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Working Memory in Bilingual Versus Trilingual Children from Urban High Socioeconomic Indian Families

Kamlam Gopalkrishnan Iyer, M.Phil., Ph.D.
S. Venkatesan, M.Phil., Ph.D.

Abstract

Linguistically rich country like India has children speaking multiple languages. This is more prevalently observed in the urban Indian metropolitans. Though bilinguals have cognitive gains, trilingual children and their cognitive gains need to be evaluated. A sample of 55 children aged 6 to 8 years, with 27 in bilingual and 28 in trilingual groups, was recruited through purposive non-probability sampling technique from parental reports of their functional linguistic use. They were assessed for background measures of developmental level, intellectual functioning, and socioeconomic status. Working memory tasks comprising of verbal and visuospatial components were conducted on the sample. Results depicted a significant difference between the groups with bilingual children outperforming the trilingual children. Evidence concordant and discordant to these findings are discussed. Recommendations are provided to implore further studies for multilingual homes and formal education set-ups.

Keywords: Working memory, Children, Cognitive, Multilingual, Urban High Socioeconomic families, Language, Typical

India is a land of multiple cultures with language diversity. Each state boasts of different language and culture. Multilingualism cannot be avoided in an urban Indian city. Bilingualism is at the grass-root level in India (Mohanty, 2006). A metropolitan city of India would inevitably be a mixture of cosmopolitan inhabitants. This makes multilingualism an everyday necessity of such a population.

One of India's fastest-growing metropolitan urban cities is Bangalore (World Urbanization Prospectus, n.d.). Known as the "Silicon Valley of India," Kannada, English, Telugu, Tamil, and Hindi, Marathi languages are included in the list of spoken languages (Maps of India, n.d.). Thus, urban bilingualism was 55.70%, and urban trilingualism in Karnataka was 73.84% as per the census 2011. The percentage of bilinguals and trilinguals in Karnataka has been more than the national average (Mallikarjun, 2019).

Many factors could be enlisted for multilingualism in families of Bangalore. Urban private schools which encourage children to learn from multiple languages from their pre-primary levels of education, high inter-state mobility owing to change in locations in the IT industry and other similar sectors, mixed state marriages are some of the reasons many children from these families are also multilingual.

Much evidence has been reported linking executive functioning (EF) skills to a "bilingual brain" (Ramirez & Kuhl, 2017). A significant advantage is noted in terms of attentional control, inhibitory capacity, and cognitive flexibility exhibited by bilinguals across the life span (Bialgstok, 2015, Mindt et al., 2008; Engel de Abreu, 2011). Several disadvantages have been noted, such as achievement of conversational proficiency vis-à-vis higher-order cognitive proficiency levels in languages, vocabulary size and semantics of the second language in bilinguals and losing ground of both the languages when immersed in a non-native language environment such as schools (Mindt et al., 2008; Thomas & Collier, 2002).

Most of the current evidence in language development or acquisition, vocabulary development, and cognitive abilities is compared with monolingual and bilingual peers only (Mieszkowsha et al., 2017). Nevertheless, these are studies conducted in the west, where few places have as much language diversity as the Indian subcontinent.

Many Indian studies on language acquisition and auditory processing factors in multilingualism have been notable (Prasad & Prema, 2013; Kumar et al., 2020). Research assessed WM in monolingual and bilingual children from Karnataka, India. They found a "bilingual advantage" in their study (Raju & Nataraja, 2016). In another study, SES was linked to language development in Indian children (Dadlani et al., 2018).

Hence, a consideration of social factors is essential to ascertain the nature of cognitive advantages or disadvantages of multilingualism. Specifically, many language acquisition factors come into the picture in the developing child. The age, critical period of exposure and learning, and socioeconomic status (SES) are social factors in language acquisition (Mayberry & Kluender, 2018; Chen & Hartshorne, 2021; Ramirez et al., 2017). Critical periods of language acquisition (in terms of first learning of a native language and then a second language) have been in the debate by theorists, although childhood and pubertal periods are considered most conducive for able language learning (Chen & Hartshorne, 2021; Hartshorne et al., 2018).

