were asked to correctly recall the pattern by putting (√) mark at the same part. After the presentation of card assigned immediate memory test was done. The correct responses on geometric design were added together, which denoted the level of VSPAN.

c) **Operation Span Task (OSPAN):** OSPAN task consisted of 30 math equations. Each card contained one word. These cards were categorized under five sets based on increasing the number of Math equation with words. For instances, 1st set of the task includes 2 cards sets and 2nd set of task contains 4 cards and so on. Immediate memory test was done. The participants were given a set of equation and accompanying with words. They read the equation aloud as soon as it appeared. Then, were asked to solve a series of math equations while, trying to remember sets of unrelated words. Lastly, they were asked to recall all words in the proper order. The total of correctly recalled items denoted the level of memory span (OSPAN). Finally on the basis of total scores obtained on three types of task, the level of overall working memory in children was determined.

RESULTS

Data obtained on various measures from the participants were scored according to rules given in manuals. Scores were treated statistically in terms of Comparative Analysis.

Therefore, a 3x3x2 factorial analysis of variance with three levels of socioeconomic status (High, Middle & Low) X three age groups of participants (Children, Pre-adolescents & Adolescents) X two levels of learning ability (Learning disabled & Non-learning disabled) was used to examine the effect of SES, age and learning disability on working memory (WM) and its various domains (Phonological WM, Visuo-Spatial WM and Central Executive WM). Results are displayed in tables and figures and reported separately for each domain of working memory and working memory as a whole.

1. Phonological Working Memory (WM) as a function of SES, Age, and Learning Disability (LD)

Table 1 displays Mean and S.Ds. of phonological WM as responded by participants belonging to different groups. Results (Table-1) evinced that the extent of phonological working memory differed across the level of SES, age and level of learning disability.

Table-1 : Mean and S.D. of Phonological Working Memory by SES, Age, and Learning Disability (LD)

		Children		Pre- Adolescents		Adolescents	
High SES		LD	Non-LD	LD	Non-LD	LD	Non-LD
	Mean	7.667	14.916	7.667	15.041	6.00	17.788
	SD	(.577)	(2.55)	(1.154)	(4.185)	(3.741)	(5.750)
Middle SES	Mean	5.529	13.100	6.167	13.800	5.823	18.500
	SD	(1.374)	(2.024)	(2.148)	(2.394)	(2.555)	(2.223)
Low SES	Mean	2.250	2.291	2.578	11.667	3.736	18.428
	SD	(11.667)	(.516)	(2.036)	(1.751)	(2.600)	(4.649)

Moreover, to determine the influence of SES, age and learning disability on phonological working memory, a 3X3X2 factorial analysis of variance was computed. Obtained results are displayed in Table-2 and Figures (1-4)

Table-2: Summary of 3X3X2 ANOVA (SES X Age X level of LD) of phonological working memory

Source of Variation	Sum of Squares	df	Mean Square	F
A (SES)	374.433	2	187.217	26.074**
B (Age)	397.731	2	198.866	27.697**
C (Total LD)	4056.967	1	4056.967	565.025**
A X B	19.981	4	4.995	.696
AXC	28.999	2	14.500	2.019
BXC	425.166	2	212.583	29.607**
AXBXC	42.940	4	10.735	1.495
Within	1593.995	222	7.180	

N=240, **P< .01, *P<.05

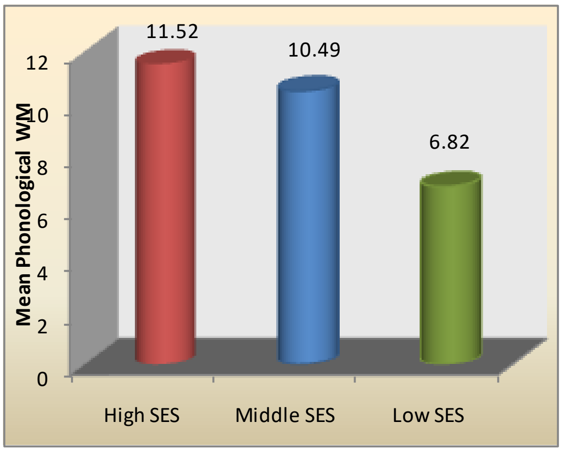

Fig: 1 –Phonological WM as a function of SES

It is clear from table-2 and figure-1 the main effect of socio-economic status of respondents was found significant [F (2, 222) = 26.074, P<.01), on phonological working memory which revealed that participants with high socio-economic status performed far superior on phonological working memory as compared to participants with middle and low socio-economic status respectively. Therefore, an increasing pattern was found from low SES to middle and high SES group of participants.

