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Role of Rehearsal Language in Working Memory in Bilingual Children

Alitta Tom, MASLP.
alittatomjacob@gmail.com ; Contact No: 8281924294

Vini Abhijith Gupta, Assistant Professor
Dr. M.V. Shetty College of Speech and Hearing, Mangalore

Introduction

Memory is defined as the ability to encode, store, and retrieve information (Squire, 2009). It is an important element of cognitive function because it allows us to be flexible and adapt to information from our constantly changing environment. The ability to think back on the past, remember certain people or events, and base actions in the future on what has previously served well. Memory makes it simple to complete all of this. Memory processes are actions that use information in particular ways to make it accessible later or to retrieve it into the present processing stream.

Human memory is divided into several stages- Sensory memory, Short-term memory (STM), and Long-term memory (LTM). The level that momentarily stores unprocessed impulses from the sensory systems is known as the Sensory Memory or Sensory Storage. For instance, the nose and the adjacent nerve cells gather up environmental impulses and temporarily store them until they procreate further or are lost. STM or temporary working memory is the second level which has a meagre capacity and a maximum storage time of a few minutes. A comparatively long-term storage is offered by the LTM which makes up the third level. Atkinson and Shriffon,1971; cited in Varma and Varma (1989), who were particularly interested in the STM, suggested this multi-store approach. They centered their idea more on STM because they thought that activity at this level controlled how information moved across the overall memory system.

Gathercole and Alloway (2008) defined the capacity to temporarily store and process information in the mind as 'Working Memory' (WM). It is frequently defined as a versatile mental workspace which can store significant data while performing challenging mental tasks. Mental arithmetic is an excellent illustration of how WM is used in everyday situations. Take the example of trying to multiply two two-digit numbers without using a calculator or paper and pencil. WM is essential because it supports skills in many domains, including comprehension, learning, and reasoning.

Baddeley and Hitch first presented the 'WM Model' in 1974, and Baddeley (2007); cited in Henry (2011) later made revisions to it. Three parts make up the original

WM model, which included a controlling attentional system that oversaw and coordinated a number of subsidiary slave systems. This attentional controller was referred to as the Central Executive, and two slave systems were referred to as the Articulatory or Phonological loop, which is in charge of manipulating speech-based information, and the Visuo-spatial sketchpad, which is in charge of organizing and modifying visual images. The ‘episodic buffer’, a fourth component, was later added to the WM model. This component offered a few significant additional features.

The WM model is a fundamental theory of memory developed to explain how humans process and temporarily store information along with thinking and reasoning tasks. The model makes it easier to comprehend how memory functions are used during routine, everyday tasks as well as during more difficult tasks that need more effort and creative thought. It also makes it simple to compare memory development between children who are typically developing (TD) and children who have different types of developmental disorders.

Extension of WM is largely attributed by the increase in the use of strategies including chunking, organisation and subvocal verbal rehearsal. Age-related development along with growth in broad executive processing and strategy use results in more efficient functioning of cognitive resources. The rehearsal strategy employed and the word length effect both affect a participant's performance on a WM task.

The rehearsal strategy can be used with WM as well as STM. Gathercole (1999); cited in Dehn (2008) explained verbal rehearsal as a process of serial repetition that helps individuals retain information for a longer time period. Simple rehearsal strategies are often used by children as early as age 5, although spontaneous rehearsal does not start until age 7.

The substantial improvement in memory span after age six is assumed to be mostly attributable because of the emergence and increased use of verbal rehearsal methods. Children with special needs may struggle to independently develop or apply verbal rehearsal strategies. Explicit rehearsal training greatly enhances children's WM capacities, both with and without limitations, according to several studies (Comblain, 1994; Conners et al., 2001; cited in Dehn, 2008).

Adults with short WM spans have also demonstrated improvement following instruction in basic rote rehearsal techniques (Dunning & Holmes, 2014).

Several brain regions may be activated simultaneously including locations in the frontal. parietal and temporal lobes depending on the WM task.

According to Bialystok, Craik, Green and Gollan (2009), speakers' cognitive abilities may alter as a result of their regular practice of speaking two or more languages.

Such individuals who speak two or more languages are called Bilingual. Certain languages are more favourable to mental arithmetic than others. Chan and Elliott (2011) through his investigation found that Chinese fared better on digit memory span tasks than their Malay counterparts as Chinese had shorter pronunciation of their digit names than Malay digit names. Therefore, bilinguals can effectively use linguistic characteristics in word/digit lengths and rehearsal methods while performing memory tasks like listening span and digit span, among others to perform better.

Moralesa, Calvo and Bialystok (2013) conducted two investigations comparing the performance of monolingual and bilingual children on tasks requiring various levels of WM involving 56 and 125 children with ages 5 and ages 5 and 7, respectively. The studies' findings showed that bilingual children did better in WM, especially when the task calls for more executive function than usual.

Kaushanskaya, Gross and Buac (2014) found that the bilingual group of children (English speaking children exposed to Spanish for an average of two years in dual-immersion schooling) from classroom exposure outperformed the monolingual group on measures of verbal working memory and a measure of word learning.

Iyer and Venkatesan (2021) reported that bilingual children outperform trilingual children on WM tasks that included verbal and visuospatial components among 6 to 8-year-old children.

