Research Article

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# Working memory in children with intellectuality disability (ID)working memory in children with intellectuality disability (ID)


## Abstract

Working Memory (WM) and Short Term Memory (STM) performance were examined in children with Intellectual Disability. They were aged between 4 to 16years. The study also explored the relationship of Intelligence Quotient (IQ) with WM and STM. The study found that the children with Intellectual Disability (ID) were impaired on all the measures of WM/STM, albeit with specific areas of strength displayed by children functioning within the Borderline range of ID. Overall, children with delay in intellectual functioning performed significantly lower compared to typically-developing children.


**Keywords:** children, intellectuality disability, working memory

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**Abbreviations:** ID, intellectuality disability; WM, working memory; STM, short term memory; IQ, intelligence quotient; VCI, verbal comprehension index; TD, typically developing

## Introduction

Previous research suggests the implications of working memory among the Intellectually Disabled (ID) population; however, very few researches have used comprehensive working memory-specific instruments. Studies in the past mainly focused on population with known diagnoses such as down and Williams syndromes, focusing on the implications of verbal working memory only. This research was undertaken to measure verbal and visual-spatial STM/WM of children varying in range between moderate-mild-borderline intellectual disability and with no known syndrome.

Working memory plays an important role in learning; and hence contributes towards the development of cognitive functioning. According to Baddeley,[1] working memory is a system that supports temporary storage and manipulation of information required for complex cognitive tasks such as language comprehension, learning and reasoning..This definition of working memory is highly suggestive of deficits of working memory within the ID population. Research conducted in this area, support the theoretical framework of working memory within the Intellectually Disabled (ID) population, seem to have relied mostly on the principles of Baddeley's multi-component storage and processing unit that contribute to higher order cognitive function.[2,3]

Studies have shown the relationship between WM and intelligence, for example, Just and Carpenter (1992) in their research proposed the relationship of intellectual functioning and working memory. They have suggested that intellectual performance may be enhanced if the individual is able to maintain more information in a temporary store and to simultaneously process it. Many studies were subsequently conducted to find high correlations between WM and intelligence but this relationship could not be established with the STM [4-6] Kane et al. (2005). WM was also considered to predict the intellectual performance. The relationship of ID and WM was also explored by many other researchers,[7–14]

Henry,[8] for example, studied children with typical mild ID, with no known syndrome, and observed a reduced phonological-loop capacity and poor performance on tasks measuring Central Executive Functions. This may contribute to their low performance on the verbal working memory tasks. Rosenquist, Conners, and Roskos-Edwoldsen (2003) found that automatic rehearsal was deficient in children with Mild Intellectual Disability (MID). Henry & Maclean[2] compared memory performance of MID children and the findings supported the assumptions of low performance on tasks that is considered to be responsible for holding information in phonological-loop and Central Executive tests by MID children. Van der Molen et al.,[12] replicated the study by comparing three groups of children with MID, and the overall pattern of results seemed to be consistent with a developmental delay account of MID.

The findings of most of the research have indicated that children with ID performed poorly on most of the working memory tasks, such as Digit Span Forwards and Backwards tasks, as well as on span tasks such as Corsi Blocks task, compared to typically developing children of similar mental age, regardless of level of intelligence or aetiology of ID.[15–17] Vicari et al.,[18] also found no deficits on Forward Span tasks among people with ID compared to control groups.[18] The importance of working memory and its auxiliary components is evident from these researches, as it contributes to a greater extent in developing cognitive functioning.

The need for the present research is felt as the existing research have not yet fully answered the questions of implications of verbal STM/WM and Visual Spatial STM/WM within the ID children. This research intends to focus on measuring both verbal and visual-spatial aspects of STM and WM components of children. The goal of the present study was to examine working-memory functioning in children with mild-borderline ID with the following considerations:

It was hypothesised that children with Intellectual Disabilities would perform generally poor on the memory tasks than the average-ability control group. Based on previous researches, it was also hypothesized that STM/WM would have a strong relationship with cognitive abilities.

## Methods

### Participants

The study was conducted on total 53 English speaking children with the following breakdown across groups:

## Intellectually Disabled children

The ID group consisted of 32 children (21 boys and 11 girls), attending special schools or mainstream schools. The mean chronological age was 9.75 (SD = 36months; range = 56-192months. Children with a standard score of less than Full Scale IQ score of 79 on Wechsler Intelligence Scale for Children-IV (WISC-IV, Wechsler, 2003, or the Wechsler Primary Pre-school Scale of intelligence-III (WPPSI-III; Wechsler, 2003) were retained in this group. Children with a co-morbid diagnosis, such as attention deficit hyperactivity or medical conditions were excluded from the study.