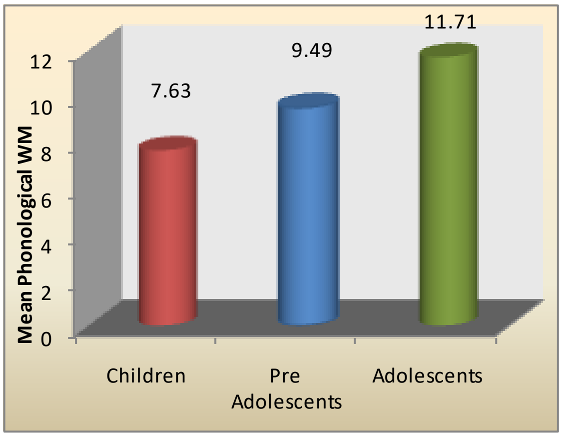

Fig: 2 – Phonological WM as a function of Age

Further, the significant main effect of age [F (2,222)= 27.697, P<.01] on phonological working memory suggests that adolescents performed better on phonological component of working memory as compared to children and pre adolescents . Thus, it shows a developmental pattern on the performance of phonological WM from childhood to adolescence respectively (Table-2 & Fig-2).

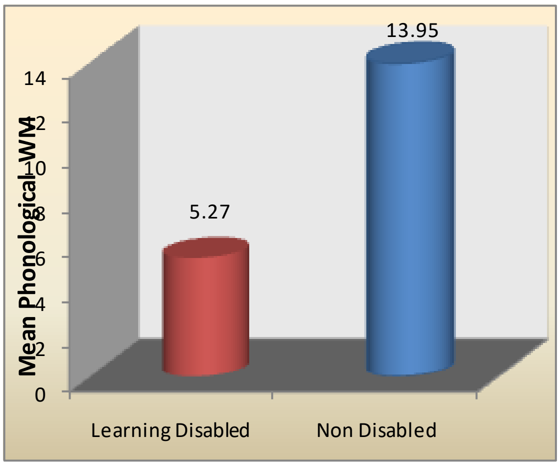

Fig: 3 -Phonological WM as a function of Learning Disability

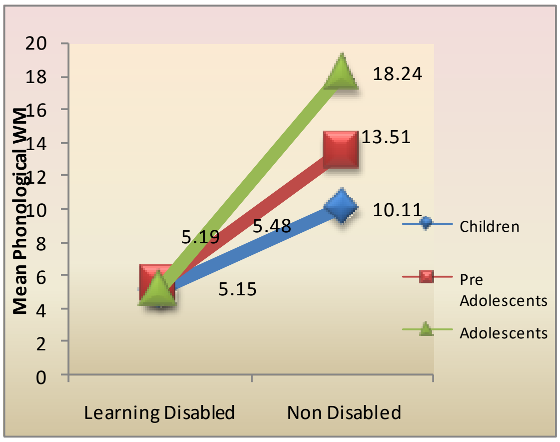

Fig.-4 Phonological WM as a function of interaction of Age and Learning Disability

Likewise, main effect of learning disability [F (1, 222) =565.025, P<.01] was found significant which indicates that participant with learning disability (LD) performed very inferior on phonological working memory as compared to Non-LD participants (Table-2 & Fig.3).

Moreover, the interaction effect of age and level of learning disability on phonological working memory was found significant [F(2,228)= 29.607, P<.01]. As interaction graph shows that in the case of LD group, performance on phonological working memory was very poor and very little variation among three age groups was identified. Whereas, In the case of Non-LD group, children performed inferior on phonological working memory as compared to pre adolescents and adolescents. In other words, a developmental pattern in phonological working memory was found in Non-LD group (Fig-4).

2. Visuo-spatial working memory as a function of SES, Age and level of Learning Disability

Table 3 displays Mean and S.D. of visuo-spatial working memory scores across the socioeconomic status (SES), age and learning disability (LD). Results indicate that the level of visuo-spatial working memory differed in accordance with SES, age and level of learning disability.

