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Research Article

Working Memory Correlates Musical Sensitivity in Children: An Exploratory Study

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ABSTRACT

A well-developed musical sensitivity requires a good working memory capacity in children. Primary aim of present study was to analyse the relationship between children's working memory and musical sensitivity. Children's working memory consisted of phonological loop, visual spatial sketchpad, central executive function and long-term memory retrieval. In the study, children's musical sensitivity was limited to their music perception skill and musical performance. Researcher was interested to know whether boys and girls differed or similar with respect to their working memory capacity, music perception skill and musical performance. The study was exploratory in nature and based on quantitative data. Investigator employed purposive sampling technique to select 20 girls and 20 boys of standard VII from a Bengali medium Government aided school in Howrah District, West Bengal, India. Several standardised tests were used to measure working memory capacity in children. 'PROM-S' tool was administered to examine children's music perception skill. To measure children's musical performance, investigator developed and standardized a musical performance test which was limited to singing songs mentioned in Bengali (L1) textbook prescribed by WBBSE, Kolkata. Pearson's Product Moment correlation coefficients showed that there existed statistically significant positive correlations between children's working memory, music perception skill and musical performance. Data analysis revealed that boys and girls did not differ in their working memory capacity, music perception skill and musical performance.

Key Words: Working Memory, Musical Sensitivity, Music Perception Skill, Musical Performance, PROMS-S.

1. Introduction

Music is an organized sequence of sounds and silent moments. It is an art-form that expresses human emotions via harmonic frequencies. It is a popular type of entertainment; people find it intriguing and enjoy. Most music consists of humans singing with their voices (vocal music) or playing musical instruments (such as tabla, flute, harmonium, piano, guitar, drums, violin, etc.). From research point of view, Music is a multidisciplinary research area. It has been explored in different disciplines including education, cognitive psychology, health psychology, general psychology, musicology, cultural studies, literature, music, medical and so on. Many studies have examined positive association of music on children's overall development including cognitive, linguistic, emotional and behavioural aspects. Recently, academicians have noted that humans' cognitive capacities can influence their musical sensitivity. Sensitivity refers to an organism's (or organ's) ability to respond to external stimuli or stimulants. Peters (1970) defines musical sensitivity as "the ability to receive and respond to musical stimuli." Musical sensitivity is also known as susceptibility to music; because humans have an innate ability/capacity to be easily impacted by different musical components (pitch, tone, melody, note, tune, etc.) and genre (classical, jazz, pop, instrumental, etc.). As noted by Mishra and Shastri (2018), "Music is a powerful stimulant, and sensitivity is another trait with low and high ends of the spectrum." Sree and Venukapalli (2020) has mentioned, "Musical sensitivity is an aesthetic experience and aesthetic sensitivity. Ability to perceive, react or respond and produce music aesthetically. It exists in all human beings but it varies from individual

to individual. Some people are highly creative in music and some others are with low level of sensitivity towards music.....Musical knowledge and musical sensitivity is generally considered as musicality. It is an ability to perceive, understand, interpret and experience the nuances of music along with creative production of different music forms. In other words, musical receptivity and musical creativity are two important aspects of musicality of a person."

Sutton (2017) has mentioned "musicality can be construed as a set of skills and it may comprise the following skills: Playing by ear; Singing in tune; Jamming; Having good rhythm; Writing music; Writing notation; Improvising a solo; Talking music; Understanding Music Theory; Clapping in time; Knowing your instrument inside and out; Tuning your instrument by ear; Reading notation; Sight-reading music; Playing from a lead sheet; Performing live and Playing multiple instruments." According to Mula (2012) musical ability is, "the combination of three different abilities, namely, one, musical perception, the ability to grasp the sense of music; two, memory and three, ability to sing or perform, what is perceived and memorized." Musical sensitivity can be viewed as the technical capacity of humans to create and reflect on a wide range of sounds including vocals and instrumentals; variations in performances such as singing and playing musical instruments. It is the awareness of when the voice should be soft and when it should be loud, known as voice modulation and intonation with respect to linguistics as well as music. It will help children understand various musical elements such as pitch, rhythm, melody, melody-pitch, structure, musical notes and composition. It is the understanding of how music should be played, when to slightly adjust the melody/lines to evoke different human emotions through music. It is the understanding of vocal effects that allows someone to become more appealing to audiences (Connor, 2016).