The 'word length effect' was introduced by Baddeley (1973); cited in Dehn (2008). They came to the conclusion through a number of trials that the 'word length effect' was always in favour of shorter words over longer words. It takes a varying amount of time to articulate the names of numbers in different languages. Ellis (1992) came to the conclusion from his three experiments that word lengths of a language's number names have a decisive impact on how easy it is to mentally calculate and count in that language.

Jagadeesh and Uppunda (2020) investigated the impact of rehearsal languages on WM spans in 24 bilingual individuals between the ages of 18 and 25. They found that there were word-length effects at the level of rehearsal strategies, with rehearsal in English (shorter digit length) leading with higher scores.

Manoochehri (2020) found no significant difference between males and females' mean score of forward digit span done in 16-25 years old adults from persian population.

Therefore, it is important to consider the role of rehearsal language in WM for Malayalam - English bilinguals, also the performance of WM on the basis of age and gender is necessary to be assessed.

Review of Literature

The mental processes of learning, storing, and retrieving information are collectively referred to as memory (Radvansky, 2017). Human memory is made up of different stages, including sensory memory, STM and LTM. Although the terms WM and STM are sometimes used interchangeably, some theorists contend that the two types of memory are separate because WM permits manipulation of information that has been stored while STM simply permits short-term storage.

Baddley (2007); cited in Henry (2011) defined WM as a temporary storage system under attentional control that underpins our capacity for complex thought. This simple definition gives us the following idea that the first WM involves transitory storage, or what we are doing right now. Second, the system is under attentional control, indicating that we typically direct our attention in a particular direction. Finally, the system is crucial for any form of higher order thinking or reasoning work since it supports our capacity for sophisticated thought.

The WM model is a fundamental theory of memory created to explain how we manage and temporarily store information when doing thinking and reasoning tasks. The original WM model has three parts. The most crucial element is a mechanism for managing attention known as 'the central executive'. In order to accomplish the predetermined goals, this is utilised to make sure that WM resources are focused and employed effectively. There are two other systems for short-term storage available- phonological loop and the visuospatial sketchpad. Later, the 'episodic buffer' was a fourth element to the WM model.

The phonological loop is simply said to be a short-term memory storage system for heard information, particularly speech. It is responsible for phonological STM, which is the capacity of individuals to retain brief amounts of heard information.

According to neuroimaging research, the phonological loop is further divided into two subcomponents, both of which are thought to be located in the left hemisphere of the brain. The phonological store and the articulatory rehearsal mechanism are these two subcomponents. The part of the system where speech information is temporarily stored is called the phonological store. The phonological store's information is constantly referred to as the 'memory trace', and the phenomenon of rapid fading is known as 'trace decay'. The fact that phonological representations are transitory rather than fully correct, durable representations of events experienced is reflected in trace decay. Only about two seconds' worth of speech-based materials can be kept due to the phonological store's rapid trace decay, which is only long enough to remember a phone number before dialing it.

In order to slow the rate of phonological storage information decay, the articulatory rehearsal mechanism is used. The material is recited once more into the phonological store so that it does not deteriorate right away. This articulatory rehearsal mechanism, according Dehn (2008), is like a two-second tape loop or tape recorder. The technique of recitation might stop the material from deteriorating by continuously refreshing it. This recitation technique, also known as ‘articulatory rehearsal’ or ‘verbal rehearsal’, is a key strategy for boosting WM's capacity.

The other mechanism described in the WM model is the visuo-spatial sketchpad which is capable of temporarily storing visual and spatial information so that it can be used for thinking, remembering, and processing tasks.

A completely new component known as the ‘multi-modal-temporary store’ is the episodic buffer. It interacts with information from many distinct modalities rather than merely storing information in one (such as auditory, visual, spatial, or kinesthetic).

The WM model has inspired a wave of study on how children with developmental problems and children with intellectual disabilities (CWID) form their memories. This implies that using the same justification and test types, typical and atypical groups can be directly compared.

The parietal lobe is responsible for storing information whereas the frontal lobe is in charge of controlling WM. (Baddeley, Eysenck and Anderson 2015)

A study by Paulesu et al. (1993) cited in Baddeley, Eysenck & Anderson, (2015) using positron emission tomography (PET) was based on the phonological loop concept. They discovered two distinct areas: one in the left hemisphere, between the parietal and temporal lobes, which appeared to be in charge of phonological storage, and another, more frontally located area, known as Broca's area, which is involved in speech production and may well be related to subvocal rehearsal.

Based on the neuroanatomy of WM, the phonological loop is situated in the left hemisphere's temporal lobes, visuo-spatial memory is located in the right hemisphere, and the dorsolateral prefrontal cortex is principally responsible for central executive functions.

In essence, verbal rehearsal is a serial repeated procedure that helps information be retained for longer periods of time, facilitating long-term encoding (Gathercole, 1999 cited in Dehn, 2008). Although many children begin employing a basic rehearsal technique around age five, spontaneous rehearsal does not start until about age seven. It is believed that at least a portion of the significant improvement in memory span that occurs after age six can be attributed to the growth and increased usage of verbal rehearsal strategies. (Dehn, 2008).

Children with disabilities may struggle to independently overlap or use verbal rehearsal techniques. According to several studies, intentional rehearsal training dramatically enhances both children with and without disabilities' WM capacities. Adults with reduced WMs have also demonstrated improvement after training in straightforward rote rehearsal techniques.