The Present Study

Managing and using multiple languages could be viewed as multitasking (Poarch & Bialystok, 2015). While multitasking, various cognitive skills related to working memory (WM) could be at use. WM is one of the core EF functions (Miyake et al., 2000). It is a system that stores information over short periods and when this information is used to complete some goal-directed activity (Redick et al., 2015). WM is one of the important parameters of information processing in human development and the maturation of cognition (Cowan, 2016). This area of research has impacted many aspects, including language development and skills.

The present study explores our understanding of multilingualism in children vis-à-vis WM. There are two groups of children from the urban city of Bangalore. The first group (referred to as $BL_{Children}$ hereafter in the study) is the children with conversational and functional usage and proficiency of two languages. The second group (referred to as $TL_{Children}$ hereafter in the study) is the children with conversational and functional use and proficiency in three languages. Both the groups are classified based on the report of their biological mothers (the primary caregivers in both groups). These two groups of children are from high socioeconomic (SES) backgrounds. They are similar in age, IQ, and developmental assessment.

The moot question raised in this study is based on the evidence of better EF skills in bilinguals (Mindt et al., 2008). Hence the children switching more than two languages ($TL_{Children}$) might differ from the $BL_{Children}$ in the EF skill (Poarch & van Hell, 2012) --- in this study, WM. So, is there a "trilingual advantage" in the high SES school-going children in WM? If there is an advantage, is it to be observed in verbal, visuospatial, or both the components of WM. What could explain the findings?

This study attempts to compare school-aged $BL_{Children}$ and $TL_{Children}$ on the verbal and visuospatial components of WM. The following research questions are associated with this study.

Research Questions

1. Is Verbal WM performance significantly different in the $BL_{Children}$ in comparison to the $TL_{Children}$?
2. Is Visuospatial WM performance significantly different in the $BL_{Children}$ in comparison to the $TL_{Children}$?

Operational Definitions

1. $TL_{Children}$ = Children who have three languages in conversational fluency and functional use. The three languages being: (a) Native language of the child
   (b) English
   (c) Language X (another native language of Karnataka, India)

2. $BL_{Children}$ = Children who have two languages in conversational fluency and functional use. The two languages being: (a) Native language of the child
   (b)English
3. WM = Standardized and valid tests were used for measuring verbal and visuospatial WM. N-Back tests for verbal WM and N-Back and spatial span tests for visuospatial tests.
4. SES = Measured using a valid test based on parental education, annual income, occupation.

Method

A cross-sectional exploratory study was designed. The sample was recruited only with the written consent of the parents and the assent from the children. The data included in the manuscript is compliant with all the ethical rules necessary for bio-behavioral research (Venkatesan, 2009a). The period of collection of the data was from May 2019 to October 2020.

Participants

A non-probability purposive and snowball techniques were used to collect the sample. The sample consisted of typically developing probands (N= 55) in 6 to 8 years, including boys and girls. This sample consisted of:

(a) Typically developing probands with the functional use and conversational fluency of exactly two languages. The children spoke ***Native Language-English***. The children of this group will be referred to as $\mathbf{BL_{Children}}$ hereafter in this study.

(b) Typically developing probands with the functional use and conversational fluency of exactly three languages. The children spoke ***Native Language-English-Language X***. Language X was one other of the native languages spoken in the state of Karnataka. The children of this group will be referred to as $\mathbf{TL_{Children}}$ from hereafter for this study.

Recruitment of Clinical Sample

Families from the schools/apartment dwellings/communities in east Bangalore were shortlisted. These families were contacted and requested to participate in the study. A total sample of 28 probands in $BL_{Children}$ and 27 probands in $TL_{Children}$ were recruited. The children were of Indian origin, right-handed with no visual-hearing impairment, and studying in English medium private schools.

Criteria for the inclusion of the probands were according to Table 1.