Musical sensitivity has numerous components (dimensions) including music appreciation, aptitude, perception, preferences, production and so on. However, it is not certain that all these traits will be evident equally in every individual. Every child cannot be sensitive to all components of musical sensitivity; instead, they will be specific to one. Some children may be better in producing music while others are better at receiving it. Due to the individual differences, music industries employ singers, instruments players, lyricists and composers.

The current study focused on music perception skills and musical performance as components of musical sensitivity in children. Perception, according to Merriam-Webster dictionary, is "awareness of the elements of the environment through physical sensation". Children's perception of music is rapid, acute and intuitive cognition. It is the ability to comprehend musical stimulis. According to Ukkola-Vuoti, Kanduri, Oikkonen, Buck, Blancher et al., (2013), "Like intelligence or language, music perception and practice are complex cognitive functions of the human brain". Pallesen et al., (2010) define music perception as a neurophysiological process (including working memory) that allows an organism/individual to become aware of and respond to external stimuli (music). Mula (2012) has defined music perception as the "...meaningful interpretation of the knowledge we obtain through our senses. For a good knowledge of music, one must be able to grasp the sense of music as a whole, one must be able to hear, remain attentive and be able to discriminate the musical nuances i.e., sruti, laya etc." In this study, musical sensitivity was further assessed in terms of musical performance in children. Musical performance is a set of musical knowledge and skills which enable children to perform (engage in musical activities) voluntarily in any circumstance. It allows people to become more versed and professional in their sector over time. Tierney, Bergeson, and Pisoni (2009) have defined musical performance as a complex activity which includes auditory, visual, somatosensory and motor skills of human beings. They also stated that a broad range of skills associated with music practice (performance) and instruction reflects individual differences and diversity.

2. Literature Review

Musical sensitivity, as a broad research area, is underexplored. Scholars across the world have primarily concentrated on how personality, emotion, parenting and socio-cultural circumstances construct musical sensitivity in people of all ages. An increasing body of research has acknowledged that, in addition to the factors stated above cognitive styles, intelligence (general and emotional), creativity, primary cognitive abilities and human memory (long term memory, working memory) may affect musical sensitivity in children and adults.

Saito (2001) examined the association between working memory components such as phonological loop, short-term memory with rhythm (a widely researched component of music perception). The study concluded that the phonological loop was positively correlated with rhythm in both females and males. Hansen, Wallentin, and Vuust (2013) conducted a study of twenty-six women and twenty-four men to find out relationship between working memory and musical competency. Participants in the study comprised expert musicians, amateur musicians and non-musicians. Data analysis revealed that musicians

outperformed non-musicians on all musical competence tests. A statistically significant positive correlation was found between working memory and musical competence in both musician and non-musicians. Gillis (2014) undertaken correlational research on working memory, music perception and production (performance) in women and men. Music perception was classified into pitch and melody discrimination. Musical production was limited to singing (pitch production on one, two and four notes). Data analysis revealed that working memory was positively connected with melody discrimination. In the investigation, researcher did not find significant positive correlation between working memory and participants' singing (performance/production).

Lesiuk (2015) investigated seventy-one girls and boys aged nine to fourteen years who had executive function deficits. The study aimed to determine the association between children's executive functions (a component of working memory) and music perception, specifically melodic tone discrimination, pitch discrimination, rhythm discrimination, duration discrimination and pulse count. The study revealed that shifting (a component of central executive function) was positively associated with melody, duration and rhythm perception. Working memory (as a whole) had a statistically significant positive correlation with all aspects of music perception. Swaminathan (2017) conducted a correlational study on undergraduate students' general cognitive abilities including nonverbal intelligence, working memory with their music perception skill. Analyses demonstrated that students' intelligence and working memory skills were closely associated with their music perception skill.

After reviewing existing literature critically researcher has noticed that there are a very few studies available in musical sensitivity in relation to working memory. Investigator did not find any such studies in Indian context. So, current study will be a break through in the area of musical sensitivity research.

3. Research Methodology

3.1. Research Questions

After reviewing existing literature on working memory and musical sensitivity, researcher raised a few questions-

i) To what extent children's working memory is associated with their music perception skill and musical performance?
ii) To what degree/extent boys and girls are similar or different with respect to their working memory, music perception skill and musical performance?