Dehn (2008) reported that rehearsal is associated with the anterior temporal frontal area and phonological storage is provided via a neural network in the left hemisphere encompassing inferior parietal areas.

Dehn (2008) claimed that Broca's region supports articulatory rehearsal while the supramarginal gyrus supports phonological storage.

Gathercole & Hitch (1993) found that verbal rehearsal in children gradually emerged, maybe beginning with the overt naming of each thing as it was shown. Then covert (i.e. subvocal) naming has developed, the mature form of covert cumulative rehearsal for groups of things may then gradually arise.

Children practise more slowly than adults since they read and speak at slower speeds. As children aged, their reading and articulation skills improved, allowing for faster rehearsal rates and a higher memory span. The relationship between memory span and reading rate was investigated by Nicholoson (1981) in three groups of ten children aged 8, 10, and 12 using words of 1-4 syllables. He reported that word length effects were present across all groups. Additionally, all groups demonstrated faster reading speeds for shorter words than for longer words.

Gathercole & Hitch (1993) reported that rehearsal emerged more rapidly with auditory presentation than visual presentation because of the close and direct links between hearing and speech.

Bilingualism is "knowing two languages" (Butler and Hakuta, 2004). Bilingual children outperform monolingual children on all metalinguistic tasks demanding high degrees of mental control (Raju and Nataraja, 2016).

Digit span is referred to as a "span test" because the length of the digit lists that must be remembered is gradually increased to find the longest list that can be accurately and perfectly remembered.

Henry (2011) reported that memory span significantly increases with age; a large portion of this gain, particularly beyond preschool years, is due to the employment of memory strategies. He said that the number of distinct units of information that can be retained has a fundamental structural restriction. There are strategies that can be used to raise this number of items, which falls between three and five.

Word length effects arise from the fact that verbal rehearsal of long items takes longer than that of short items in real time. The memory trace within the phonological storage has more time to decay due to the word length disadvantage for larger items. On the other hand, short items can be practised quickly, allowing for the retention of more words within the phonological store's two second time limit. Gathercole & Hitch (1993) reported that word length effects resulted from the links between speaking and hearing.

Western Studies

Alloway & Copello (2013) reported that WM is essential for a range of academic tasks, from challenging ones like reading comprehension, mental math, and word problems to easy tasks like copying from the board and finding a way through the school. WM is important from kindergarten to tertiary classes.

Reading achievement is predicted by WM task results in TD children without the use of phonological awareness tests (Alloway and Copello, 2013).

Verbal WM has a significant impact in math abilities in 7-year-olds and is a consistent predictor of arithmetic challenges in the first year of formal schooling (Alloway and Copello, 2013).

Molen, Van Luit, Jongmans & Van der Molen (2007) found CWID performed poorly on phonological loop capacity and central executive tests compared to peers their own age, but only slightly worse than peers their own mental age. As a result, remedial training is crucial for CWID.

According to Montgomery, Magimairaj & Finney (2010), the assessment, diagnosis, and treatment of language problems in SLI should take into account the potential impact of WM.

Wells, Kofler, Soto., Schaefer, & Sarver (2018) discovered that digit span backward becomes a reliable indicator of WM at the same time when testing for paediatric attention deficit hyperactivity disorders (ADHD) is typically discontinued.

Robinson, Mervis, & Robinson (2003) found children with Williams Syndrome (WS) had a significantly stronger relationship between WM, as determined by backward digit span, and grammatical ability than did their control group, which had a mean chronological age of 10 years and 2 months.

Wilson, Bettger, Niculae & Klima (1997) reported that WM architecture is influenced by language modality. Additionally, they noted that the performance of forward and backward digit spans suggests that the processing limits of language rehearsal mechanisms vary. The fact that native American Sign Language (ASL) speakers performed well on tests of backward and forward digit span suggests that the serial order information for ASL is stored without preference for one direction over another.

Withagen, Kappers, Vervloed, Knoors & Verhoeven (2013) compared the STM and WM of 10-year-old blind children with those of sighted children. Word span, name learning, and digit span forward activities were used to measure STM, whereas listening span and digit span backward tasks were used to assess WM. The results showed that on both STM and WM activities, the blind children excelled above their sighted peers. Additionally, it was found that the blind children performed verbal WM tasks significantly better than their sighted peers.

Bialystok (2009) reported that bilingual speakers' cognitive abilities may alter as a result of their regular practice of speaking two or more languages.

Morales, Calvo & Bialystok (2013) reported that fifty six 5-year-olds, bilingual children performed better on executive functioning tasks than monolingual children under all conditions and responded to incongruent trials with more accuracy on Simon type tasks.

Comblain (1994) concluded from his investigation that children and adolescents with Downs' syndrome can considerably increase their WM capacity with rehearsal training.

Alhola & Polo-Kantola (2007) argued that complete sleep deprivation caused by gadget addiction impacts other processes including attention, WM, LTM and decision-making in students.

Anufrieva & Gorbunova (2021) concluded that there are discrepancies between WM and attention processes in real-world and virtual environments. Additionally, the digital world might be seen as a cueing system that facilitates the accomplishment of challenging activities requiring WM and attention.

Gathercole, Pickering, Ambridge & Wearing (2004) examined the organisation of WM and how it changed throughout the course of childhood in children between the age of 4 and 15. The findings showed that WM has a basic modular structure that is present from 6 years of age, probably earlier, and that each component significantly expands in functional capability from the early and middle school years to adolescence.