## Typically Developing (TD) children

The 23 children (12 boys and 11 girls) TD children had a mean chronological age of 10.5years (SD = 6months; range 48=190). They were assessed on WISC-IV/WPPSI-III and children who obtained a FSIQ score of above 80 were retained with no significant discrepancy across the sub-domains of the test.

## Procedure

A standardized procedure of assessment was adapted by administering the IQ test followed by memory assessment of 60-120minutes over two to three days with small breaks. The following assessment tools were administered:

## Cognitive assessment

Wechsler Intelligence Scale for Children (WISC-IV; 2003) was administered on children aged ranging from 6-16years and Wechsler Primary Pre-school Scale of Intelligence (WPPSI-III; 2002) was administered on children aged between 3 to 7years. The WISC-IV provides scores on four indexes; Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Working Memory Index (WMI) and Processing Speed Index (PSI). The Full Scale IQ (FSIQ) was also calculated which was the sum of the four indexes.

Working Memory Assessments: AWMA- for age group from 4-220[19]

The AWMA is a computerized battery for measuring multiple components of short term and working memory. The reliability and validity of the test is reported in Alloway et al.;[20] Alloway.[21]

The AWMA[19] batteries consist of 4 sets of measures of memory which include the following:

Verbal Short Term Memory (VSTM), which consisted of Digit recall, Word recall, and non-word recall.

Verbal Working Memory (VWM): This consisted of backward digit recall, and Listening recall.

Visual-Spatial Short Term Memory (VSSTM): which consisted of Block Recall, Mazes and Dot Matrix?

Visual Spatial Working Memory (VSWM): which consisted of Odd One Out, Mr X, and Spatial Span.?

The AWMA provides standardized scores, with a mean value of 100 and standard deviation of 15, for 4 to 11 year-olds.[19] Prior to the commencement of each task, the child was presented with examples and practice items to familiarize him/her with the task. In addition, the child was also given further explanations of the task by the present researcher if he or she was considered in need for further clarification in order to facilitate clarity of instructions.

## Verbal short-term memory

The child is presented with a sequence of digits, words, or non-words and the child is required to recall them in the correct serial order. Digit lists consist of digits randomly constructed ranging from 1-9, which are spoken at a rate of one digit per second. The word lists are monosyllabic words with a consonant-vowel-consonant structure, and no stimuli are repeated. The non-words have the same structure and were developed using the same pool of phonemes as the words used in the word recall subtest.

## Verbal working memory

In the Digit Backward recall test, a child is required to recall a sequence of spoken digits presented to him, in reverse order. In the listening recall task, a child is presented with a series of spoken sentences. The child is expected to confirm whether the sentence is right or wrong by stating "true" or "false" and he/she is also to recall the final words for each sentence in sequence. In the counting recall test, a child is presented with a visual array of red circles and blue triangles and the child is expected to count only the circles by putting his finger on each circle and when the presentation disappears, the child has to call out the number of circles he has counted.

## Visuo-spatial Short term memory

In the Block Recall test, there are nine randomly located cubes on a specially designed board. The presenter taps a sequence of cubes with a finger on a specifically designed board. A child's task is to watch and repeat the sequence in the same order as the presenter has demonstrated. In the maze memory test, the child observes a two-dimensional line maze with a path drawn through the maze for 3seconds. The same maze appears on the screen without the path, and the child is asked to recall the same path by tracing it with his fingers, following the same direction on the maze. In the dot matrix task, a sequence of red dots is presented on a 4 x 4 grid, and the child is required to point to the positions of each dot that appeared for 2seconds.

## Visuo-spatial working memory

In the Odd One Out task, a child is presented with a horizontal row of three boxes with three shapes, one in each box. The child needs to identify the shape that does not match the other two shapes and also to remember its location. The child is then presented with a blank set of three boxes on the screen and the child needs to point to the location of the odd one shaped where it had appeared in the correct order. In the Mr X task, a child is presented with a picture of two Mr X figures, one with a yellow hat and the other one with a blue hat. Mr X can be rotated to change his position of his hand as well. In the Spatial span task, a child views a picture of two identical shapes, except that the shape on the right side of the screen has a red dot on it. The child identifies whether the shape on the right is the same or opposite of the shape on the left. The shape with the red dot may also be rotated.