3.2. Objectives

To find out answers of the questions mentioned above, researcher framed four objectives mentioned below-

i) To study the relationship between children's working memory and their music perception skill.
ii) To examine the relationship between children's working memory and their musical performance.
iii) To examine whether girls and boys differ or similar with respect to their working memory skill.
iv) To examine whether girls and boys differ or similar in their music perception skill and musical performance.

3.3. Research Procedure

Present study was exploratory in nature. Investigator used correlational research design for the study. Quantitative research approach was adopted. Children's working memory was considered as independent variable and their music perception skill and musical performance were considered as dependent variables. All school going children of standard VII in West Bengal, India who were being taught Bengali as first language (L1) were considered population for the study. Purposive sampling technique was employed to select 20 girls and 20 boys of standard VII from a Bengali medium Government-aided school of Howrah district, West Bengal, India. To examine children's working memory and musical sensitivity, researcher adopted several standardized tools discussed below.

3.4. Tools Used in the Study

In present study, children's music perception skill was assessed by Shortened- Profile of Music Perception Skills (PROMS-S) developed and standardized by Zentner and Strauss (2017). It was an online, culture-fair test to measure perceptual ability of music in children. Researcher developed and validated musical performance test for students. The test comprised of three Bengali songs which was prescribed in Bengali (L1) textbook of VII, developed by West Bengal Board of Secondary Education (WBBSE), Kolkata, West Bengal, India. Investigator measured four components of working memory in children such as phonological loop, visual-spatial sketchpad, central executive function and long-term memory retrieval. In the study, researcher used several standardized tests to measure components of working memory in both

online and paper-pen modes. The online tests were administered by using 'Inquisite Millisecond' website. Details of the tests along with developer's name and edition were given in table 1 below.

Table 1
List of Tests Used to Measure Working Memory in Children

Variable		Test	Test Mode
Phonological Loop	Phonological Short-Term Memory	Revised Digit Span Test (Blackburn & Benton, 1957)	Offline
	Verbal Working Memory	Listening Recall Test (Daneman & Carpenter, 1980)	Offline
Visual-Spatial Sketchpad	Visual-Spatial Short-Term Memory	Visual Digit Span Task (Woods et al., 2016)	Online
	Visual-Spatial Working Memory	Corsi- Block Tapping Test (Kessels et al.,2000)	Online
Central Executive	Shifting	Plus-Minus Task (Jersild, 1927; Hull et al., 2008)	Offline
	Updating	Keep Track Task (Friedman et al, 2008)	Online
	Inhibition	Stroop Test (Stroop, 1935)	Offline
Long Term Memory Retrieval		Word Fluency Test (Ekstrom et al., 1976)	Offline

4. Data Analysis and Interpretation

In the beginning of data analysis, researcher performed Shapiro-Wilk Test of Normality to check normal distribution of collected data. Result of the analysis showed that collected data were normally distributed. Investigator started analysing collected data with the help of descriptive statistics of variables mentioned in table 2 below. Pearson's product moment correlation coefficients (r) were computed to explore the degree of associations between children's working memory, music perception skill and musical performance. Researcher performed independent sample t-tests to determine gender differences in the mean scores achieved by boys and girls in working memory, music perception skill and musical performance tests.

Table 2
Descriptive Statistics of the Variables Used in the Study

Measures	N	Maximum	Minimum	Mean	SD
Working Memory	40	126	102	111.58	6.012333
Music Perception Skill	40	62	51	57.70	2.936944
Musical Performance	40	40	27	32.175	5.4404393

4.1. Correlation between Children's Working Memory and Music Perception Skill

To find out the relationship between children's working memory and music perception skill, researcher framed the following hypothesis-

Hypothesis 1: There exists a statistically significant correlation between children's working memory and music perception skill.

For statistical testing, research hypothesis was translated into null form-

H_0: There exists no statistically significant correlation between children's working memory and their music perception skill.

Pearson's product moment correlation coefficient (r) was computed to find out the association between children's working memory and music perception skill. Result of the analysis was given in table 3 below.