Table-3: Mean and S.D. of visuo-spatial working memory by SES, Age and Learning Disability

		Children		Pre- Adolescents		Adolescents	
High SES		LD	Non-LD	LD	Non-LD	LD	Non-LD
	Mean	5.667	13.542	7.667	15.875	5.750	19.956
	SD	(1.154)	(2.765)	(2.081)	(4.089)	(3.304)	(2.549)
Middle SES	Mean	5.411	12.600	5.667	10.500	5.941	19.00
	SD	(1.622)	(2.170)	(2.700)	(1.957)	(2.946)	(2.108)
Low SES	Mean	4.550	12.166	5.105	10.833	3.053	15.857
	SD	(1.932)	(1.602)	(2.705)	(.983)	(1.928)	(3.532)

In order to ascertain the effect of SES, age and learning disability on visuo-spatial working memory, ANOVA analysis was done and obtained results are presented in Table-4 and Figures (5-9).

Table-4 Summary of 3X3X2 ANOVA (SES X Age X level of LD) of visuo-spatial working memory

Source of Variation	Sum of Squares	df	Mean Square	F
A (SES)	171.973	2	85.986	12.462**
B (Age)	215.086	2	107.543	15.586**
C (Total LD)	3093.581	1	3093.581	448.347**
A X B	90.579	4	22.645	3.282*
AXC	18.217	2	9.108	1.320
BXC	376.083	2	188.041	27.253**
AXBXC	8.896	4	2.224	.322
Within	1531.793	222	6.900	

N=240, **P< .01, *P<.05

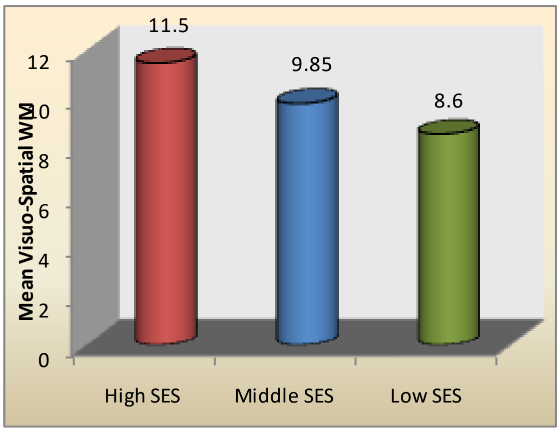

Fig: 5 – Visuo-spatial WM as a function of SES

ANOVA results revealed that the main effect of socio-economic status of respondents was found significant [F (2, 222) =12.462, P<.01), on visuo-spatial working memory which indicates that high SES group of respondents performed far superior on visuo-spatial working memory as compared to participants with middle and low socio-economic status. Thus, again an increasing pattern was found from low to middle and high SES group respectively (Table-4 & Fig-5).

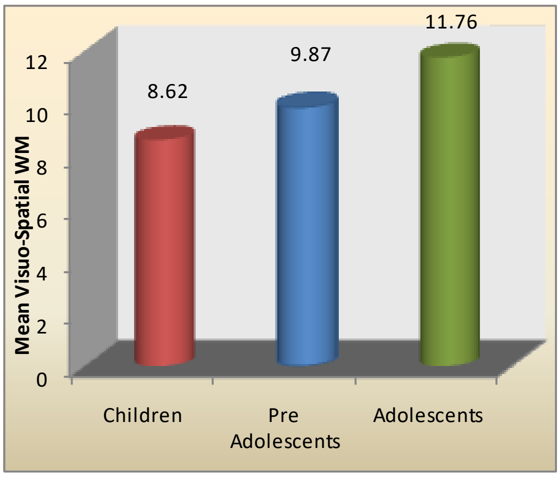

Fig: 6 – Visuo-spatial WM as a function of Age

Again, the significant main effect of age [F (2, 222) = 15.586, P<.01), depicted that the level of visuo-spatial working memory varied across age. As above graph shows (Fig-6) adolescents performed better on visuo-spatial working memory in comparison to children and pre-adolescents. Therefore, again a growing pattern in visuo-spatial working memory was identified.

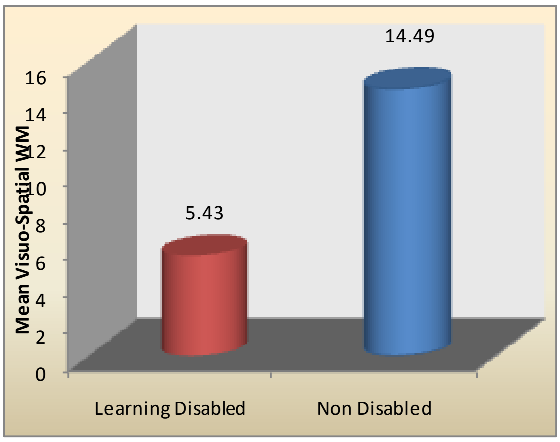

Fig: 7 – Visuo-spatial WM as a function of learning disability

Moreover, the main effect of learning disability was found significant [F (1, 222) =448.347, P<.001), which denotes that LD respondents displayed very poor visuo-spatial working memory in comparison to Non-LD participants (Table-4 & Fig. 7). Despite this, interaction effects were also found significant.

