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Comparing Visuo-Spatial Perception and Verbal Memory in Children Learning- Not Learning Music

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Abstract

The present study aimed to study visuo spatial perception and verbal memory among children learning music (key board instrument and vocal) and children not learning music; and to study if there was a difference in visuo spatial perception and verbal memory among children learning key board instrument and vocal music. A Quasi experimental between group designs with convenient sampling was opted for the study. Boys and girls aged between 9 and 12 years from different schools with and without music training with inclusion criteria of children learning either vocal music or key board instrument continuously at least for past two years, with average intelligence (on Colour Progressive Matrices), average digit span (forward) (on Digit Span Test), adequate attention (on number cancellation test), and below cut off point on Children's Behaviour Questionnaire were administered the tools of Benton's Visual Retention Test and Logical Memory Test (Story Recall Immediate). The assessment tools were scored and results analysed using average, standard deviation and't' test. The results indicated that children learning music and key board instrument were better on Visuo spatial perception and verbal memory than children not learning music. Children learning key board instrument were better on Visuo spatial perception than children learning vocal music and Children learning vocal music were better on verbal memory than children learning key board instrument.

Keywords: Visuo Spatial Perception; Verbal Memory; Children Learning Music

Introduction

Music is an art form that involves the creation, performance, and/or reception of organized sound and silence, which may be expressive of emotion, mood, or feeling, and which may communicate ideas, thoughts, or messages to an audience or performer [1]. Cook [2] defines music as "a creative and communicative process, in which sounds and silences are organized in time and space in a way that reflects cultural, social, and historical contexts. Juslin PL, et al. [3] describes music as a complex, dynamic, and multi-dimensional stimulus that engages various cognitive, emotional, and social processes in the listener. Overall, these definitions emphasize different aspects of music, such as its emotional and communicative power, its cultural and historical significance, and the cognitive and social processes involved in experiencing it.

Visuo-spatial perception is defined by different authors in different ways in terms of the ability to analyze and

interpret visual stimuli and organize them into meaningful spatial relationships [4], the ability to perceive, analyze, and mentally manipulate visual information about spatial relationships among objects and their spatial orientation in the environment [5] and also to understand the spatial relationships between objects and oneself in the environment [6].

Visuo-spatial perception is a critical cognitive ability which is necessary for a wide range of activities, from basic motor skills to complex problem-solving. Visuo-spatial perception is needed in driving [7], sports [8], art and design [9,10], reading maps, navigating unfamiliar places, and performing household tasks [11,12], academic performance with underlies skills such as reading, math, and science [13], development of memory and problem-solving skills [14,15], motor development with better motor coordination and balance [16,17], social development in terms of social skills [18,19], digital learning materials [20] etc. Improving visuo-spatial perception can be beneficial for individuals with learning difficulties and for older adults to maintain cognitive function.

Patel AD, et al. [21] suggest that musical training enhances the ability to mentally manipulate spatial representations, which in turn improves visio-spatial abilities. A review article by Hetland L, et al. [22] suggests that music can enhance visio-spatial abilities by improving spatial-temporal reasoning.

Verbal memory refers to the ability to store and retrieve information that is presented verbally, such as words, sentences, and stories [23]. The Wechsler Memory Scale defines verbal memory as "the ability to recall a list of words or a short paragraph after a brief delay, with attention to the semantic content and organizational cues of the material" [24]. These definitions highlight the importance of verbal memory in various aspects of daily life, such as education, communication, and cognitive function.

Verbal memory is an important cognitive function that is used in various activities and situations, especially among children. Verbal memory is crucial for language learning and acquisition. Children with better verbal memory are often better language learners [25]. Verbal memory is also related to academic achievement, as it is used in various school activities, such as reading, writing, and listening comprehension. Children with better verbal memory tend to perform better in academic subjects, such as language arts and social studies [26]. Verbal memory is also used in social communication. Children with better verbal memory are often better communicators and more socially competent [27]. Verbal memory is also related to executive function, which refers to the set of cognitive processes that regulate and control behavior. Children with better verbal memory tend to have better executive function, which is important for academic and social success [28]. These applications and uses of verbal memory highlight the importance of this cognitive function for various aspects of children's development.