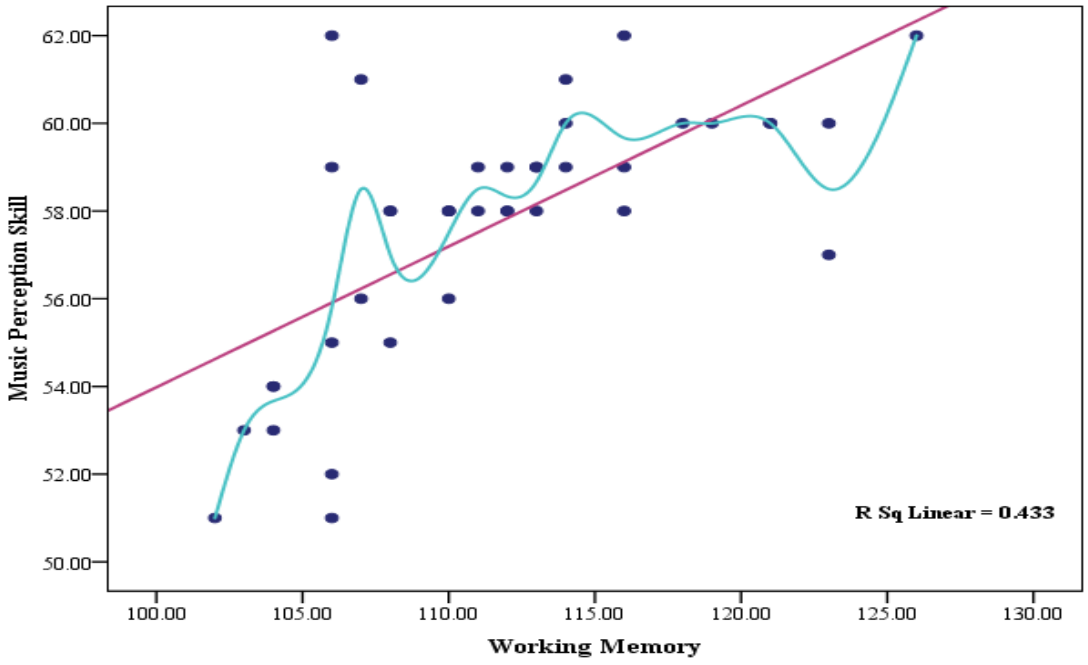
Table 3
Correlation between Children's Working Memory and Music Perception Skill

Measures		WM	MPS
Working Memory (WM)	Pearson Correlation	1	.658**
	Sig. (2 tailed)		.001
	N	40	40
Music Perception Skill (MPS)	Pearson Correlation	.658**	1
	Sig. (2 tailed)	.001	
	N	40	40

Note: **Correlation was significant at the 0.01 level (2-tailed)

From table 3, the analysis showed that Pearson's product moment correlation coefficient (r) of children's working memory and music perception skill was 0.658 and p-value was 0.001, which was <0.05. It could be inferred that there existed a statistically high significant positive correlation between children's working memory and music perception skill. Hence, null hypothesis was rejected and alternative hypothesis was accepted. It could be further inferred that children's working memory was positively associated with their music perception skill. Result of correlation analysis was given in figure 1 below.

Figure 1
Scatterplot Depicting Correlation between Children's Working Memory and Music Perception Skill



4.2. Correlation between Children's Working Memory and Musical Performance

To find out the association between children's working memory and musical performance, researcher framed following hypothesis-

Hypothesis 2: There exists a statistically significant correlation between children's working memory and musical performance.

For statistical testing, research hypothesis was translated into null form-

H_0: Children's working memory and musical performance are not positively correlated.

Pearson's Product Moment Correlation Coefficient (r) was computed to find out the relationship between children's working memory and musical performance. Corelation analysis between children's working memory and musical performance was discussed in table 4 below.