Reed, Gallagher, Sullivan, Callicott & Green (2017) investigated in 111 young adults and found that there were gender differences at high loads of WM across tasks and within each task, such that males showed superior accuracy even among groups that were matched for performance at lower loads.

Zilles, Lewandowski, Vieker, Henseler, Diekhof, Melcher, Keil & Gruber (2016) concluded from their investigation utilising functional magnetic resonance imaging (fMRI) that females had a slightly reduced capacity in both verbal and visuospatial WM modalities.

Manoochehri (2020) found no significant difference between males and females' mean score of forward digit span done in 16-25 years old adults from persian population.

Indian Studies

In the investigation by Jagadeesh & Uppunda (2020) of the impact of rehearsal languages on WM spans in 24 bilingual individuals between the ages of 18 and 25. They found that there were word-length effects at the level of rehearsal strategies, with rehearsal in English (shorter digit length) leading with higher scores than Kannada digits.

Gupta & Sharma (2017) reported that children with learning disabilities (LD) frequently struggle to study because the high WM demands of the learning activity frequently surpass their WM capacity. These children' academic performance can also be enhanced by remedial training, teaching proper WM strategies, and other measures.

Prathap & Singh (2021) concluded from their investigation on college students that the deterioration in students' prospective memory was correlated with how dependent they were on their digital devices and how much cognitive offloading they were doing.

Iyer & Venkatesan (2021) revealed that bilingual children outperform trilingual children on WM tasks that included verbal and visuospatial components among 6 to 8-year-old children.

Need for the Study

Working memory is the term used to describe the system or systems that are thought to be required in order to maintain information while carrying out difficult tasks like reasoning, comprehension, and learning. (Baddeley, 2010)

WM skills are specifically impaired in children with autism, ADHD and dyslexia. The operational effectiveness of WM is a key predictor of a child's school achievement in the areas of literacy and numeracy. Also the important role that WM plays in speech perception, particularly in difficult auditory environments such as in the presence of background noise, it is likely that variations in WM function and capacity will make it more difficult for hearing aid users to understand speech in noisy environments (Javanbakht, Moosavi and Vahedi, 2021). Poor WM abilities can be addressed by SLPs by taking into account both changes to the environment and child-enacted knowledge and skills, which may help to lessen their negative effects on learning and academic achievement (Boudreau and Costanza-Smith, 2011).

Ames & Whitfield (2003) reported that the use of a rehearsal strategy resulted in higher WM span scores. A study done by Jagadeesh & Uppunda (2020) on the impact of rehearsal languages on WM spans in 24 bilingual individuals between the ages of 18 and 25. They found that there were word-length effects at the level of rehearsal strategies, with rehearsal in English (shorter digit length) leading with higher scores. Surprisingly little research has been done to support the efficacy of the role of rehearsal language in bilingual children (Malayalam-English), effects of age and gender on WM capacities.

Hence to assess how the language of rehearsal affects the WM capacities of bilingual children between the ages of 8.0 to 10.11 years and if age-related and gender differences are observed in WM capacities. Analysis of TD children will serve as a baseline for the purpose of applying rehearsal techniques to help children with developmental delays improve their WM.

Method

Aim

The purpose of the present study is to determine whether rehearsal language affects the performance of WM in TD children aged through 8.0 to 10.11 years. Age related and gender differences in WM capacities were also assessed.

Participants with Inclusive and Exclusive Criteria

Participants included 60 (30 girls and 30 boys) TD sequential bilingual children in fourth through sixth grades who spoke Malayalam as their first language and the medium of instruction in the classroom was English. Age of the children ranged from 8.0 to 10.11 years. This age range was chosen because, according to Dehn (2008), spontaneous rehearsal does not begin until age 7 and the majority of children have normal articulation abilities by the time they are 8 years old (Farquharson, Hogan & Bernthal, 2018).

Children with a history of speech and language disorders, reading and writing disorders, hearing disorders, neurological issues, and cognitive issues such as poor attention, memory were excluded. Children should perform above average academically.

Materials Used

Digits between zero to nine which were bisyllabic were presented in Malayalam language for all three rehearsal conditions of the experiment. The stimuli were spoken by a native female speaker.

Procedure

Through teacher interviews, potential participants were identified from the classroom. All participants had their backward digit spans assessed.

- A random number sequence was presented with a one-second gap between each stimulus. The allotted time to rehearse the sequence aloud was 30 seconds after the last digit in the series was presented.
- The participant wrote the numbers backward. Additionally, they were told to substitute '__' for any missing digits in the sequence.
- The allotted time for participants to record their responses was 30 seconds.
- The number of digits in the next sequence (span length) increased by one for each correct response or sequence, whereas the span length decreased by one for each incorrect response.
- Six reversals were performed in total (from correct to wrong and vice-versa) for each participant. The last four reversals' means were used to determine the backward digit (BD) spans after the initial two reversals were eliminated.
- Feedbacks were provided for correct responses.

Three different rehearsal instructions were used to measure verbalization of BD spans:

(i) No instruction on the language of rehearsal (NI),

(ii) Instructed to rehearse in Malayalam (RM), and

(iii) Instructed to rehearse in English (RE).

All participants were tested initially on the NI condition, which serves as the control condition. No directions were offered on the rehearsal language for this condition. To prevent participants from becoming biased in favor of/against rehearsal in either Malayalam or English, the NI condition was carried out first.