Table 1
Inclusion Criteria for $BL_{Children}$ and $TL_{Children}$

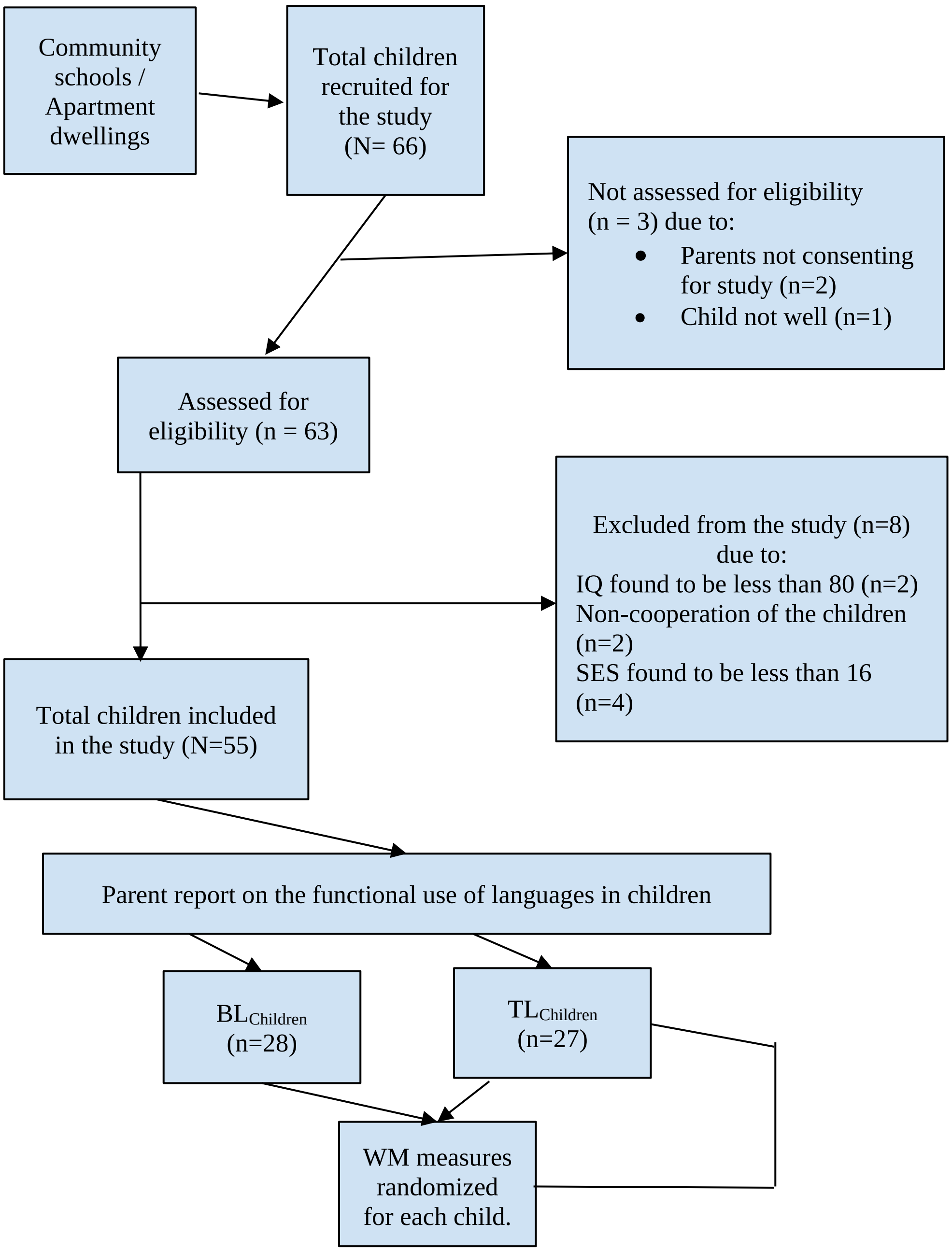
No.	$BL_{Children}$	$TL_{Children}$
1.	In the ages of 6 to 8 years	In the ages of 6 to 8 years
2.	Having no delay in any of the developmental domains	Having no delay in any of the developmental domains
3.	IQ of equal or above 80	IQ of equal or above 80
4.	Staying with biological parents	Staying with biological parents
5.	Children not on medication	Children not on medication
6.	Belonging to high SES	Belonging to high SES
7.	Family size of 4 or 5, including the child	Family size of 4 or 5, including the child
8.	Both the parents staying together	Both the parents staying together
9.	Children are of Indian origin	Children are of Indian origin
10.	Uses two languages in conversational fluency and functional use	Uses three languages in conversational fluency and functional use
11.	Only English as the medium of instruction in school	Only English as the medium of instruction in school
12.	Living and growing in Bangalore	Living and growing in Bangalore