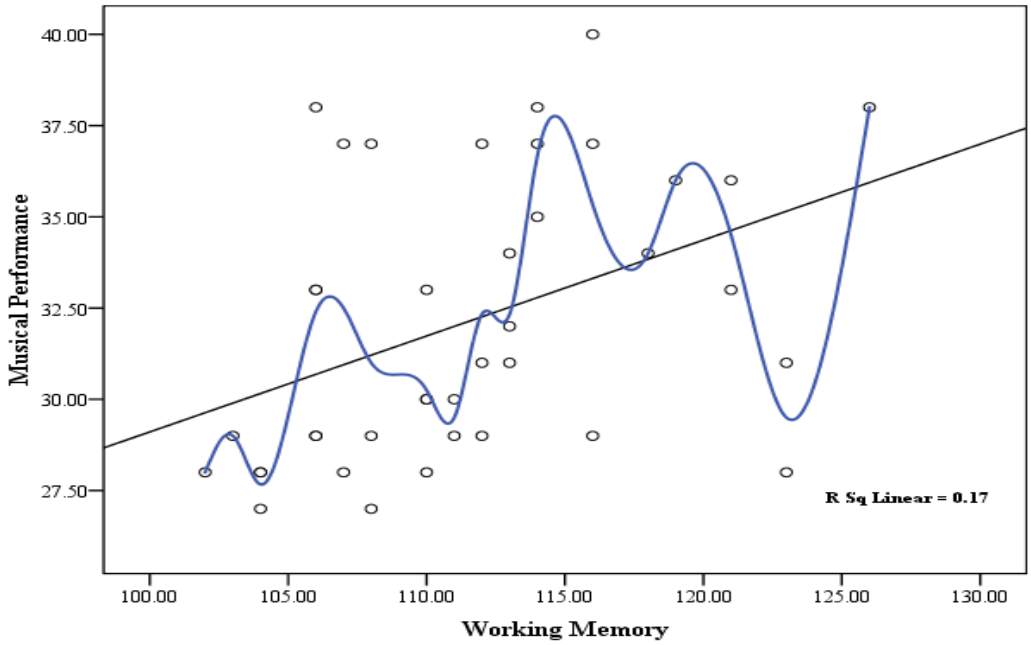
Table 4
Correlation between Children's Working Memory and Musical Performance

Measures		WM	MPER
Working Memory (WM)	Pearson Correlation	1	.412**
	Sig. (2 tailed)		.008
	N	40	40
Musical Performance (MPER)	Pearson Correlation	.412**	1
	Sig. (2 tailed)	.008	
	N	40	40

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

From table 4 it was evident that the Pearson's product moment correlation coefficient (r) of children's working memory and musical performance was 0.412 and p-value was 0.008, which was <0.05. It could be inferred that there existed a statistically significant positive correlation between children's working memory and musical performance. Thus, researcher rejected null hypothesis and accepted research hypothesis. It could be further inferred that children's working memory was positively associated with their musical performance. Result of the correlation analysis was given in figure 2 below.

Figure 2
Scatterplot Depicting Correlation between Children's Working Memory and Musical Performance



4.3. Gender Differences in Children's Working Memory

In the study, researcher was interested to know whether boys and girls differed or not with respect to their working memory. Investigator assumed that there were gender differences in among boys and girls with respect to their working memory capacity. To test the assumption, researcher framed following hypothesis-

Hypothesis 3: Boys and girls differ significantly with respect to their working memory score.

For statistical testing, research hypothesis was converted into null form.

H_0: Boys and girls do not differ significantly with respect to their working memory score.

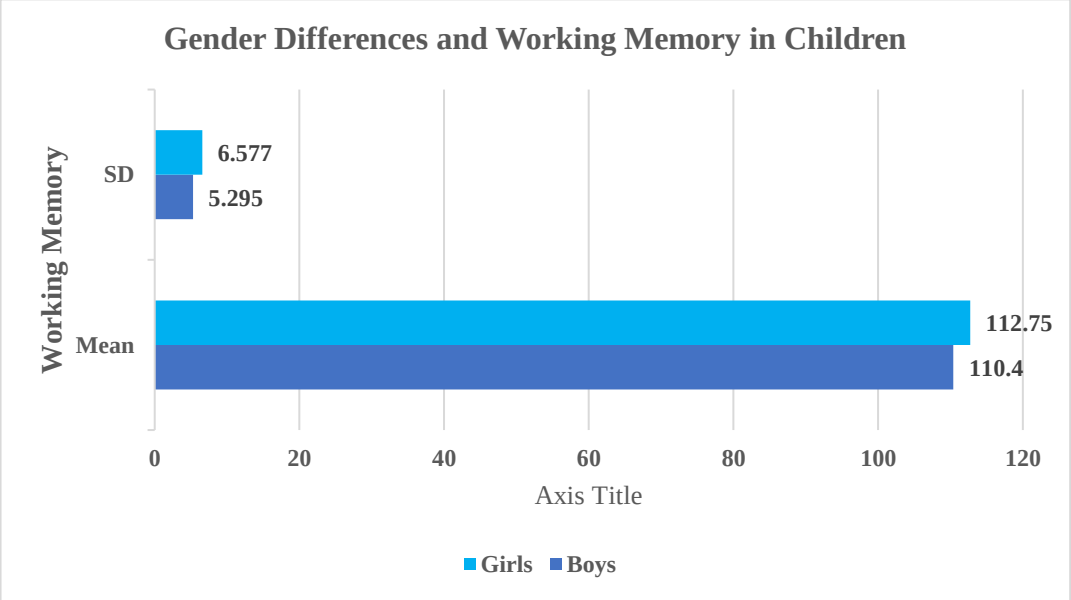
Independent sample t-test was computed to measure the gender differences in mean scores achieved by boys and girls in working memory test. Result of the test was given in table 5.