# Results

The descriptive statistics for the sample on various assessment measures are given in Table 1. The mean scores of children with ID show very low performance on almost all the sub-scales of the AWMA batteries.

A MANCOVA was performed (Table 2) on the four composite memory sub-scales to find out differences in performance. For this purpose, General Ability Index (GAI) was calculated instead of Full

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Scale IQ (FSIQ). The FSIQ is a combination of all the subtests which include working memory and processing speed. Whereas the GAI consists of the scores of Verbal Comprehension Index (VCI) and Perceptual Reasoning Index (PRI). The GAI is highly recommended for assessing children with Intellectual Disabilities (ID). Therefore, the GAI was maintained as a co-variate in order to statistically control its effect. The overall group term was observed to be significant, ($F = 4.79$, $p < .000$).

When the GAI was a co-variate, the results were significant on the verbal STM/WM and Visual-Spatial WM; and no significant difference was observed on the visual spatial STM. . Hence, these results suggest that processing speed is probably affecting the performance of ID children on the memory tasks. As it is now established that WM tasks require mental agility to process information.

When the PSI was a co-variate, the overall group term was observed to be non significant ($F = 1.19$, p>ns). The only significant difference were obtained on the Visual-Spatial STM ($F = 7.04$, $p <.012$. This result would indicate that when the verbal reasoning abilities were controlled, the difference between the two groups was only restricted to the Visual Spatial STM.

When the PRI was a co-variate, the overall group showed significant difference (F=17.20.07, $p < .000$). The ID group performed lower on all the four major components compared to the TD children. This would indicate that when the PSI was controlled statistically, a significant difference was observed between the two groups.

## Performance of Low-High Functioning ID children

The ID group was divided into two groups based on their acquired scores on the ability tests. One group consisted of children who scored FSIQ less than 65 and the other group consisted of children whose scores were ranging from 66-79. This divide was created not only to have an equal number of cases but also to have a good range of scores between the groups. An independent t-test was conducted to compare their performance on different components of AMAMA scales (Table 3). There were significant differences only on three sub-components and one Composite score of the AWMA. The significant difference was observed between the scores on the sub-components Verbal Working Memory Listening Recall for the low functioning group ($M= 69.80$, $SD = 9.00$) and high functioning group ($M= 81.12$, $SD = 12.99$); $t(30) = -2.83$, $p = .008$. There was a significant difference between the scores on the sub-components Visual Spatial STM Mazes recall for low functioning group ($M= 75.87$, $SD = 16.42$) and high functioning group ($M= 92.76$, $SD = 13.36$); $t(30) = -3.21$, $p = .003$. There was a significant difference between the scores on the subcomponents Visual Spatial Working Memory Odd-One-Out for low functioning group ($M= 72.20$, $SD = 12.57$) and high functioning group ($M= 81.76$, $SD = 13.21$); $t(30) = -2.09$, $p = .045$. The only significant difference observed on the Composite Scores was on the Visual Spatial STM CS for low functioning group ($M= 72.67$, $SD = 14.55$) and high functioning group ($M= 81.34$, $SD = 8.5$); $t(30) = -2.09$, $p = .045$.

## Correlation of IQ scores with STM/WM

The final analysis examined the relationship of IQ with the subcomponents of AWMA tasks. Table 7 presents a correlation matrix of the ID group on AWMA and Ability test. A Two-Tailed Pearson Product Moment Correlation (PPMC) was conducted and the results indicate significant correlations between IQ and STM/WM.

## Discussion

The present study explored the role of different components of short term and working memory among children with Intellectual Disabilities within the context of Baddeley[22] model. The results obtained support the findings from previous empirical studies that have been reported with regards to working memory deficits in children with ID.[23–28] The outcome of the present research also supports the earlier studies of general memory deficit in ID subjects that is independent of modality (visual or auditory) and memory components (STM or WM).[29,30]

The important outcome of this research is that children performed poorly on the STM as well as WM. This outcome supports the model presented by Engles et al.,[7] who proposes the role of attentional control for STM. Case (1985, p. 351) proposed that the operating space for a given class of tasks declines as processing efficiency increases, leaving more space for storage. In case of children with ID, with limited processing abilities, they may have limited space available for storing new information for a short period of time. This could be the reason for the poor performance on the STM tasks. This paradigm corresponds to Atkinson & Shiffrin[31] modal which has been promoted by Newell & Simon,[32] that short term memory constitutes a temporary working memory. In Swanson[30] study, the STM and WM loaded on different factors, suggesting that both areas of deficits were independent, but co-occurring in his subjects.