To become accustomed to the task, all participants underwent a practice trial first. This was not included for calculating the BD span scores.

Analysis

The total number of digits written correctly during each of the three conditions was calculated. For the scoring purpose, the raw score of the total number of correct digit spans obtained was retained and subjected for statistical analysis. For example, if the child repeats digits backward in NI condition as "742", the number of correct digits was considered as three.

Statistical Analysis

To determine any significant differences across the language of rehearsal, repeated measures ANOVA and bonferroni post hoc analysis was carried out. Whereas one way ANOVA and bonferroni post hoc analysis were used to find any significant differences in BD span score across age groups. The 't' test was used to evaluate whether there were any statistically significant variations between the genders in the mean values of the BD span scores for the three language rehearsals.

Results and Discussion

Despite the fact that the digits were presented only in Malayalam, the study intends to observe the variations in BD span scores with rehearsal in Malayalam versus English. Additionally, whether TD children between the ages of 8.0 and 10.11 have any differences in their ability to use WM in relation to language practice were assessed. Furthermore, it sought to determine if there are any gender differences in WM skills across age groups under the three rehearsal conditions. The study's findings are addressed in more detail below. Despite the fact that Malayalam was the language of presentation, all of the participants (n=60) practiced in English under the NI condition.

Comparison between the rehearsal conditions:

Table 4.1:

Showing the mean and SD scores of BD spans across the language of rehearsal in bilingual children.

Age group	Gender	BD span score in rehearsal condition	N	Mean	Std. Deviation	Repeated measures ANOVA p value	Post hoc analysis by Bonferroni test		
							No instruction vs Malayalam	No instruction vs English	Malayalam vs English
8.0 - 8.11 years	Boys	BD span score in NI	10	3.000	0.4714	0.000, HS	0.002 HS	1.000 NS	0.002 HS
		BD span score in RM	10	2.000	0.4714				
		BD span score in RE	10	3.000	0.4714				
	Girls	BD span score in NI	10	3.200	0.4216	0.000, HS	0.002 HS	1.000 NS	0.002 HS
		BD span score in RM	10	2.200	0.4216				
		BD span score in RE	10	3.200	0.4216				
9.0 - 9.11 years	Boys	BD span score in NI	10	4.000	0.4714	0.000, HS	0.003 HS	1.000 NS	0.003 HS
		BD span score in RM	10	3.100	0.5676				
		BD span score in RE	10	4.000	0.4714				

	Girls	BD span score in NI	10	4.000	0.4714	0.000, HS	0.002 HS	1.000 NS	0.002 HS
		BD span score in RM	10	3.000	0.4714				
		BD span score in RE	10	4.000	0.4714				
10.0 -10.11 years	Boys	BD span score in NI	10	5.000	0.0000	0.000, HS	0.004 HS	1.000 NS	0.004 HS
		BD span score in RM	10	4.000	0.4714				
		BD span score in RE	10	5.000	0.0000				
	Girls	BD span score in NI	10	4.900	0.3162	0.000, HS	0.002 HS	1.000 NS	0.002 HS
		BD span score in RM	10	3.900	0.3162				
		BD span score in RE	10	4.900	0.3162				

*HS- High Significance, NS- No Significance.

Table 4.1 displays the BD span results for the three different rehearsal instructions (In NI, RM, and RE).

The findings of the statistical analysis revealed a highly significant difference between the RM vs. NI and RE conditions. In conclusion, across all age groups, BD span scores were lower in the RM condition than they were in the other two conditions (NI & RE).

Fig 4.1:

Showing the graphical representation of mean scores of BD span in comparison across the language of rehearsal in bilingual children. X- axis represents the age groups of bilingual children and Y-axis represents the mean scores of BD span scores across the rehearsal conditions(Rehearsal in NI, RM and RE).

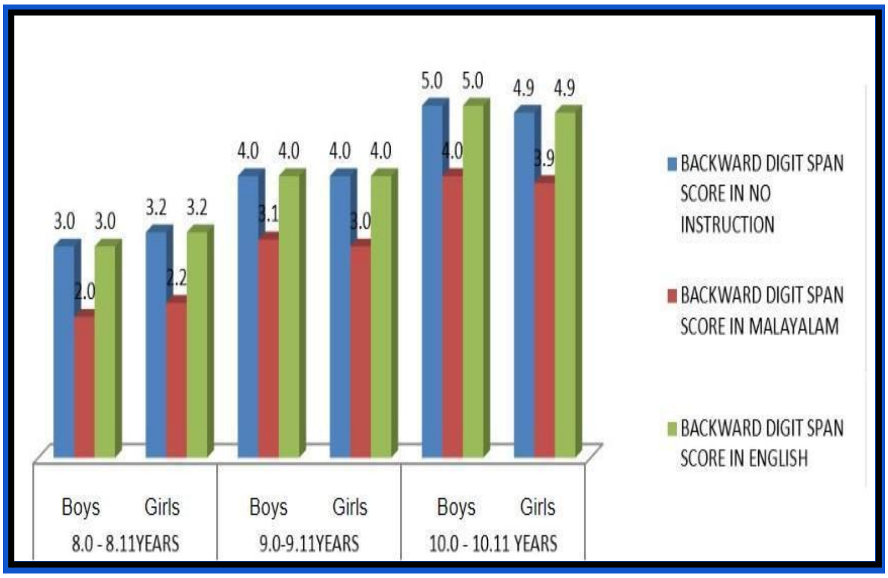

Table 4.2:
Showing the mean scores of BD span in comparison across the language of rehearsal in bilingual children.(In NI, RM and RE).