The mechanisms by which learning music enhances the development of verbal memory are not fully understood, but several researchers have proposed some potential reasons and rationales. One understanding is that music training may improve auditory processing and attention, which in turn may benefit verbal memory [29]. In another way it is indicated that music training may enhance the neural connectivity and plasticity of brain regions involved in verbal memory, such as the hippocampus and prefrontal cortex [30]. Yet another proposed mechanism is that music training may enhance executive functions, such as working memory and attention control, which are important for verbal memory [31]. These studies suggest that learning music may benefit verbal memory through various cognitive and neural processes.

Research has shown that music can have a positive impact cognitive development including improvements in memory, attention, and executive function and academic achievement in children [32,33]. Studies have generally indicated that active engagement with either vocal music or instrumental learning has an impact on visuo spatial [34] aspects and verbal memory [33,35]. Therefore, comparing visuo-spatial perception and verbal memory in children learning- not learning music in children can have important implications for education and cognitive development.

Methodology

The aim was to study the level of visuo spatial perception and verbal memory among children learning key board instrument, vocal music and children not learning music. Another aim was to study the difference in the level of visuo spatial perception and verbal memory between children learning key board instrument, vocal music and children not learning music. It was hypothesized that there will be a significant difference in visuo spatial perception and verbal memory between children learning key board instrument and children not learning music; between children learning vocal music and children not learning music; between children learning key board instrument and vocal music. A Between Groups Design with purposive sampling was opted for the study.

Sample

The sample consisted of boys and girls aged between 9 and 12 years from different schools and music classes.

Inclusion Criteria

- Children learning vocal music continuously from at least for past two years.
- Children learning key board instrument continuously from at least for past two years.
- Children who have never been part of learning music till now.
- Children with average intelligence on Colour Progressive Matrices.
- Children with average digit span (forward) (at least between 5 and 6) on Digit Span Test.
- Children with adequate attention on Number Cancellation Test.

Exclusion Criteria

- Children learning vocal music and key board together continuously from at least for past two years were not considered for the study.
- Children who scored above cut off score on Children's Behaviour Questionnaire.
- Children with any reported major physical or psychological problems (on demographic data sheet).

Tools

Children's Behaviour Questionnaire (CBQ)

The Children's Behaviour Questionnaire (CBQ) was developed by Michael Rutter in 1967 [36]. It is a parent-report measure designed to assess a child's behavior, temperament, and emotional well-being which consists of 60 items that are rated on a three-point Likert scale. The items are divided into six subscales of Conduct Problems, Anxiety Withdrawal, Hyperactivity, Peer Problems, Prosocial Behavior and Emotional Symptoms.

Internal consistency of the CBQ subscales has been found to be high, with Cronbach's alpha coefficients ranging from .68 to .94 across subscales [36-38]. Test-retest reliability of the CBQ subscales over a two-week period has correlation coefficients ranging from .69 to .93 [38]. The CBQ has been found to have good convergent and discriminant validity [38]. Overall, the CBQ is a reliable and valid measure of children's behavior, temperament, and emotional well-being, with strong psychometric properties.

Coloured Progressive Matrices

The Coloured Progressive Matrices (CPM) is a non-verbal intelligence test developed by John C. Raven in 1947 and was designed to be culturally fair [39]. A study by Jayanthi M, et al. [40] reported high reliability of the test, with a Cronbach's alpha coefficient of .93 and good construct validity. Rane S, et al. [41] found that the CPM scores were positively correlated with academic achievement. Bhattacharyya AK, et al. [42] found that the CPM was able to distinguish between children with mild and moderate intellectual disability. Overall, the CPM is a reliable and valid measure of non-verbal intelligence, with good standardization properties and applicability to the Indian population.

Digit Span Test (forward) (Sub Test of Tests of Memory for Children)

The Digit Span Test is a subtest of the Tests of Memory for Children battery and was developed by Barnabas G, et al. [43]. The Digit Span Test was developed as a measure of auditory attention and working memory. The test involves the auditory presentation of digit sequences, which the child is required to repeat back in either the same order (forward).

The Digit Span Test has been standardized on a sample of Indian children aged 6 to 16 years. The internal consistency of the Digit Span Test was found to be high, with Cronbach's alpha coefficients ranging from 0.80 to 0.85 for the forward and backward versions of the test, respectively. Test-retest reliability was also found to be high too with correlation coefficients ranging from 0.71 to 0.82 for the forward and backward versions of the test, respectively. Correlations between the Digit Span Test and the WISC-III subtests were found to be moderate to high, indicating good concurrent validity. Significant correlations were found between the Digit Span Test scores and academic achievement scores, providing evidence for predictive validity.