However, in the present study, we did not observe any difference in the performance between STM and WM, as the subjects with ID performed poorly on both the constructs. Therefore, it could not be suggested on the basis of the present study alone that STM and WM reflect separate processing deficits as suggested by Swanson's.[30] Rather, it indicates that children with ID have deficits both in visual-Spatial Sketchpad and Phonological storage system which is feeding into STM/WM. And this limitation could occur due to poor attention control of the executive system. Based on the outcome of this analysis, it is possible that both STM and WM abilities could be considered as relevant to the understanding of long term cognitive deficits. Gathercole et al.,[23] also suggested that phonological processing ability is directly related to the capacity to hold information. Their theoretical framework would suggest that poor phonological encoding or storage within STM and WM systems may have contributed to poor performance on the WM tasks.

The second assumption was partially approved indicating that high functioning ID children did not perform well on all the tasks of the AWMA compared to low functioning ID children. It was only on some areas where high functioning children performed better than low functioning ones, such as Listening Recall, which is a sub-component of Verbal Working Memory.[33–35] The Listening Recall task appears to be quite difficult compared to Digit Recall and Counting Recall tasks within the Verbal Working Memory. The Listening Recall tends to be highly demanding not only on the phonological loop, but also requires an element of reasoning abilities. The child has to think whether the sentence is right or wrong. In the area of visual spatial domain, they have performed better on tasks such as Mazes and Odd-One-Out. These results suggest that ID children may have deficits on verbal short term and in Verbal Working Memory, which may possibly be related to the lack of attentional control and storage capacity; but there seems to be segments of intact visual-spatial STM/WM in children with Borderline Learning Disability. Henry[8] found that children with borderline learning disabilities obtained high scores on visuo-spatial

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memory span measure, compared to mild and moderate learning disabilities. However, if we further analyse the result of the present study, these results were not in line with Henry's research. In the present study, High Functioning children performed better on only two components out of six components of Visual-Spatial STM/WM tasks. This outcome may again point to the proposition that children with ID across the board present difficulties both in verbal and Visual-Spatial STM and WM tasks, which can again be possibly attributed to central attentional control for both verbal and visual-spatial domains.

The correlation matrix suggests significant relationship of most of the sub-components of the AWMA; these include Listening Recall, Digit Recall of the Verbal WM. Of the Visual Spatial STM, the correlation was high on the Dot Matrix, Mazes, Block Recall with a range between .36 and .67, which were not as high as obtained by Henry,[8] which were between .67 and .73 between working memory and mental age.

In summary, it was found that a child's learning disability had huge implications on STM and WM performance which resulted in significant difficulties with the development of linguistic and academic skills. All the groups of children with learning disabilities showed impairment on all the tasks irrespective of their IQ level and chronological age. There were some pockets of abilities indicated (on some of the sub-components of visual-spatial tasks) by children within high functioning ID group such as odd-one-out and Mazes.

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## Conflicts of interest

Author declares there are no conflicts of interest.