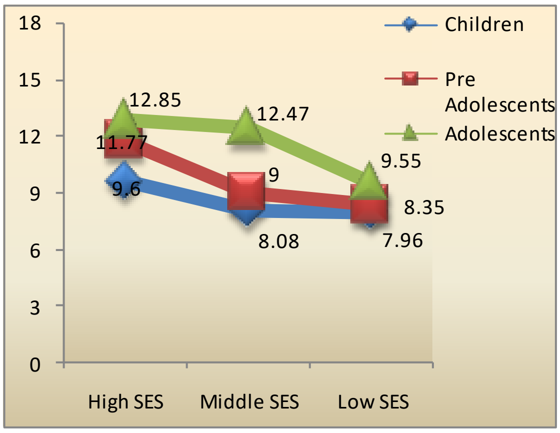

Fig.-8 Visuo-spatial WM as a function of interaction of Age and Socioeconomic Status (SES)

The significant interaction effect of age and socioeconomic status (SES) [F (4, 222) =3.282, P<.05], on visuo-spatial WM indicates that in the case of high SES group, an increasing pattern was found among all three age groups. Whereas, in case of middle SES, there was no difference found between the performance of children and pre adolescents but adolescents performed superior than children and pre adolescents. Whereas, in case of low SES group adolescents performed better on visuo-spatial WM in comparison to pre adolescents and children respectively (Fig-8).

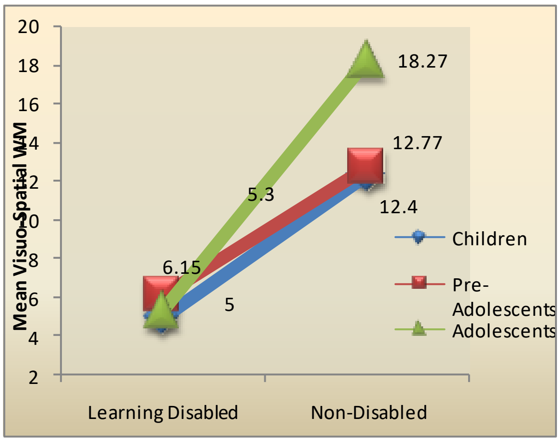

Fig.-9 Visuo-spatial WM as a function of interaction of Age and Learning Disability

Further, The significant interaction effect of age X learning disability [F (2, 228) =27.253, P<.01], on visuo-spatial working memory denotes that in the case of LD group, pre adolescents performed little better in comparison to children and adolescents. Whereas, in the case of Non-LD group, adolescents scored maximum than pre adolescents and children on visuo-spatial working memory (Fig-9).

3. Central Executive Working Memory as a function of Socioeconomic Status (SES), Age and level of Learning Disability

Table 5 presents Mean and S.D. of central executive working memory scores responded by participants. Results revealed that central executive working memory varied across level of SES, age and level of learning disability (Table-5).

Table-5: Mean and S.D. of Central Executive Working Memory by SES, Age and Learning Disability (LD)

		Children		Pre- Adolescents		Adolescents	
High SES		LD	Non-LD	LD	Non-LD	LD	Non-LD
	Mean	4.667	13.167	5.333	15.291	7.250	21.608
	SD	(.557)	(2.664)	(3.511)	(3.276)	(2.629)	(2.856)
Middle SES	Mean	4.352	11.900	5.277	13.900	5.647	20.100
	SD	(1.868)	(1.100)	(1.903)	(2.079)	(1.835)	(2.233)
Low SES	Mean	1.900	11.166	3.947	12.833	4.056	19.428
	SD	(1.483)	(.408)	(2.222)	(3.060)	(2.040)	(2.299)

Furthermore, to determine the influence of SES, Age and level of LD on central executive working memory, a 3X3X2 ANOVA was computed. Obtained results are displayed in Table 6 and Figures (10-13).