Number Cancellation Test (Sub Test of NIMHANS Index of Specific Learning Disability)

The Number Cancellation Test is a subtest of the NIMHANS Index of Specific Learning Disability and was developed by Kapur M, et al. [44]. The Number Cancellation Test was developed as a measure of attention and visuospatial perception and also to assess an individual's ability to sustain attention and concentration while performing a visual search task. The test consists of a grid of 100 numbers (10 rows and 10 columns) and it is expected to cross out as many of the target numbers as they can within a time limit.

The Number Cancellation Test has been standardized on a sample of Indian children aged 8 to 12 years. The test has high internal consistency (Cronbach's alpha) of 0.94 and Test-retest reliability was found to be high (0.87). The test was found to have good discriminant validity, as it can differentiate between children with and without specific learning disabilities. The test has also been found to have good convergent validity, as it correlates with other tests

of attention and executive function. Overall, the Number Cancellation Test is a reliable and valid tool for assessing sustained attention and concentration in children.

Benton's Visual Retention Test (Benton, 1974):(Sub Test of Tests of Memory for Children)

BVRT was designed to assess visual memory in children aged 8 to 12 years and first developed by Arthur Benton in 1955 and was later revised in 1974. The BVRT consists of 10 plates, each containing a unique design of black and white geometric shapes. The child is shown each plate and then asked to draw the design from memory. The test measures visual memory, spatial perception, and attention [43].

The test-retest reliability of the BVRT has been found to be high, with coefficients ranging from 0.79 to 0.87. The internal consistency of the test is also high, with coefficients ranging from 0.85 to 0.91. The BVRT has demonstrated good validity. The test has been found to discriminate between children with and without memory deficits, and between children with different types of memory deficits. The BVRT has also been found to be sensitive to changes in cognitive function over time.

Logical Memory Test (Story Recall Immediate) (Sub Test of Tests of Memory for Children)

The Logical Memory Test (Story Recall Immediate) is a subtest of the Tests of Memory for Children (Tests of Memory for Children) battery. It was developed by Wechsler in 1945 to assess verbal memory in children [24]. In this subtest, the child is read a short story and asked to recall as many details as possible immediately after the story is read. The story is presented in two trials, and the scores are based on the number of details correctly recalled in each trial [43].

The test-retest reliability of the subtest has been found to be high, with coefficients ranging from 0.80 to 0.90. The internal consistency of the test is also high, with coefficients ranging from 0.85 to 0.92. The Logical Memory Test has demonstrated good validity. The subtest has been found to discriminate between children with and without memory deficits, and between children with different types of memory deficits. The Logical Memory Test (Story Recall Immediate) is a reliable and valid tool for assessing verbal memory and learning ability in children.

Procedure

Boys and girls aged between 9 and 12 years from different schools and music classes - with and without music training, with inclusion criteria of children learning vocal music continuously at least for past two years, learning key board instrument continuously at least for past two years, and children not involved in training of music with average intelligence (on colour progressive matrices), average digit span (forward) (on digit span test) and adequate attention (on number cancellation test) and individuals with below cut off point on Children's Behaviour Questionnaire were administered the other tools of Benton's Visual Retention Test and Logical Memory Test (Story Recall Immediate). Totally 120 boys and girls were considered for the study. The assessment tools were scored and results analyses.

Analysis of Data

Mean, standard deviation was computed for descriptive analysis. 't' test was computed to study the significant difference in the mean scores on visuo spatial perception and verbal memory between children learning key board instrument and children not learning music; between children learning vocal music and children not learning music.

Results and Discussion

The study aimed of having at least 40 boys and girls in each category (with key board education, vocal music education and without music as their education) and approached children aged between 9 and 12 years studying from 4th to 6th standard from different schools and music classes. Students willing to be part of the study were administered the Coloured Progressive Matrices, Digit Span Test and Number cancellation Test and those with average intelligence, with average digit span (forward) and with adequate attention were administered Children's Behaviour Questionnaire (filled by teachers). Those who had scores below cut off scores on Children's Behaviour Questionnaire were considered for the study. Finally Benton's Visual Retention Test and Logical Memory Test (Story Recall Immediate) were administered. The number of children who were considered for the study and excluded for the study is represented (Table 1).