Table 5
Working Memory and Gender Differences in Children

Measure	Gender	Mean	SD	SE Diff.	df	t Value	p Value
Working Memory	Boys	110.40	5.295	1.888	38	1.2447	0.2209
	Girls	112.75	6.577				

From table 5, it was observed that mean and SD of boys and girls in working memory tests were 110.40, 5.295 and 112.75, 6.577 respectively. Standard error of difference was 1.888 and degree of freedom was 38. The observed t-value was 1.2447 and p-value 0.2209. The calculated two tailed p-value was greater than $\alpha = 0.05$. The observed p value indicated that there was a 22.09% chance that null hypothesis could be true. It could be inferred that mean difference of the scores achieved by boys and girls in working memory test was not statistically significant. Therefore, null hypothesis could not be rejected. It could be concluded that boys and girls did not differ significantly in their working memory capacity. Result of the t-test was given in figure 3.

Figure 3
Gender Differences among Boys and Girls with respect to Their Working Memory



4.4. Gender Differences in Children's Music Perception Skill

In present study, researcher assumed that gender played major role in deciding children's music perception skill. To test the assumption, research hypothesis was framed-

Hypothesis 4: Boys and girls differ significantly with respect to their music perception skill.

For statistical testing, research hypothesis was converted into null form, i.e.-

H_o: Boys and girls do not differ significantly with respect to their music perception skill.

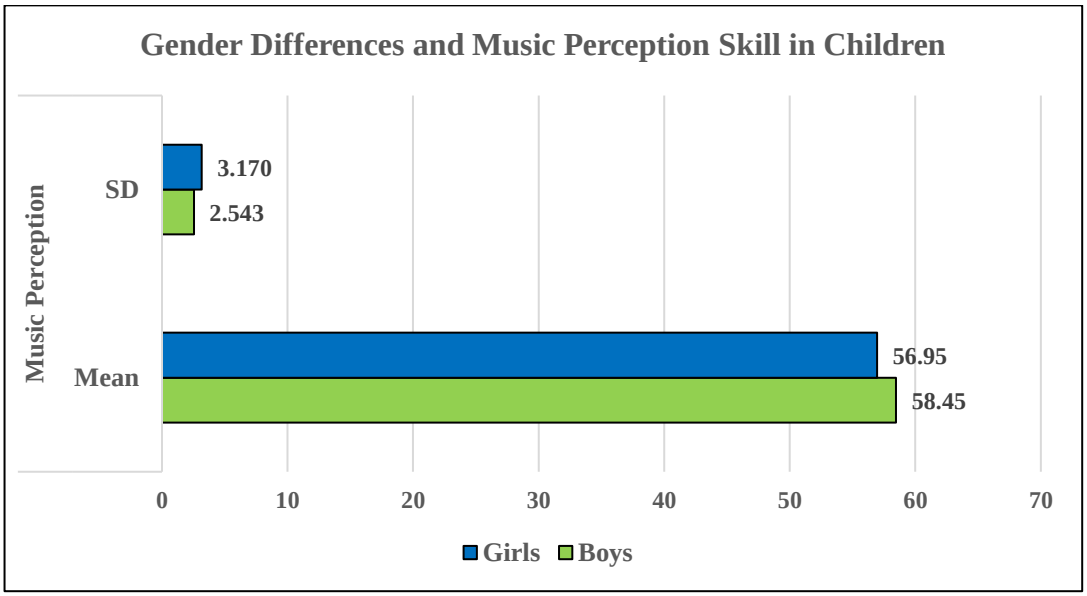
An independent sample t-test was computed to measure gender differences in the mean scores achieved by boys and girls in music perception skill test. Result of the t-test was given in table 6 and figure 4 below.