Note. The recruitment of the sample was based on the inclusion criteria used for the study.

The recruitment of the sample is portrayed in the flow diagram in Figure 1.

Figure 1

Flow Diagram of the Recruitment of the Sample



Note. The recruitment of the children for the two groups is depicted here.

In the group of $BL_{Children}$, there were 17 boys (60.71 %) and 11 girls (39.29 %). In the $TL_{Children}$ group, 17 boys (62.96 %) and ten girls (37.04 %). Table 2 provides the characteristics of the sample. The children were maximum in grade II for both groups ($BL_{Children}$ = 67.9%; $TL_{Children}$ = 55.6%).

Table 2

Characteristics of the Sample

Variables		**$BL_{Children}$**	**$TL_{Children}$**
N		28	27
Boys : Girls		17 : 11	17 : 10
Education (in %)	Upper Kindergarten	---	3.7
	Grade I	21.4	25.9
	Grade II	67.9	55.6
	Grade III	10.7	14.8

Note. The sample size, gender ratio, and education of the children are provided in this table. N = 55

Tasks and Procedure

The investigator (first author) used a computer-coded and amenable data intake and record sheet for every child to facilitate ease of scoring and administration of the measures. The probands and their parent/s were assessed in well-lit rooms of either the clinics/centers or their homes in two or three sessions of 45 minutes each by the investigator who has a Rehabilitation Council of India (RCI) approved pre-doctoral qualification in clinical psychology and doctoral qualification in psychology. The details of the tasks presented are provided in the following inter-related sections.

1. ***Assessment of background variables in probands:*** They were assessed on development and intellectual ability measures.
   (a) *Assessment of development:* This was done with Activity Checklist for Preschool Children with Developmental Disabilities (ACPC-DD; Venkatesan, 2004). The number of items in each of the eight child development domains is fixed at 50 items. On each item, the child receives a score from 0 to 5 depending on the level of assistance required to perform that given item. Children with no delays in any of the domains were included.
   (b) *Intellectual Functioning:* Intellectual functioning was assessed using the Binet-Kamat Intelligence Scale (BKIS; Kamat, 1967; Venkatesan, 2002). It is a normatively indexed age scale. Many tasks combining both speed and power in their verbal, numerical, and

visuospatial components are included. Scoring is in the form of credits for partial or complete successful completion of each task. Basal, Ceiling, and Mental ages are computed to derive intelligence quotient (IQ) accordingly. Though BKIS has been outdated, the test has been robust through the times (Gopalkrishnan & Venkatesan, 2019). Hence, scoring has been according to the newer calculation of adjusted IQ as proposed to the same item list (Roopesh, 2020).

(c) *Parent Report of Child's Language Skills:* A direct report on the child's conversational fluency and functional language use from the parent (mother) was obtained. The $BL_{Children}$ were either simultaneous bilinguals who grew up learning both the languages or learned their native language at home and learned the second language as English at school. Similarly, the $TL_{Children}$ used three languages either through the parents, school, or the surrounding community setting. Both the groups of children were exposed to the languages from birth to five years of life.