40 boys and girls each from three categories of with learning key board education, vocal music and without music, aged between 9 and 12 years studying in 4th to 6th standard, belonging to nuclear and joint family, studying in government and private schools, belonging to different religions and categories were considered for the study (Table 2).

On the visuo spatial perception (BVRT) the key board learning group, vocal music group and non-music group has secured the mean scores of 6.75 (1.50), 5.18 (1.11) and 4.68 (0.83) respectively and percentile of 60, 20 and10 respectively (Table 3); indicating that key board learning group has average visuo spatial perception ability, whereas Vocal music group and non-music group have below average visuo spatial perception ability. Of the three groups the key

board learning group has performed the best followed by vocal music group and non-music group.

Sl no	Process of sample participation	Children learning key board	Children learning vocal music	Children not learning key board /vocal music
1	No. of children willing to be part of the study	52	50	54
2	No. of children - below average intelligence on CPM	3	2	4
3	No. of children with below on digit span	4	3	3
4	No. of children - below average on Number cancellation	2	2	4
5	No. of children with above cut off point on CBQ	1	2	2
6	No. of children incomplete in assessment tools	2	1	1
7	Total no. of children	40	40	40

Table 1: Process of sample participation.

Areas	Categories	Children learning key board	Children learning vocal music	Children not learning key board / vocal music
Gender	Boys	24	15	20
	Girls	16	25	20
Age	9-10 years	8	15	13
	10-11 years	15	12	13
	11-12 years	17	13	14
Standard	4th standard	8	14	13
	5th standard	16	13	14
	6th standard	16	13	13
Type of family	Nuclear family	32	28	30
	Joint family	8	12	10
Type of institute	Government	1	4	8
	Private	39	36	32
	Music class	40	40	40
Religion	Hindu	1	0	12
	Muslim	1	2	2
	Christian	8	6	1
	Others	40	40	40
Category	SC/ST	1	4	4
	OBC	22	24	22
	GM	17	12	14

Table 2: Sample characteristics.

Areas	Children	N	Mean	SD	Percentile	Interpretation
Visuo Spatial Perception	Key Board Music	40	6.75	1.5	60	Average
BVRT	Vocal Music	40	5.18	1.11	20	Below Average
	Non-Music	40	4.68	0.83	10	Below Average

Table 3: The average and interpretation on visuo spatial perception for Music and Non-Music children.

On the visuo spatial perception (BVRT) the 't' values (t = 7.57; Significant p<0.01) (Table 4) indicate that there is a significant difference in performance between the means of key board learning group and non-music group, hence the result of the study is in accordance to the hypothesis stated that there will be a significant difference in visuo spatial perception between children learning key board instrument and children not learning music. The results indicated that key board learning group has performed significantly better than non-music group.

On the visuo spatial perception (BVRT) the 't' values (t = 2.26; Significant p<0.05) (Table 4) indicate that there is a significant difference in performance between the means of vocal music group and non-music group, hence the result of the study is in accordance to the hypothesis stated that there will be a significant difference in visuo spatial perception between children learning vocal music and children not learning music. The results indicated that vocal music group has performed significantly better than non-music group.

On the visuo spatial perception (BVRT) the 't' values (t = 5.28; Significant p<0.01) (Table 4) indicate that there is a significant difference in performance between the means of key board learning group and vocal music group, hence the result of the study is in accordance to the hypothesis stated that there will be a significant difference in visuo spatial perception between children learning key board and children learning vocal music. The results indicated that key board learning group has performed significantly better than vocal music group.

Children	N	Mean	SD	t
Key Board Music	40	6.75	1.5	7.57**
Non-Music Children	40	4.675	0.83	
Vocal Music	40	5.175	1.11	2.26*
Non-Music Children	40	4.675	0.83	
Key Board Instrument	40	6.75	1.5	5.28**
Vocal Music	40	5.175	1.11	

Table 4: The mean, SD, 't' value and significance on visuo spatial perception for Music (children learning key board instrument and vocal music) and Non-Music children.
**Significant p<0.01level * Significant p<0.05level

Comparing the present study results with other studies, it can be seen that there have been studies that have compared visuo-spatial abilities in children who have been exposed to music with those who have not. Forgeard M, et al. [33] found that children who had received musical training showed greater improvement in spatial-temporal abilities compared to those who had not received any musical training. Kaviani H, et al. [45] found that children who had been exposed to music showed better performance on a visuo-spatial task compared to those who had not been exposed to music. Even in the present study it can be seen that group with music training had significantly better visuo spatial perception than the group without music training.