Age group	Gender	Mean		
		BD span score in NI	BD span score in RM	BD span score in RE
8.0 - 8.11 years	Boys	3.0	2.0	3.0
	Girls	3.2	2.2	3.2
9.0 - 9.11 years	Boys	4.0	3.1	4.0
	Girls	4.0	3.0	4.0
10.0 - 10.11 years	Boys	5.0	4.0	5.0
	Girls	4.9	3.9	4.9

The mean scores of BD span in comparison across the language of rehearsal are shown in the aforementioned figure 4.1 and table 4.2 for bilingual children. It can be inferred that across all age groups and for both genders, rehearsal in the Malayalam (RM) condition was lower than both the English (RE) and ‘No Instruction’ (NI) conditions.

Comparison Between the Age Groups

Table 4.3

Showing the comparison of BD span scores in three rehearsal conditions across the age groups (8.0-8.11, 9.0-9.11 and 10.0-10.11 years).

Rehearsal conditions	Gender	Age groups	N	Mean	Std. Deviation	ANOVA p value	Post hoc analysls by Bonferroni test		
							8 - 8.11 VS 9 - 9.11	8 - 8.11 VS 10 - 10.11	9 - 9.11 VS 10 - 10.11
BD span score in NI	Boys	8.0 - 8.11 years	10	3.000	0.4714	0.000, HS	0.000, HS	0.000, HS	0.000, HS
		9.0 - 9.11 years	10	4.000	0.4714				
		10.0 - 10.11 years	10	5.000	0.0000				
	Girls	8.0 - 8.11 years	10	3.200	0.4216	0.000, HS	0.000, HS	0.000, HS	0.000, HS
		9.0 - 9.11 years	10	4.000	0.4714				
		10.0 - 10.11 years	10	4.900	0.3162				
BD span score in RM	Boys	8.0 - 8.11 years	10	2.000	0.4714	0.000, HS	0.000, HS	0.000, HS	0.000, HS
		9.0 - 9.11 years	10	3.100	0.5676				
		10.0 - 10.11 years	10	4.000	0.4714				
	Girls	8.0 - 8.11 years	10	2.200	0.4216	0.000, HS	0.000, HS	0.000, HS	0.000, HS
		9.0 - 9.11 years	10	3.000	0.4714				
		10.0 - 10.11 years	10	3.900	0.3162				

BD span score in RE	Boys	8.0 - 8.11 years	10	3.000	0.4714	0.000, HS	0	0	0
		9.0 - 9.11 years	10	4.000	0.4714				
		10.0 - 10.11 years	10	5.000	0.0000				
	Girls	8.0 - 8.11 years	10	3.200	0.4216	0.000, HS	0.000, HS	0.000, HS	0.000, HS
		9.0 - 9.11 years	10	4.000	0.4714				
		10.0 - 10.11 years	10	4.900	0.3162				

*HS- High Significance, NS- No Significance.

The BD span results for the three rehearsal instructions (in NI, RM & RE) in age ranges of 8.0–8.11 years, 9.0–9.11 years, and 10.0–10.11 years are shown in Table 4.3. Results of the statistical analysis revealed a highly significant difference between all age groups (p=0.00). Consequently, it can be said that WM performance gets better with age.

Fig 4.2

Showing the graphical representation of the mean scores of BD span scores in three rehearsal conditions across the age groups (8.0-8.11, 9.0-9.11 and 10.0-10.11 years) in boys and girls. X-axis represents the age groups in different rehearsal conditions and Y-axis represents the BD span scores obtained.

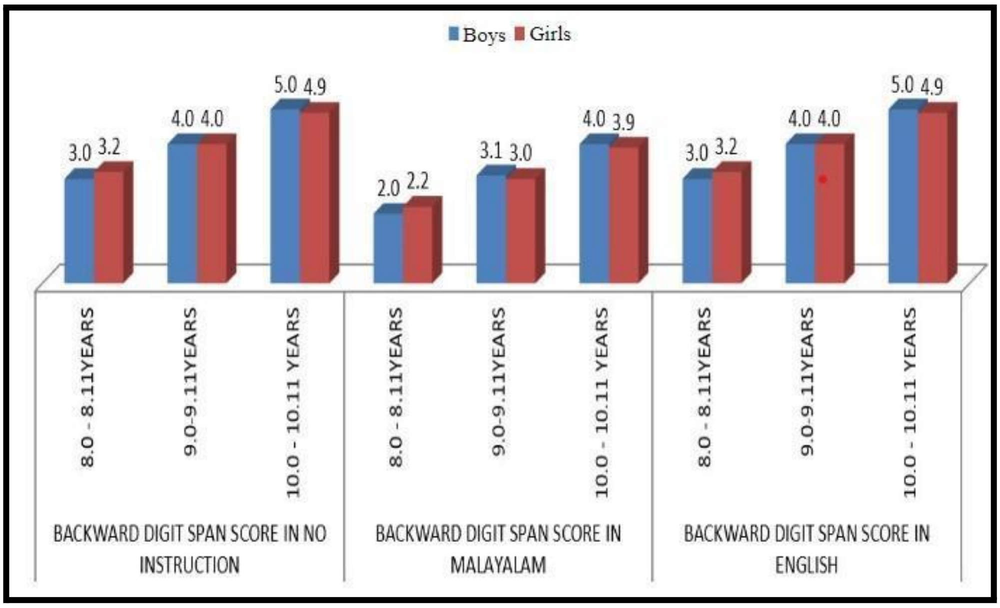

Table 4.4

Showing the mean scores of BD span scores in three rehearsal conditions across the age groups (8.0-8.11, 9.0-9.11 and 10.0-10.11 years) in boys and girls.