Table-6 Summary of 3X2X2 ANOVA (SES X Age X LD) of Central Executive Working Memory

Source of Variation	Sum of Squares	df	Mean Square	F
A (SES)	124.481	2	62.241	11.641**
B (Age)	731.223	2	365.611	68.379**
C (Total LD)	4377.174	1	4377.174	818.643**
A X B	4.609	4	1.152	.216
AXC	8.333	2	4.167	.779
BXC	312.738	2	156.369	29.245**
AXBXC	6.259	4	1.565	.293
Within	1187.005	222	5.347	

N=240, **P< .01, *P<.05

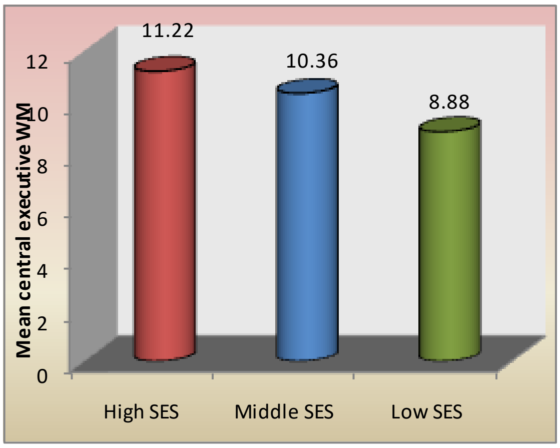

Fig: 10 – Central Executive WM as a function of SES

The main effect of socioeconomic status was found significant [F (2, 222) =11.641, P<.01)] on central executive WM which denoted that participants with low socioeconomic status (SES) displayed poor central executive WM as compared to middle and high SES group. Therefore, a decline was found on central executive WM from high SES group to middle and low SES group (Table 6 & Fig-10).

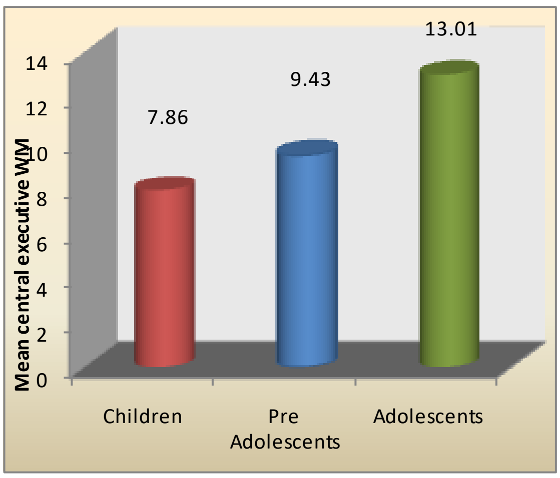

Fig: 11 – Central Executive WM as a function of Age

The significant main effect of age [F (2, 222) =68.379, P<.01)], denoted that adolescents performed far better on visuo-spatial working memory in comparison to pre adolescents and children. Thus, a developmental trend was found on the central executive working memory (Table 6 & Fig-11).

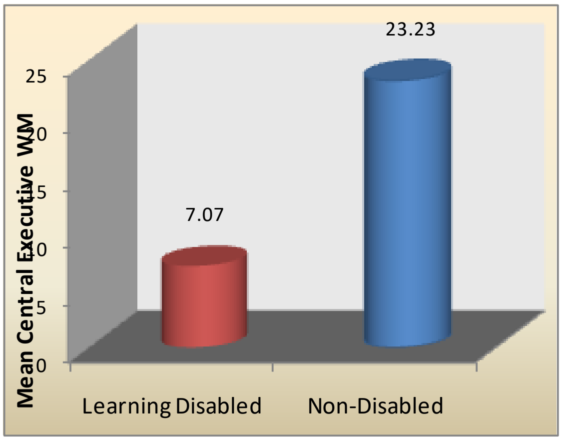

Fig: 12 – Central executive WM as a function of Learning Disability

Results further depicted that main effect of learning disability [F (1, 222) = 818.643, P<.01), was also found significant which reveals that LD group of respondents showed very poor central executive working memory in comparison to non-LD participants (Table 6 & Fig-12).

The significant age x learning disability effect [F (1, 228) = 30.653, P<.01)], indicated that LD participants of all the three age groups performed very poor than Non-LD participants. More specifically, in the case of learning disability group, children performed inferior as compared to pre-adolescents and adolescents respectively. However, in case of Non-LD participants, a developmental pattern (an increasing order) was found. Adolescents displayed far better central executive working memory as compared to pre-adolescents and children respectively (Fig-13).