Overall, the studies suggest that exposure to music can have a positive effect on visuo-spatial abilities in children. However, the extent of these effects may depend on factors such as the type and amount of musical training, as well as individual differences in cognitive abilities. Schellenberg EG, et al. [46] conducted a study to investigate the effects of music lessons on visuo-spatial abilities in children and found that children who received keyboard or voice lessons showed greater improvement in visuo-spatial abilities compared to children who received drama lessons or no lessons at all. Hetland L, et al. [22] suggest that learning to play a musical instrument that requires spatial-temporal coordination, such as a keyboard instrument, may provide greater benefits for visuo-spatial abilities than vocal music training. Another study by Moreno S, et al. [47] found that children who received keyboard training showed greater improvements in visuo-spatial abilities compared to children who received singing training. A study by Rauscher FH, et al. [48] found that children who received keyboard training performed better on spatial-temporal tasks compared to a control group. Even in the present study it can be seen that key board learning group has performed significantly better than vocal music group on visuo spatial perception.

However, it is important to note that both types of musical training can provide benefits for visuo-spatial abilities. A study by Rauscher FH, et al. [48] found that listening to music can enhance spatial task performance, suggesting that even passive exposure to music can improve visuo-spatial abilities. Hetland L, et al. [22] conducted a review of studies on the effects of arts education, including music, on academic achievement and found that music education was positively

associated with improvements in visuo-spatial abilities. So both vocal music and keyboard playing can provide benefits for visuo-spatial abilities. Even in the present study it was found that groups with vocal music training and key board training had significantly better visuo spatial perception than the group without music training.

On Verbal Memory Test the Key board learning group, Vocal music group and Non-music group have secured the mean scores of 5.95 (1.36), 7.43 (1.66) and 4.88 (1.38) respectively and percentile of 50, 70 and 40 respectively (Table 5); indicating that all the three groups i.e. key board learning group, vocal music group and non-music group have average verbal memory. Of the three groups the vocal music group has performed the best followed by the key board learning group and non-music group.

Areas	Children	N	Mean	SD	Percentile	Interpretation
Verbal memory	Key Board Music	40	5.95	1.36	50	Average
	Vocal Music	40	7.43	1.66	70	Average
	Non-Music	40	4.88	1.38	40	Average

Table 5: The average and interpretation on verbal memory for Music and Non-Music children.

Children	N	Mean	SD	t
Key Board Music	40	6	1.36	3.47**
Non-Music Children	40	5	1.38	
Vocal Music	40	7	1.66	7.37**
Non-Music Children	40	5	1.38	
Key Board Instrument	40	6	1.36	4.29**
Vocal Music	40	7	1.66	

Table 6: The mean, SD,'t' value and significance on verbal memory for Music (children learning key board instrument and vocal music) and Non-Music children.
**Significant p<0.01level * Significant p<0.05level

On the Verbal Memory Test the't' values (t = 3.47; Significant p<0.01) (Table 6) indicate that there is a significant difference in performance between the means of key board learning group and non-music group, hence the result of the study is in accordance to the hypothesis stated that there will be a significant difference in verbal memory between children learning key board instrument and children not learning music. The results indicated that key board learning group has performed significantly better than non-music group.

On the Verbal Memory Test the't' values (t = 7.37; Significant p<0.01) (Table 6) indicate that there is a significant difference in performance between the means of vocal music group and non-music group, hence the result of the study is in accordance to the hypothesis stated that there will be a significant difference in verbal memory between children learning vocal music and children not learning music. The results indicated that vocal music group has performed significantly better than non-music group.

On the Verbal Memory Test the't' values (t = 4.29; Significant p<0.01) (Table 6) indicate that there is a significant difference in performance between the means of key board learning group and vocal music group, hence the result of the study is in accordance to the hypothesis stated that there will be a significant difference in verbal memory between children learning key board and children learning vocal music. The results indicated that vocal music group has performed significantly better than key board learning group.