(d) *Socioeconomic Status:* The family's SES of the child was assessed using NIMH-SES readapted version (Venkatesan, 2009b), as direct questions might elicit vague or inappropriate answers. A family SES score of 16 and above were included.

2. ***Assessment of Working Memory:*** Probands were assessed for the following variables using the measures as given below. The measures of WM were administered to both the groups in random order as provided from the table of random sets generated using computer software (Urbaniak & Plous, 2013). N-back and Spatial span tasks were incorporated to measure verbal and visuospatial components of WM for both probands. The tasks for probands are from the NIMHANS Child Neuropsychological Battery (Kar et al., 2004).

3.

(a) *Verbal WM:* Verbal 1-back was presented for probands consisting of 30 consonants from Indian languages. The child is to tap his hand on the table if the consonant gets repeated consecutively. The 2-back task consisted of 54 consonants. The child responds by tapping the table if the consonant gets repeated after an intervening consonant.

(b) *Visuospatial WM*: Visual 1 and 2 back tasks for both groups of children consisted of 36 cards of the same dimensions, with a black dot placed randomly on the card, again of the same dimension throughout. In the 1-back task, the child will respond by tapping the table if the dot repeats itself in the same location consecutively. In the 2-back task, the child responds if the dot is seen at the same place after one intervening random card. The number of accurate responses and errors in both the verbal and visual tasks form a score.

The span task for the probands consisted of 1-inch cubes of 4 arranged in a row with 1 inch in between. The examiner used the fifth cube for different sequences as provided in the NIMHANS Child Neuropsychological Battery (Kar et al., 2004). The child should repeat the sequence exactly like the examiner. Both forward and backward sequence is provided, and the accuracy scores are the number of correct sequences tapped for both the conditions. The total score being the scores obtained on all the successful trials.

Data Analysis and Statistics

All analysis proper was conducted using the SPSS (version 23.0; IBM Corp, 2015). Data were screened for skewness, kurtosis, and normality using Shapiro Wilk's test. Depending on the obtained results, parametric (normal distribution) and non-parametric (skewed distribution) tests were conducted to infer appropriately.

Results

The study's findings are presented in the following two distinct but interrelated headings: (a) Sample demographic characteristics (b) Distribution of WM scores for the sample.

(a) Sample demographic characteristics

A perusal of demographic characteristics of the sample (Table 2) shows the probands (N: 55) were on average in the early childhood of development and with an average intellectual functioning of 112. Table 2 depicts the demographic details of age, SES, and development of the sample. Their mean level of development for both groups was 1967-1968 scores. The average age group of the children was 6.7 years. The children's family belonged to high SES at the time of assessment. Age (*t = 0.40, p>.05*), IQ (*t= 0.15, p>.05*), SES (*t = 1.14, p>.05*), and developmental level (*t = 0.13, p>.05*) of the children in both the groups were not significant.

Table 3

Demographic Details for the Sample

Variables	**BL$_{\text{Children}}$ (N = 28)**			**TL$_{\text{Children}}$ (N = 27)**			**t-test**	**p-value**
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**		
Age	6.79	.56	8 - 6	6.73	.54	7.8 - 6	0.40	.69
SES	19.86	.45	20 - 18	19.96	.19	20 - 19	1.14	.26
Developmental Scores	1967.25	20.7	1996-1931	1968.15	28.57	2000-1891	0.13	.89
Intellectual Functioning	114.99	13.00	95.31-145.94	115.55	14.31	93.44-158.13	0.15	.88

Note. The details on age, socioeconomic status, developmental level, and intellectual functioning of the children.
N = 55
p > .05

Table 4 depicts the distribution of scores on the cognitive functions --- WM. They were classified as verbal and visuospatial WM.