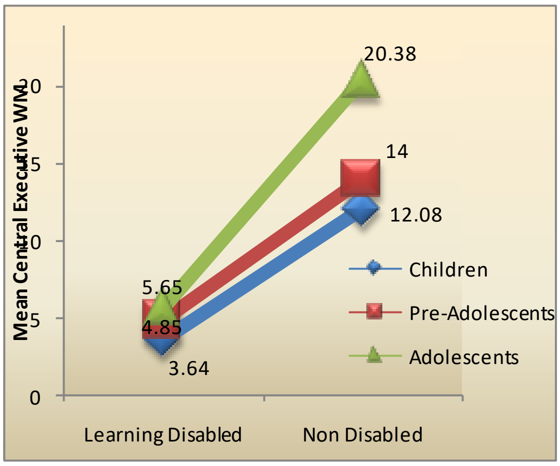

Fig.-13 Central executive working memory as a function of interaction of age and learning disability

4. Overall Working Memory as a function of Age, SES and level of Learning Disability

The influence of SES, age and level of learning disability on overall working memory was also determined. Results (Table-7) revealed that the level of working memory of respondents differed across level of SES, age and level of LD.

Table-7: Mean and S.D. of Overall Working Memory by SES, Age and Learning Disability (LD)

		Children		Pre- Adolescents		Adolescents	
High SES		LD	Non-LD	LD	Non-LD	LD	Non-LD
	Mean	18.000	41.666	20.667	46.208	19.000	65.217
	SD	(1.000)	(1.948)	(2.886)	(5.793)	(1.000)	(3.544)
Middle SES	Mean	15.294	37.600	17.166	38.200	17.529	57.600
	SD	(1.311)	(.516)	(.985)	(1.032)	(.875)	(.966)
Low SES	Mean	8.550	35.00	11.421	35.333	10.789	53.714
	SD	(2.645)	(1.788)	(2.987)	(1.751)	(4.276)	(2.360)

Furthermore, ANOVA was computed to assess the effect of SES, age and LD on overall working memory. Results are displayed in Table 8 and Figures (14-17).

Table-8 Summary of 3X3X2 ANNOVA (SES X Age X level of LD) of Overall Working Memory

Source of Variation	Sum of Squares	df	Mean Square	F
A (SES)	1933.743	2	966.871	111.792**
B (Age)	3783.642	2	1891.821	218.738**
C (Total LD)	34472.106	1	34472.106	3985.760**
A X B	27.525	4	6.881	.796
AXC	134.440	2	67.220	7.772*
BXC	3263.907	2	1631.953	188.691**
AXBXC	37.402	4	9.351	1.081
Within	1920.037	222	8.649	

N=240, **P< .01, *P<.05

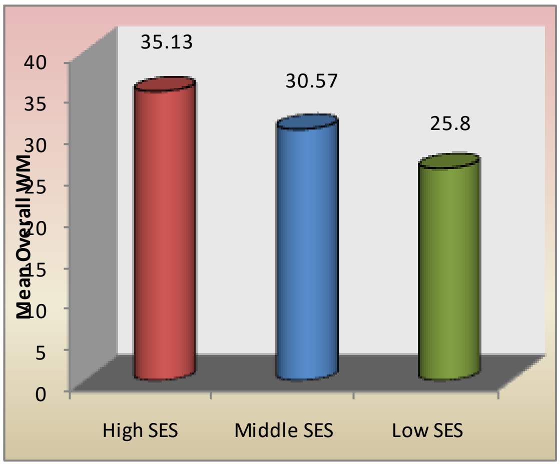

Fig: 14– Overall WM as a function of SES

The main effect of socioeconomic status (SES) was found significant [F (2,222) =111.792, P<.01)] which revealed that participants with high SES performed far better on working memory as compared to middle and low SES group. Consequently, a developing trend was found in overall WM from low SES group to high SES group (Table 8 & Fig-14).

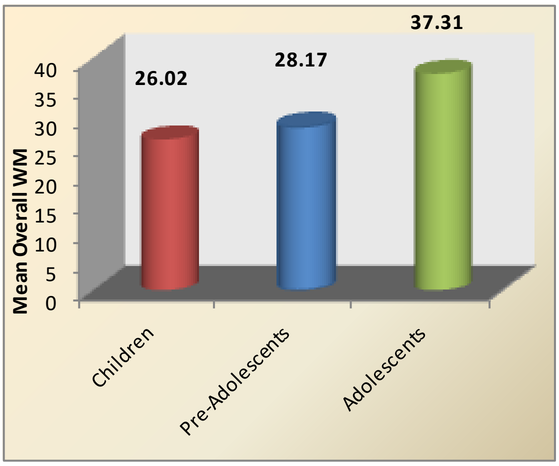

Fig: 15 – Overall WM as a function of Age

Again, the significant main effect of age [F (2, 222) =218.738, P<.01), indicated that children performed inferior on overall working in comparison to Pre-adolescents and adolescents. So, a developmental pattern found in all three age groups (Table 8 & Fig-15).