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## References


1. Baddeley AD. Exploring the central executive. *Quarterly Journal of Experimental Psychology A*. 1996;49(1):5–28.
2. Alloway TP, Gathercole SE, Willis C. A structural analysis of working memory and related cognitive skills in young children. *J Exp Child Psychol*. 2004;87(2):85–106.
3. Baddeley AD. The episodic buffer: a review component of working memory? *Trends Cogn Sci*. 2000;4(11):417–423.
4. Kyllonen PC, Christal RE. Reasoning ability is (little more than) working memory capacity? *Intelligence*. 1990;14(4):389–433.
5. Oberauer K. Binding and inhibition in working memory: individual and age difference in short-term recognition. *J Exp Psychol Gen*. 2005;134(3):368–387.
6. Engle RW, Tuholski SW, Laughlin JE, et al. Working memory, short-term memory and general fluid intelligence: *a latent variable approach J Exp Psychol Gen*. 1999;128(3):309–331.
7. Henry LA. How does the severity of a learning disability affect working memory performance? *Memory*. 2001;9(4–6):233–247.
8. Henry LA, Maclean M. Working memory performance in children with and without intellectual disabilities. *Am J Ment Retard* . 2002;107(6):421–432.
9. Alloway TP. Working memory and executive function profiles of individuals with borderline intellectual functioning. *J Intellect Disabil Res*. 2010;54(5):448–456.
10. Schuchardt K, Gebhardt M, Mäehler C. Working memory functions in children with different degrees of intellectual disability. *J Intellect Disabil Res*. 2010;54(4):346–353.
11. Van der Molen MJ, Van Luit JE, Jongmans MJ, et al. Verbal working memory in children with mild intellectual disabilities. *J Intellect Disabil Res*. 2007;51(Pt 2):162–169.
12. Van der Molen MJ, Van Luit JE, Jongmans MJ, et al. Memory profiles in children with mild intellectual disabilities: strengths and weaknesses. *Res Dev Disabil* . 2009;30(6):1237–1247.
13. Henry L, Winfield J. Working memory and educational achievement in children with intellectual disabilities. *J Intellect Disabil Res*. 2010;54(4):354–365.
14. Hulme C, Mackenzie S. Working Memory and Severe Learning Difficulties. *Lawrence Erlbaum Associates*, Hove, UK. 1992.
15. Pulsifer MB. The neuropsychology of mental retardation. *J Int Neuropsychol Soc*. 1996;2(2):159–716.
16. Pennington BF, Bennetto L. Toward a neuropsychology of mental retardation. In: Burack JA, et al. (Eds.), Handbook of Mental Retardation and development, Cambridge University Press, Cambridge, USA. 1998. p. 80–114.
17. Vicari S, Carlesimo A, Caltagirone C . Short term memory in persons with intellectual disabilities and Down's syndrome. *J Intellect Disabil Res*. 1995;39(Pt 6):532–537.
18. Alloway TP. Automated Working Memory Assessment (AWMA). London: Harcourt Assessment, UK. 2007.
19. Alloway TP, Gathercole SE. Working memory and neuro developmental disorders. Hove, UK: Psychology Press, UK. 2006.
20. Alloway TP, Gathercole SE, Kirkwood H, et al. The cognitive and behavioural characteristics of children with low working memory. *Child Dev*. 2009;80(2):606–621.
21. Baddeley A. Working memory: Theory and practice. New York: Oxford University Press, USA. 1986.
22. Gathercole S, Baddeley AD. Phonological memory deficits in language disordered children: Is there a causal connection? *Journal of Memory and Language* . 1990;29:336–360.
23. Ceci SJ. A developmental study of learning disabilities and memory. *J Exp Child Psychol*. 1984;38(2):352–371.
24. Kirchner DM, Klatzky RL. Verbal rehearsal and memory in language disorders children. *Journal of Speech and Hearing Research*. 1985;28:556–565.
25. Schuchardt K, Maehler C, Hasselhorn M. Working memory deficits in children with specific learning disorders. *J Learn Disabil*. 2008;41(6):514–523.
26. Lewis C, Hitch GJ, Walker P. The prevalence of specific arithmetic difficulties and specific reading difficulties in 9- to 10- year-old boys and girls. *J Child Psychol Psychiatry*. 1994;35(2):283–292.
27. Rutter M, Caspi A, Ferguson D, et al. Sex differences in developmental reading disability: new findings from 4 epidemiological studies. *JAMA*. 2004;291(16):2007–2012.
28. Isaki E, Plante E. Short-Term and Working Memory Differences in Language/Learning Disabled and Normal Adults. *J Commun Disord*. 1997;30(6):427–437.
29. Swanson HL. Short-term memory skills in normally achieving and learning disabled children. *Developmental Psychology*. 1994;24(1):28–37.
30. Atkinson RC, Shiffrin RM. Human Memory: A proposed system and its control processes. In: KW Spence (Eds.), In the Psychology of Learning and Motivation: Advances in Research and Theory. New York: Academic Press, USA. 1968. p.89–195.

31. Newel A, Simon HA. Human Problems Solving. Englewood Cliffs, *NJ: Prentice Hall*, USA. 1972.

32. Just MA, Carpenter PA. A capacity theory of comprehension. *Individual differences in working Psychol Rev*. 1992;99(1):122–149.

33. Marcell MM, Weeks SL. Short-term memory difficulties and Down's syndrome. *J Ment Defic Res*. 1998;32(Pt 2):153–162.

34. Wechsler D. The Wechsler Intelligence Scale for Children. (4th edn), (WISC-IV). Toronto, ON: *The Psychological Corporation*, USA. 2003.

35. Wechsler D. The Wechsler Preschool and Primary Scale of Intelligence. (3rd edn), (WPPSI-III). The Psychological Corporation Limited, 32 Jamestown Road, London NW1 7B, USA. 2003.