Rehearsal conditions	Age groups	Boys	Girls
BD span in NI	8.0 - 8.11 years	3.0	3.2
	9.0 - 9.11 years	4.0	4.0
	10.0 - 10.11 years	5.0	4.9
BD span in RM	8.0 - 8.11 years	2.0	2.2
	9.0 - 9.11 years	3.1	3.0
	10.0 - 10.11 years	4.0	3.9
BD span in RE	8.0 - 8.11 years	3.0	3.2
	9.0 - 9.11 years	4.0	4.0
	10.0 - 10.11 years	5.0	4.9

The mean scores of the three rehearsal conditions for boys and girls in the age ranges (8.0-8.11, 9.0–9.11, and 10.0–10.11) are shown in Figure 4.2 and Table 4.3. As a result, we can observe that both boys and girls exhibit an increase in WM capacity as age increases in all three instruction conditions.

Comparison between genders:

Table 4.5:

Showing the BD span scores in boys and girls across three rehearsal conditions.

Age group	Rehearsal conditions	Gender	N	Mean	Std. Deviation	t test p value	
8.0 - 8.11 years	BD span score in NI	Boys	10	3.00	0.47	0.331	NS
		Girls	10	3.20	0.42		
	BD span score in RM	Boys	10	2.00	0.47	0.331	NS
		Girls	10	2.20	0.42		
	BD span score in RE	Boys	10	3.00	0.47	0.331	NS
		Girls	10	3.20	0.42		
9.0-9.11 years	BD span score in RI	Boys	10	4.00	0.47	1.000	NS
		Girls	10	4.00	0.47		

	BD span score in RM	Boys	10	3.10	0.57	0.673	NS
		Girls	10	3.00	0.47		
	BD span score in RE	Boys	10	4.00	0.47	1.000	NS
		Girls	10	4.00	0.47		
10.0 - 10.11 years	BD span score in RI	Boys	10	5.00	0.00	0.331	NS
		Girls	10	4.90	0.32		
	BD span score in RM	Boys	10	4.00	0.47	0.584	NS
		Girls	10	3.90	0.32		
	BD span score in RE	Boys	10	5.00	0.00	0.331	NS
		Girls	10	4.90	0.32		

*HS- High Significance, NS- No Significance.

The BD span scores for boys and girls under three rehearsal conditions are shown in Table 4.4. In all three conditions, there was no significant difference in the findings between boys and girls across age groups.

Fig 4.3

Showing the graphical representation of the mean BD span scores in the three rehearsal conditions in boys and girls across the age groups.X-axis represents the boys and girls in the three rehearsal conditions and Y-axis represents the BD span scores.

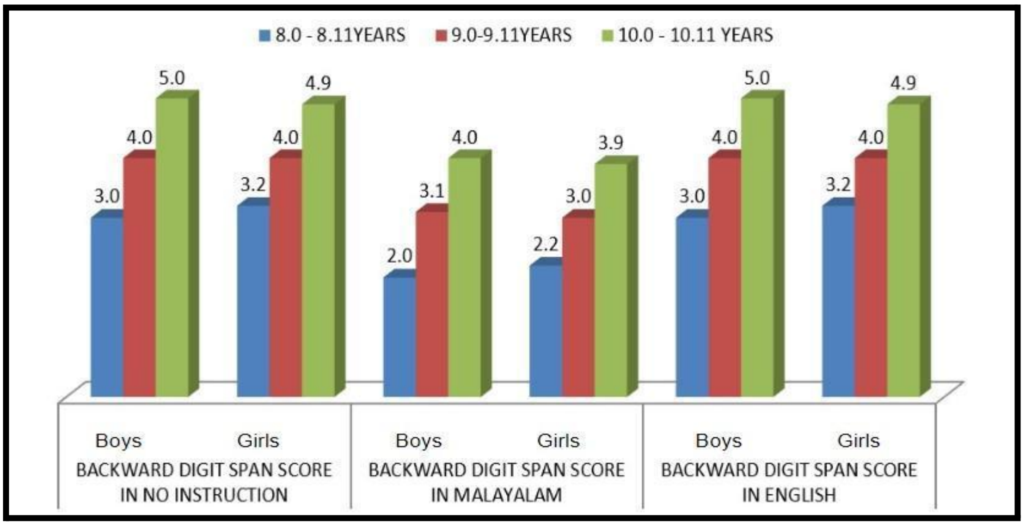

Table 4.6
Showing the mean BD span scores in the three rehearsal conditions in boys and girls across the age groups.