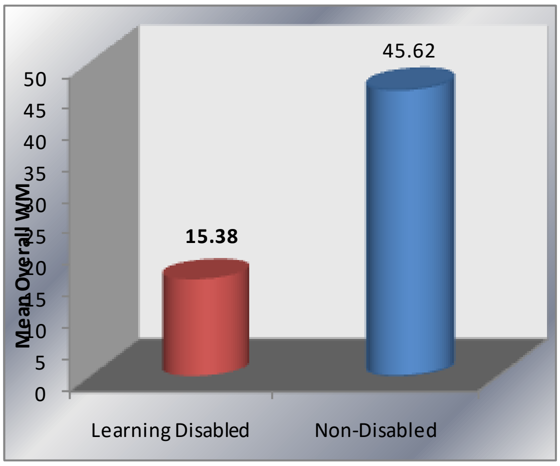

Fig: 16 –Overall WM as a function of Learning Disability

Likewise, the main effect of level of learning disability was found significant [F (1, 222) =188.691, P<.001], which denoted that learning disabled (LD) group performed very poor on overall working memory as compared to non-disabled (Non-LD) respondents (Table 8 & Fig. 16).

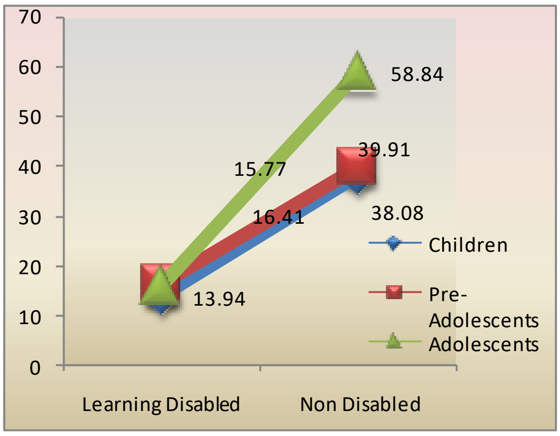

Fig.-17 Overall WM as a function of interaction of Age and Learning Disability

Significant age x level of LD interaction effect [F (2,222) =188.691, P<.01], depicted that in LD group, children showed poor level of working memory in comparison to pre-adolescents and adolescent. However, very little difference was found between pre-adolescents and adolescents performance. Further, in the case of Non-LD group, adolescents performed far better on overall working memory as compared to pre-adolescents and children respectively. Thus, a developmental trend was identified on overall WM (Fig-17).

A cursory glance at ANOVA results revealed that socioeconomic status of participants plays an important role in the development of working memory. Further, it was also found that working memory develops with growing age from childhood to adolescents. Contrary to this, learning disability has exerted negative impact on development of working memory. Due to learning disability (LD) participants performed inferior on working memory and its domains as compared to non-disabled (Non-LD) participants.

DISCUSSION

The findings of the present study have proved the hypotheses that working memory (WM) was significantly influenced by socioeconomic status (SES), age and learning disability. More specifically, participants with high SES performed far better than middle and low SES group. Further, a developmental trend in working memory was found with growing age. Specifically, adolescents performed far better on working memory and its components as compared to pre-adolescents and children. It is also proved that learning disabled (LD) group of participants scored very poor on working memory and its components as compared with Non-LD group. Infact, learning disability made children unable for storing and maintaining information. Findings have been interpreted and discussed in the light of other empirical evidences.

Present results evinced the significant influence of SES on working memory. Specifically, participants with high SES were performed superior on working memory in comparison to middle and low SES group. This result supported by several researches. Researcher have examined the association between SES and explicit memory and found that children from lower-SES backgrounds perform worse on measures of working and declarative memory than their higher-SES counterparts. [37-39] In a study Sarsour et al. [40] determined that socioeconomic status of family was strongly associated with children's inhibitory control, cognitive flexibility and working memory capacity. Gustafsson et al. [41] expressed that low socioeconomic status environments with a high stress factor can decrease the memory processing. Children who live in high-risk environments of parental abuse express fluctuations in their ability of attention and working memory capacity [41]. In another study, Mezzacappa [42] reported that parental education was strongly associated with child executive functions (i.e., working memory, inhibition and cognitive flexibility). One potential explanation for the effect of socioeconomic status on working memory is the developmental process (maturation) of working memory systems. Working memory develops slowly, continuing to mature into young adulthood. [43-44] This slow development may render the neural systems underlying working memory susceptible to environmental influences, such as the chaotic home environment and poor school quality often associated with lower-SES. [45]

Another important finding of the study is that a developmental pattern in working memory with growing age was identified. Present findings have plenty of empirical supports. In a study Gathercole et al. [46] reported that children working memory span increases steadily between 3-15 years of age. Humle et al. [47] studied the digit span and other serial recall spans in group of children aged 4, 7 and 10 years and reported an average two-to-three fold increase in span from between 2 and 3 items at the age of 4 years to about 6 items at the age of 12 years. In a study, Kwon et al. [48] reported age related increases in prefrontal cortical activation associated with visuo-spatial two-back task performance in 7 to 22 year olds.