Table 6
Gender Differences among Boys and Girls with respect to Their Music Perception Skill

Measure	Gender	Mean	SD	SE Diff.	df	t Value	p Value
Music Perception Skill	**Boys**	58.45	2.543	0.909	38	1.6504	0.1071
	Girls	56.95	3.170				

In table 6, it was observed that mean and SD of boys and girls in their music perception skill test were 58.45, 2.543 and 56.95, 3.170 respectively. Standard error of difference was 0.909 and degree of freedom was 38. The calculated t-value was 1.6504. The observed p-value was 0.1071 which was greater than chosen level of significance ($\alpha = 0.05$). The observed p value showed there was a 10.71% chance that null hypothesis was true. It could be inferred that mean differences of the scores achieved by boys and girls in music perception skill test was not statistically significant. Therefore, null hypothesis could not be rejected. It could be concluded that gender did not play any role in deciding children's music perception skill.

Figure 4
Gender Differences among Boys and Girls with respect to Their Music Perception Skill



4.5. Gender Differences in Children's Musical Performance

In the study, researcher assumed that there existed gender differences in the mean scores of musical performance test achieved by boys and girls. To test the assumption, research hypothesis was framed-

Hypothesis 5: Boys and girls differ significantly in musical performance test scores achieved by them.

For statistical testing, research hypothesis was converted into null form, i.e.-

H_o: Boys and girls do not differ significantly in musical performance test scores achieved by them.

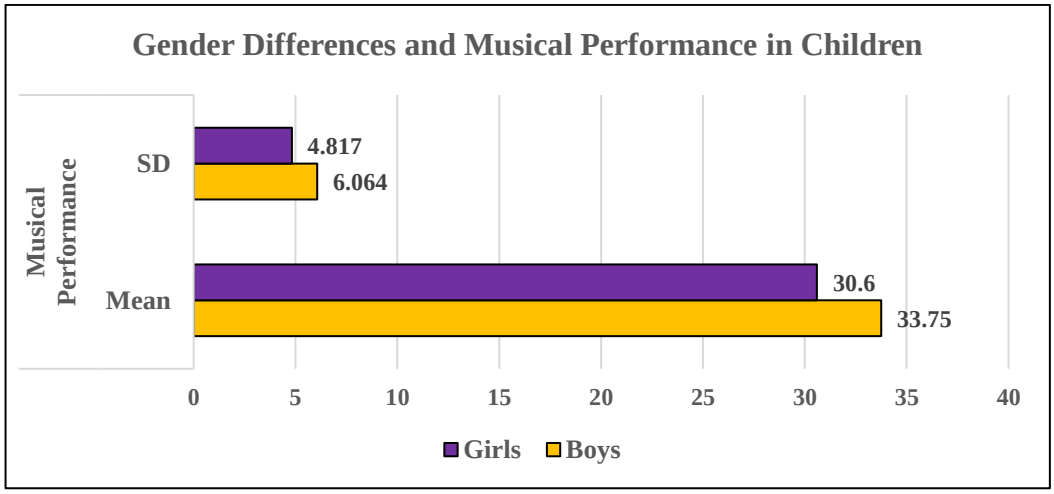
An independent sample t-test was computed to find out gender differences in the mean scores achieved by boys and girls in musical performance test. Result of the test was given in table 7 and figure 5 below.

Table 7
Gender Differences among Children with respect to Their Musical Performance

Measure	Gender	Mean	SD	SE Diff.	df	t Value	p Value
Musical Performance	**Boys**	33.75	6.064	1.732	38	1.8191	0.0768
	Girls	30.60	4.817				

In table 7, it was observed that mean and SD of boys and girls were 33.75, 6.064 and 30.60, 4.817 respectively. Standard error of difference was 1.732 and degree of freedom was 38. The calculated t-value was 1.8191 and p-value was 0.0768. The observed p-value was slightly greater than chosen p value i.e., $\alpha = 0.05$. It implied, 7.68% chances that null hypothesis was true. It could be inferred that the mean differences of the scores achieved by boys and girls in musical performance test was not statistically significant. Therefore, null hypothesis could not be rejected. It could be concluded that boys and girls did not differ significantly in their musical performances.

Figure 5
Gender Differences among Boys and Girls with respect to Their Musical Performance



5. Conclusion

Present study aimed to explore the relationship between children's working memory with their music perception skill and musical performance. The study set out to determine whether boys and girls differed or same in their working memory capacity, music perception skill and musical performance. The findings clearly indicated that working memory was positively correlated with music perception skill and musical performance in children. The most obvious findings to emerge from the study were boys and girls did not differ with respect to their working memory, music perception skill and musical performance. Present study was a breakthrough in the area of working memory and musical sensitivity research.

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