Table 4
Distribution of WM Scores for the Sample

Variables	**BL Children (N = 28)**		**TL Children (N = 27)**		**Z**	**p-value**
	Mean Ranks	**IQR**	**Mean Ranks**	**IQR**		
Verbal WM Composite	33.23	4.00	22.57	6.00	-2.48	.01*
Visuospatial WM Composite	33.41	4.75	22.39	7.00	-2.56	.01*

Note. Verbal and visuospatial WM scores is computed as a composite and compared for the two groups of children.
N = 55
*p < .01

Table 5
Distribution of Errors for the Sample

Variables	**BL Children (N = 28)**		**TL Children (N = 27)**		**Z**	**p-value**
	Mean Ranks	**IQR**	**Mean Ranks**	**IQR**		
Verbal WM Errors Composite	25.34	6.50	30.76	6.00	1.26	.21
Visual WM Errors Composite	25.14	8.50	30.96	10.00	1.35	.18

Note. The errors for the verbal and visuospatial WM are computed as composites for both groups of children.
N = 55
p > .05

Two cognitive functions --- verbal WM and visuospatial WM composite score performance for the two groups of children is provided. A non-parametric test (Mann-Whitney U statistic) was used to analyze the group differences on the tasks. Composite scoring was attempted to assess the performances of the two sets of parents broadly. Meaningful grouping of verbal and visuospatial components was attempted to compute the composite variable (Song et al., 2013). Further, the sum of each of the tasks' raw scores was taken as a natural weighting composite. The composite provided one unified score for each construct/component related conceptually (Riordian, 2017). One advantage of creating such composites, according to Riordian, was also to reduce the Type 1 error in cognitive outcome studies. Hence, verbal composite accuracy/error scores were computed as the sum of verbal 1-back, 2-back tasks. The visual accuracy score composite was computed as the sum of visual 1-back, 2-back tasks and spatial span forward and backward tasks. Visual error composite is the sum of visual 1-back, 2-back task conditions' omission, and commission errors.

The results have been detailed in the following subsections for more clarity:

(a) Composite accuracy scores
(b) Composite error analysis

Mann-Whitney U test for the group signifies both the verbal and visuospatial WM for the $BL_{Children}$ and $TL_{Children}$.

(a) *Composite Accuracy Scores*

For the $BL_{Children}$, the range of accuracy scores is higher in comparison to that of $TL_{Children}$. The trends in accuracy scores are seen to be in the same direction for the groups. A comparison of $BL_{Children}$ and $TL_{Children}$ performance depicts that, on average, $BL_{Children}$ have scored more in the verbal tasks. Given the higher mean ranks in accuracy scores and smaller variation, $BL_{Children}$ outperformed $TL_{Children}$ in the N-back verbal stimuli tasks. The two groups' performance on the visuospatial WM show a similar picture. Higher mean ranks and lower variation by the $BL_{Children}$ depict that the performance of $BL_{Children}$ was better than the $TL_{Children}$. These findings support our first and second research questions positively.

(b) *Composite Error analysis*

Additional analyses of the distribution of errors for the two groups are provided in Table 5. Contrary to accuracy scores, there seems to be no significant difference in all task errors on verbal and visual components. The omission and the commission errors on the verbal tasks are the same for the $BL_{Children}$ and $TL_{Children}$ with slight variation and similar mean ranks. The omission and the commission errors on the visual tasks are the same for the $BL_{Children}$ and $TL_{Children}$ with slightly higher variation but with similar mean ranks. Hence the $BL_{Children}$ and $TL_{Children}$ have performed similarly on verbal and visual tasks based on their analysis of errors.

Discussion

Children can learn three languages for many reasons (Schroeder & Marian, 2017). The present study assessed the performance of bilingual and trilingual children across a set of tasks assessing verbal and visuospatial WM. Based on the research questions raised, both verbal and visuospatial WM performance was significantly different between the $BL_{Children}$ and $TL_{Children}$.

"Bilingual effect" is the difference in the task performance between the bilinguals and monolinguals on various cognitive measures (Engel de Abreu, 2011). In this study, $BL_{Children}$ significantly performed better than the $TL_{Children}$ in the WM tasks. Hence concordant with many studies, only a "bilingual" effect could be observed in this study and not a "trilingual effect." This could mean that the performance is not enhanced when dealing with more than two languages. The results raise the question of why there is a dip in the performance of the $TL_{Children}$.