In the Indian context, Pandey and Tamta [49] explored a developmental trend in working memory. Hence, adolescents performed far better on working memory and its components (i.e. phonological loop, visuo-spatial sketchpad and central executive) as compared to neo- adolescents and children. Gathercole et al. [50] also reported that the developmental increase in memory capacity appear to be due to increase in speed and efficiency of the sub vocal rehearsal process. There is close association between the speed with which children and adults can articulate words and their phonological loop capacity. [51] This association is thought to reflect the fact that the faster articulation allows faster sub-vocal rehearsal. Thus, as children grow older and their rate of speaking increases, their sub-vocal rehearsal rate also increases allowing more material to be continuously recycled without decay, resulting in greater phonological loop capacity. [52]

Moreover, present study examined the impact of learning disability (LD) on development of working memory. Results revealed that learning disability exercised negative impact on the development of working memory. Specifically, learning disabled (LD) students scored very poor on working memory and its domains as compared their Non-LD counterparts. The finding of this study is consistent with previous studies. Swanson and Berninger [53] found that children with all types of learning disabilities and difficulties displayed poor working memory performance, especially in verbal and executive working memory. When learning disabled children are matched with control group that have the same I.Q., the learning disabled group of children display deficits in specific aspects of working memory. [54] Children with mathematics learning disability have problems in verbal, visuospatial, and executive working memory. [55-56] In a research, Henry [57] discovered that 11 to 12 years LD children could retain verbal instructions that contained up to three units of information whereas, normal children could manage five units of information. In a typical classroom situation, where the students have to process other information while retaining verbal instructions, students with LD can maintain only one item of information, whereas Non-LD students can handle an average of three units of information. [57] Apart from this, Gathercole and Pickering [58] conducted their study on children with special educational needs for their learning problems. They compared the profile of 10 children with learning problems and found that central executive measures discriminated children with special educational needs with high degree of accuracy.

Some investigators [59] believe that intrinsic working memory limitations are the primary cause of learning disabilities. Most of the research on working memory and learning disability is correlational, it cannot attribute causality. It has also been argued that whether working memory deficit seen in children with learning disability is a capacity deficit or strategy deficit. Swanson [60] theorized that a working memory deficit is not entirely a capacity deficit. Rather, for some children with learning disabilities, a working memory problem is primarily a strategy deficit. That is, children with a learning disability often possess sufficient working memory resources but fail to apply effective strategies spontaneously or consistently, resulting in learning failure. If working memory deficit is purely a strategy deficit, children with learning disabilities can be supported by teaching them appropriate strategy to deal with their working memory limitations. Once these children become able to overcome their working memory limitations they would be able to learn as effectively as normal children.

CONCLUSION

Findings of the study revealed that socioeconomic status, age and learning disability exerted influential roles in the development of working memory. More specifically, respondents with high SES were found superior on each dimension of working memory and overall WM as compared to middle and low SES group. Moreover, a developmental trend with growing age was found for each dimensions of working memory. Therefore, adolescents performed better on working memory than pre adolescents and children. Since adolescents have broader knowledge about the world and improved cognitive ability therefore, they were found superior as compared to pre adolescents and children. Findings of present study further evinced that working memory and its components are strongly influenced by learning disability. Specifically, learning disabled (LD) participants showed poor working memory than non learning disabled (Non-LD) group of participants. Present study provides valuable data, which focus on some of the unexplored area i.e. learning disability and its damaging role in the development of working memory. Apart from this, finding of the study suggests that parents and teachers should be made aware and provide specific working memory training to LD children so that they can improve their working memory capacity and compete with their normal (Non-LD) peers. However, there are few limitations of this study. First, generalization of the results from this study is limited as the sample size is small and limited to one region (Gorakhpur) of Uttar Pradesh. Secondly, working memory functioning and its deficit should be explored more specifically in subtypes of learning disability. Finally, researchers should implement some interview schedule to exercise other qualitative analysis to support findings of the study.

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