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Voice Instruction Enhances Children's Spatial Ability:

Tonal (Thai) Speaker Case Study

INSTRUCTION VOCALE AMÉLIORE LA CAPACITÉ SPATIALE DES ENFANTS :

UNE ÉTUDE DE CAS SUR LA LANGUE À TONS (THAILANDAIS)

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Abstract: The purpose of this study was to determine the effects of individual music instruction featuring the singing on the spatial reasoning of the tonal (Thai) speaker children. Thirty Thai children were equally assigned to one of two conditions, singing (N=15) or no music (N=15). Children in the music group received weekly individual instruction at their private music programs for a period of 3 months. All children were pretested and posttested with two spatial tasks: Mechanical Aptitude and Spatial Relations Sub-tests including Matching Part and Figures (MPF) and Spatial Views (SV). Means and standard deviations scores of music group were significantly higher than no music group in both tasks after 3 months of lessons (Music group, MPF, Mean = 8.33 (±.62) and SV, Mean = 9.33 (±.72); No music group, MPF, Mean = 5.07 (±1.34), SV, Mean = 6.40 (±1.84), respectively. The posttest scores of the music group was significantly greater than those of the no music group in both tasks (MPF, $t(14) = -8.009$, $p < .0001$; SV, $t(14) = -5.12$, $p < .0001$), respectively. The improvement for the no music group was presumably due to maturation. This study suggests that learning music is an important developmental activity in tonal (Thai) speaker children's spatial ability. Neurophysiological basis of this finding is however needed to explore changes in the structure and function of the tonal (Thai) speaker children's brain in relation to the neural circuitry involved in judging spatial skills.
Keywords: Brain; Spatial ability; Music education; Voice instruction; Tonal speaker

Résumé: Le but de cette étude était de déterminer les effets des cours de musique individuels, caractérisés par le chant, sur le raisonnement spatial des enfants qui parlent une langue à tons (thailandais). Trente enfants thaïlandais ont été également attribué à l'une des deux conditions, le chant (N = 15) ou pas de musique (N = 15). Les enfants du groupe de musique ont reçu un enseignement individuel hebdomadaire en accord avec leurs programmes de musique privés pour une période de 3 mois. Tous les enfants ont

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été pré-testés et post-testés par deux tâches spatiales: l'aptitude mécanique et les tests apparentés aux relations spatiales, y compris l'assemblage des parties et des figures (APF) et les vues spatiales (VS). Les notes moyennes et les notes standards du groupe de musique étaient significativement plus élevées que celles de groupe de pas de musique dans les deux tâches après 3 mois de cours (groupe de musique, APF, moyenne = 8,33 (± 0,62) et SV, moyenne = 9,33 (± 0,72); groupe de pas de musique, APF, moyenne = 5,07 (± 1,34), SV, moyenne = 6,40 (± 1,84). Les notes de post-test du groupe de musique ont été significativement plus élevées que celles du groupe de pas de musique dans les deux tâches (APF, t (14) = -8,009, p <0,0001;. SV, t (14) = -5,12, p <0,0001). L'amélioration du groupe de pas de musique était sans doute en raison de la maturation. Cette étude suggère que l'apprentissage de la musique est une activité importante de développement de la capacité spatiale des enfants qui parlent une langue à tons (thailandais). La base neurophysiologique de cette constatation est cependant nécessaire pour explorer les changements dans la structure et le fonctionnement du cerveau des enfants qui parlent une langue à tons, liés aux circuits neuronaux impliqués dans le jugement des compétences spatiales.

Mots-clés: cerveau; capacité spatiale; enseignement de la musique; instruction vocale, langue à tons