Rehearsal Conditions	Gender	Mean		
		8.0 - 8.11 years	9.0-9.11 years	10.0 - 10.11 years
BD span score in NI	Boys	3.0	4.0	5.0
	Girls	3.2	4.0	4.9
BD span score in RM	Boys	2.0	3.1	4.0
	Girls	2.2	3.0	3.9
BD span score in RE	Boys	3.0	4.0	5.0
	Girls	3.2	4.0	4.9

The mean BD span scores for boys and girls across all age groups and rehearsal conditions are shown in the above-mentioned figure 4.3 and table 4.5, respectively. From the results, we can conclude that gender differences are not significantly seen in terms of their WM capacities across the age groups in the three rehearsal conditions. However the errors made by boys were lower than girls in the incorrect digit span.

As a result, the following conclusions can be drawn about the investigation's findings:

- Malayalam rehearsal produced substantially lower BD spans than English rehearsal condition.
- In all three rehearsal conditions, WM capacities increased with age in both boys and girls.
- In terms of WM capacities, there were no appreciable variations between the genders across all age groups in the three rehearsal conditions. However, compared to girls, boys made fewer errors in the incorrect BD span.

Discussion

The aim of the current study was to determine whether rehearsal language played a role in rehearsal strategy and whether there were any differences in WM capacities related to age and gender across the conditions. The participants were bilingual children aged between 8.0 - 10.11 years were chosen. These participants were asked to listen carefully to a span of digits spoken in Malayalam and were asked to rehearse according to the instruction provided: in NI where the participants have to rehearse either in English or Malayalam, then rehearse in Malayalam and then in English only for 30 seconds respectively. Then the digit span should be written in reverse manner on instruction.

According to the findings, Malayalam rehearsal produced lower BD spans than the English rehearsal condition, which was consistent with the findings of the study by Jagadeesh and Uppunda (2020) to understand the role of rehearsal language of Kannada v/s English language in adults. Also the investigation done by Chan and Elliott (2020) revealed better performance on digit span in the language with shorter pronunciation.

Also, WM abilities improved with age in each of the three rehearsal conditions for both males and females. According to Bayliss, Jarrold, Baddeley, Gunn and Leigh (2005), two age-related but distinct factors - one associated with general processing speed and the other with storage capacity - were responsible for the developmental improvement in complex span. Additionally, when WM, processing speed, and storage capacity were examined in 120 children between the age of 6 and 10, there was a shared age-related contribution that was significant for higher level cognition. Several similar studies (Henry, 2011; Gathercole, Pickering, Ambridge and Wearing, 2004) report an increase in the WM skills exhibited as age increases.

In all age groups and the three rehearsal strategies, there were no gender biased differences in WM skills between boys and girls which correlated with the results of the investigation done by Manoochehri (2020) in adults. Boys, however, made fewer errors in the incorrect BD span than girls did. This is in accordance with the results of Zilles, Lewandowski, Vieker, Henseler, Diekhof, Melcher, Keil and Gruber (2016) study which revealed females had a slightly reduced capacity in both verbal and visuospatial WM modalities.

The outcomes of the current study are advantageous for a speech-language pathologist (SLP). The language and academic skills of children with disabilities depend on their WM skills. Therefore, by using a rehearsal technique tailored to the language chosen for rehearsal and the child's age, WM can be improved. Also, this will serve as a baseline for SLPs to employ this technique when assessing and intervening children with special needs who are between the ages of 8 and 10 to improve their WM skills.

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Summary and Conclusion

Our capacity to process data is called Working Memory (Alloway, 2010). This more advanced ability involves maintaining focus on a task despite interruptions or distractions. WM is connected to a variety of cognitive tasks that students perform in school, including reasoning activities, verbal comprehension, and arithmetic skills. It is a powerful indicator of successful reading as well.

WM is also linked to math outcomes: low WM scores are clearly related to poor performance on arithmetic word problems and computational skills (Alloway and

Copello, 2013). Although there is also a strong correlation between mathematical ability and WM, this link is influenced by the task and the child's age.

SLPs are crucial in the diagnosis and treatment of a variety of communication disorders such ADHD, LD, autism spectrum disorder (ASD), and SLI. Both their academic achievement and their linguistic skills are frequently lacking in these children. SLPs should therefore focus on training strategies such as rehearsal strategies that can enhance such children' WM capacities in order to boost their academic and linguistic performance. SLPs should consider the child's age and the language of rehearsal being used when implementing these rehearsal strategies with bilingual children.

The current investigation aimed to ascertain whether rehearsal language influenced the rehearsal strategy and whether there were any variations in WM capacities related to age and gender across the rehearsal conditions. The chosen participants were 60 bilingual students of age 8.0 -10.11 years (thirty boys and thirty girls) with native language as Malayalam and second language as English. The three rehearsal conditions that were examined were 'No Instruction', in Malayalam, and in English respectively. Backward digit (BD) span across all rehearsal conditions served as the testing stimulus. The outcomes were as follows: better WM scores are obtained when practising in a language with shorter word lengths. Additionally, as age progressed, WM capacities showed improvements, but no variations were observed within gender.

Limitations of the Study

- Limited sample size.
- The sample was exclusively collected from Kottayam district in Kerala.

Future Directions

- Sample size can be increased.
- The role of rehearsal language in WM can be done with respect to different dialects in Malayalam.
- Follow up studies based on age related changes in WM capacities can be done in TD of advanced age range (10 -15 years old) to obtain a baseline.
- To find out if the effect is the same across other languages in India, similar investigation can be done to obtain a normative value.
- Further studies can be done to comprehend how these cross-linguistic rehearsal techniques are used in conjunction with other, more challenging WM tasks like listening span, operation span, reading span etc.

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