Many studies provide no evidence of cognitive gains in $TL_{Children}$ in comparison to $BL_{Children}$. For instance, Poarch and van Hell (2012) ran experimental tasks with children ages 5 to 8 years. The children had varying backgrounds of language classified into monolinguals, second language learners, bilinguals, and trilinguals. The children were assessed on attentional control and interference tasks. The results showed that bilinguals and trilinguals were exerting more control on attention than the other two groups of children. However, no significant difference emerged between the attentional control or the interference tasks between the bilingual and the trilingual children. These findings allowed them to discuss that negotiating with two or more languages daily does not increase EF skills such as attentional control. In another study, Poarch and Bialystok (2015) assessed 203 children aged 8 to 11 years, classified as monolinguals, partially bilingual, bilingual, and trilingual. They found no evidence of advantage in $TL_{Children}$ when compared to $BL_{Children}$ on an EF skill task.

Schroeder and Marian (2017) explain the scenarios when there is no "advantage" of trilingualism in children and young adults.

1. They base multilingualism on the demand-and-supply-hypothesis of a cognitive process. And accordingly, one would expect more cognitive gains in trilingual. But if the demand on the cognitive process is not due to trilingualism, then no gains will be observed. In the context of the present study, the $BL_{Children}$'s cognitive demand and supply are probably observed as better performance rather than the $TL_{Children}$ (Schroeder & Marian, 2017).

2. The tasks of N-back and Spatial span, which were used in the present study, were more complex and challenging for trilingual children. The N-back task uses familiarity and recognition-based discrimination (Jaeggi et al., 2010). The spatial span task involves active recall and processing of information while holding it temporarily. As the complexity increases with the tasks (such as in 2 N-back tasks of visuospatial WM), retrieval of items requires the ability not just to focus but to shift attention (Verhaeghen & Basak, 2005). Many studies on attentional network interference control have been conducted. Studies on WM tasks in trilingualism have been sparse.

3. The sequence or learning pattern of the languages in the present study sample has not been elicited. Suppose TLChildren is immersed in their second and third language simultaneously. In that case, their demand on the cognitive process might not yield any gains. As the cognitive demands could be competing, the gains on the cognitive tasks could not be observed (Schroeder & Marian, 2017).

A few drawbacks of the present study are the evaluation of proficiency of the second and third languages. Again, the sequence of learning in the $TL_{Children}$ needs to be elicited. Hence the present parent report is subject to theoretical sophistication alone. So, it is highly recommended that future studies consider objective scales of evaluating language proficiency in children. Further, higher sample size to extend and generalize the results of the present study is warranted. Assessing other EF skills in a similar Indian sample of multilingual children is needed. Such as assessment should consider family factors such as the number of children from mixed state marriages, the presence of a hired caregiver with a different language background for the children, presence of a sibling who could influence the child's language development are all factors of language constellation that should be considered. Family factors and support are major factors affecting multilingualism in children (Arnaus Gil et al., 2020). These findings need further exploring vis-à-vis multilingual homes and in formal education set-ups.

Conclusion

Language is a multifaceted, dynamic, and complex process (Levine et al., 2016) in a developing child, which might involve many other higher-order brain functions. WM performance is better in bilingual children of the present study in comparison to trilingual children. Indian studies are needed to implore these results with a better design and analysis.

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Addresses of the Authors

Dr. Kamlam Gopalkrishnan Iyer, M.Phil., Ph.D.
Consultant Child & Adolescent Neuropsychologist
Kamlam's Clinic, D-327, Ittina Abha Apts., Marathahalli
Bangalore - 560037
iyerkamlam@gmail.com
Ph: 9632685294

Dr. S. Venkatesan, M.Phil., Ph.D.
Formerly Dean-Research, HOD & Professor
Department of Clinical Psychology
All India Institute of Speech & Hearing (AIISH),
Mysore 570006
psyconindia@gmail.com