1. INTRODUCTION

Several studies have suggested that music instruction improves preschool and elementary school children's spatial abilities (Hetland, 2000; Rauscher and Zupan, 2000). Previous meta-analysis 15 independent studies and 709 subjects has been suggested that the enhancement of children's spatial abilities may be due to differences between musicians and nonmusicians in brain structure and function as a result of their music instruction (Gruhn et al., 2002; Hetland, 2000; Rauscher, 2002; Rauscher et al., 1997; Rauscher and Zupan, 2000). Schlaug's study revealed that musicians who began piano instruction before age 7 had a larger cross-section of the anterior corpus callosum (Schlaug et al., 1995). Moreover, Elbert's study found that the dipole moments of the digits of the left hand showed significantly larger in violinists compared to non-musicians, with the greatest effects found for musicians who began instruction before age 12 (Elbert et al., 1995). A follow-up MEG study done by Pantev's study found auditory cortex dipole moments for piano tones were enlarged by about 25% in musicians relative to non-musicians (Pantev et al., 1998). It is suggested that there was a positive correlation between effect size and when participants initiated instruction: musicians who began instruction before age 9 showed the largest effects (Pantev et al., 1998; Rauscher and Zupan, 2000). Finally, researchers using MEG measured violinists' and trumpeters' cortical representations for violin and trumpet tones compared to sine wave tones (Pantev et al., 2001). The researchers found enhanced representations for timbres associated with the instrument of training, with trumpeters showing enhancement for trumpet tones and violinists showing enhancement for violin tones. This study suggests that experience with different musical instruments may affect brain function in different ways (Rauscher and Zupan, 2000).

Several studies suggest that that musical skill is an alliance of a number of separate and relatively independent abilities. The present study, thus, proposed that early music instruction emphasizing different musical skills would produce correspondingly differential effects on cognitive performance. Supporting this proposition, previous studies suggest that eight months of classroom keyboard instruction and several years of string and percussion instruction selectively improved auditory frequency and duration discrimination thresholds compared to no instruction (Rauscher and Zupan, 2000; Hinton and Rauscher, 2003). Specifically, Rauscher and Zupan's study (2000) was conducted to investigate if the effects found in the classroom keyboard instruction endured into elementary school, and further to examine the effects of the previously-initiated instruction on academic skills. The purpose of the present study was to extend these findings to tonal (Thai) speaker children in the private music school setting. The findings hope to provide information relevant to pedagogical decisions and help policymakers prioritize investments among competing curricula in Thailand.

2. METHODS

2.1 Participants

Thirty middle-income tonal (Thai) speaker children attending at private music schools participated. The private music schools include KPN Academy Music School (Siam and Pinkrow Branches) and Ratchawinit Secondary School, Bangkok, Thailand. Children in the music group received weekly individual instruction at their private music programs for a period of three months.

2.2 Procedure

Thirty Thai children were equally assigned to one of two conditions, singing (N=15) or no music (N=15). Table 1 shows the assignment of students in the two participating schools to experimental and control groups. A music specialist visited each classroom to administer 20 min voice lesions to the music group two times per week. Children in the music group received weekly individual instruction at their private music programs for a period of 3 months. All children were pretested and posttested with two spatial tasks: Mechanical Aptitude and Spatial Relations Sub-tests including Matching Part and figures (MPF) and Spatial views (SV).

Table 1: Distribution of Children in Groups and Schools

School	Group	
	Voice (*n*)	No music (*n*)
KPN Academy Music School, Siam Branch	3	0
KPN Academy Music School, Pinkrow Branch	12	0
Rachawinit Secondary School	0	15

2.3 Testing

Prior to the instruction, all children were pretested with two tasks, Matching Part and Figures (MPF) and Spatial Views (SV) taken from the Mechanical Aptitude and Spatial Relations Tests (Levy and Levy, 1992). The children were tested individually at their schools. Matching Part and Figures (MPF): There are several types of questions that test children ability to match parts and figures. Although the directions may vary slightly, each question types requires children to visualize the shape or pattern that can result from fitting together a number of cut-up pieces. Spatial Views (SV): Spatial view's questions test another aspect of children ability to comprehend static objects. In view questions, children are given a numbered picture showing the top, front, and side representations of a tree-dimensional object. Dashed lines indicate folds. Next to each numbered picture are lettered drawings. Children are to select the one of the lettered drawings that would have the top, front, and side representations shown in the numbered picture. Testing was conducted following procedures specified by the Levy and Levy (1992) test manual. Testing sessions lasted approximately 15 min and were carried out at the private music schools before lessons and again at two subsequent 3-month intervals, totaling two testing session's altogether. The voice lesions commenced immediately following pretesting. Thus, the final testing session occurred 3 months after the voice group's first lesson. Testing was conducted by a colleague blind to the experimental hypotheses and condition assignment.