Comparing the present study results with other studies, it can be seen that there are several studies that suggest that children who learn music are better in verbal memory than children who do not learn music. Studies examined the effects of music training on verbal memory and other cognitive functions in Brazilian children [47], German preschool children [31] and Chinese children [35] which found that children who received music training had better verbal memory compared to a control group of children who did not receive music training. Another study by Schellenberg EG, et al. [46] examined the effects of music lessons on cognitive abilities, including verbal memory, in 6-year-old children and found that children who received music lessons showed significant improvement in verbal memory compared to a control group of children who did not receive music lessons. The results of the present study indicated that children learning vocal music had performed significantly better than non-music group which is in accordance to the results of earlier studies.

There is no clear consensus on whether children who learn vocal music or children who learn keyboard are better in verbal memory, as the available research has produced mixed results.

A study by Brandler S, et al. [49] compared the verbal memory performance of children who learned a musical instrument (including keyboard and vocal training) to children who did not learn a musical instrument. The researchers found that

the musical instrument group had better verbal memory performance compared to the control groups. In the present study results indicated that vocal music group has performed significantly better than key board learning group which is not completely according to the earlier studies.

A study by Bugos JA, et al. [50] who investigated the effects of keyboard training on cognitive function, including verbal memory, in older adults found that keyboard training improved verbal memory. Ho YC, et al. [35] examined the effects of music training on verbal memory in Chinese children who received vocal or keyboard training. The researchers found that both groups of children showed improved verbal memory performance compared to a control group of children who did not receive music training. Even in the present study both the groups being trained in vocal music and key board showed significantly better verbal memory when compared to the group which was not trained in music. The mechanisms behind these effects may involve similar cognitive and neural processes, such as auditory processing and executive functions, which are important for verbal memory.

Conclusion

- On the visuo spatial perception (BVRT) that key board learning group has average visuo spatial perception ability, whereas vocal music group and non-music group have below average visuo spatial perception ability.
- Of the three groups the key board learning group has performed the best followed by vocal music group and non-music group on the visuo spatial perception (BVRT).
- On Verbal Memory Test all the three groups i.e. key board learning group, vocal music group and non-music group have average verbal memory.
- Of the three groups the vocal music group has performed the best followed by the key board learning group and non-music group on the Verbal Memory Test.
- On the visuo spatial perception (BVRT) the 't' values indicate that key board learning group has performed significantly better than non-music group; vocal music group has performed significantly better than non-music group; and key board learning group has performed significantly better than vocal music group.
- On the Verbal Memory Test the 't' values indicate that key board learning group has performed significantly better than non-music group; vocal music group has performed significantly better than non-music group; and vocal music group has performed significantly better than key board learning group.

Implications

- The present study provides information that children learning music were better on visuo spatial perception and verbal memory than children not learning music. Hence incorporation of music in regular activities of school would be fruitful.
- Music has long been argued to provide effective experiences for children to develop listening skills in mainstream schools and those for children with learning difficulties [51-53].
- Overall, the evidence suggests that engagement with music plays a major role in developing perceptual processing systems and verbal ability, the earlier the exposure to active music participation and the greater the length of participation the greater the impact.
- The rural and urban government schools are unlikely to be provided with costly infrastructure and educational facilities required to children and hence music as a method can be used as intervention programmes.
- The study may have implications for parents who are considering enrolling their children in music lessons and parents may be encouraged to enroll their children in music lessons.
- The study may suggest the need for further research to better understand the relationship between music education and cognitive abilities. Future studies could investigate the long-term effects of music education on cognitive abilities and examine the specific mechanisms through which music education influences cognitive development.

Limitations

- The study has a small sample size, which can limit the generalizability of the findings. It may be difficult to apply the results to a larger population without further research.
- The study has used a purposive sample, which may limit the representativeness of the sample and introduce bias in the results. A random sample may be more appropriate to generalize the findings to the larger population of children.
- The study does not have a well-matched control group, which can limit the conclusions that can be drawn.
- For the analysis of results the data was not subjected to test for normalcy and also that ANOVA followed by post hoc t test could have been more desirable to test the difference in the mean values.

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