3. RESULTS

The study determines the effects of individual music instruction featuring the singing on the spatial reasoning of the tonal (Thai) speaker children. Thirty Thai children in the music group received weekly individual instruction at their private music programs for a period of 3 months. All children were pretested and posttested with two spatial tasks: Mechanical Aptitude and Spatial Relations Sub-tests including Matching Part and figures (MPF) and Spatial views (SV). Means and standard deviations for all variables are presented in Table 2. An α level of 0.05 was used for all statistical tests.

Table 2: Mean Task Scores and Standard Deviations for Voice (n = 15) and No Music (n = 15) Groups

Groups	Tasks			
	Matching Part and Figures (MPF)		Spatial Views (SV)	
	Mean	S.D.	Mean	S.D.
Voice				
Pre-test	7.07	0.89	8.20	1.21
3 Months	**8.33**	0.62	**9.33**	0.72
No Music				
Pre-test	2.87	2.10	5.07	1.34
3 Months	**4.93**	2.28	**6.40**	1.84

Notes: The higher the score is, the better the performance.

Means and standard deviations scores of music group were significantly higher than no music group in both tasks after 3 months of lessons (Music group, MPF, Mean = 8.33 (±.62) and SV, Mean = 9.33 (±.72); No music group, MPF, Mean = 4.94 (±2.28), SV, Mean = 6.40 (±1.84), respectively. The posttest scores of the music group was significantly greater than those of the no music group in both tasks (MPF, t(14) = -8.009, p < .0001; SV, t(14) = -5.12, p < .0001), respectively (see Figure 1 and 2). The improvement for the no music group was presumably due to maturation.

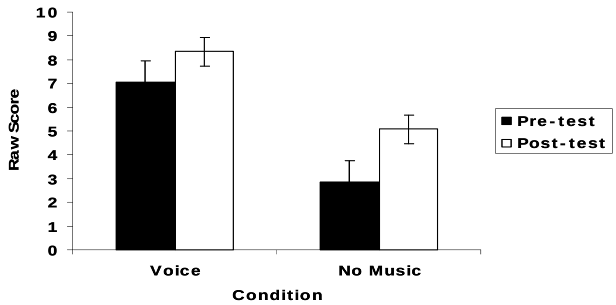

Figure 1: Mean Matching Part and Figure (MPF) pre- and post-test standard scores for voice and control groups. MPF is a spatial task that requires children to visualize the shape or pattern that can result from fitting together a number of cut-up pieces. Error bars represent standard deviation (SD)

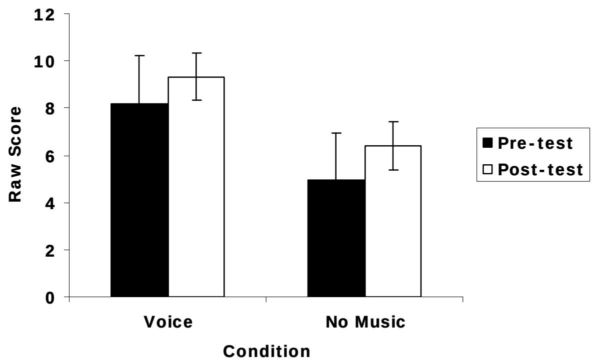

Figure 2: Mean Spatial View (SV) pre- and post-test standard scores for voice and control groups. MPF is a spatial task that tests another aspect of children ability to comprehend static objects. Error bars represent standard deviation (SD)

The first set of analyses focused on the group factors that may have predicted the skills enhancements found. Two-factor group (voice, no music) X time (pretest, 3 months) mixed analyses of variance (ANOVAs) with time as the repeated measure on each task. The outcome of this analysis is reported in Table 3. The ANOVA performed on the Matching Part and Figures (MPF) task showed significant main effects for both group and time and a significant interaction between group and time. Similar effects were found for the Spatial View (SV) task. However, the ANOVA performed on Spatial View (SV) yield a main effect for both group and time, but not for the interaction between group and time (see Table 3).

Table 3: Two-Factor (Group, Time) Analyses of Variance for Matching Part and Figure (MPF) and Spatial Views (SV) Tasks

Source	*F*		
	df	**Matching Part and Figures (MPF)**	**Spatial Views (SV)**
Group (G)	3	45.08**	21.90**
Time (T)	1	74.27**	19.45**
G X T	3	4.15*	1.58
S within-group error	56	(0.79)	(1.20)

Notes: Values enclosed in parentheses represent mean square errors.
S = subjects
** $p < .0001$; * $p < .05$

We next performed separate three-factor group (voice, no music) X time (pretest, 3 months) X Tasks (Matching Part and Figure, Spatial View) mixed analyses of variance (ANOVAs). The outcome of this analysis is reported in Table 4. The ANOVA performed significant main effects for group, time and task, and a significant interaction between group and time as well as the interaction between time and task. However, the ANOVA performed the significant interaction between group and time and interaction between time and task, but not the interaction between group and task. Additionally, the ANOVA did not show a significant interaction between groups; time and task (see Table 4).

Table 4: Three-Factor (Group, Time, Task) Analyses of Variance for Matching Part and Figure (MPF) and Spatial Views (SV) Tasks

Source	***df***	***F***
Group (G)	3	39.88**
Time (T)	1	70.75**
Tasks (K)	1	81.81**
T X K	1	4.50*
G X T	3	3.81*
G X K	3	2.55
G X T X K	3	1.09
S within-group error	56	(0.89)

Notes: Values enclosed in parentheses represent mean square errors.
S = subjects
** $p < .0001$; * $p < .05$

4. DISCUSSION

This study suggests the important of learning music effects to the developmental activity in tonal (Thai) speaker children's spatial ability. The contribution of this study was to demonstrate of tonal (Thai) speaker children in private music classroom. The results revealed that the tonal (Thai) speaker children exposed to singing lessons improved significantly on the two spatial tasks administered in the private music school environment. The enhancements found in this study are in the line with those found similar studies (Rauscher and Zupan, 2000; Rauscher et al., 1994, 1997), despite vast different in the setting in which the instruction occurred and the participation of older children (Rauscher and Zupan, 2000). Furthermore, the data reported here provide partial support for our hypothesis that voice instruction affects spatial cognition in tonal (Thai) speaker. Consistent with previous research (Rauscher and Zupan, 2000) found that children who received music instruction scored significantly higher on spatial-temporal tasks than children who did not. The ANOVA revealed a significant interaction between group and time for this variable. This interaction was caused by a slight decrease in the no music group's scores after 3 months of instruction. In addition, our prediction revealed that the mental imagery scores of children who study singing would be higher than children who did not. For example, the singing group's scores on both Matching part and figure and the Spatial view tasks were higher than those of the control group.

As predicted, children's spatial abilities differ for the voice instruction group following lesions. Children who studied singing would score higher on spatial tasks than children who studied no music. This prediction was supported by the data and previous studies (Rauscher and Zupan, 2000). The Matching part and figure and the Spatial view post-test scores of children in the singing group were significantly higher than those of controls group. This suggests that training in a singing may influence the neural circuitry involved in judging spatial ability and temporal duration. However, future research exploring the neurophysiological basis of these findings will determine whether these selective effects are accompanied by changes in the structure and function of the brain. These findings support previous studies (Leng and Shaw, 1991; Rauscher and Zupan, 2000) that early music training enhances spatial-temporal reasoning. Moreover, our findings are consistent with previous studies that found improved spatial-temporal task scores in preschoolers after music instruction (Costa-Giomi, 1999; Gromko and Poorman, 1998; Mallory and Phibrick, 1995; Rauscher and Zupan, 2000; Rauscher et al., 1994, 1997). Importantly, children in the present study were provided with lessons in an individually rather than groups training of Rauscher and Zupan's study (2000). The private lessons show the enhancement of spatial skills of children. Moreover, the present study support Rauscher's studies that there is no different between effects observed in prior studies conducted both with and without the inclusion of an additional control (Rauscher et al., 1994, 1997). This research supports the previous study (Rauscher and Zupan, 2000) that the study of music lesson and instruction is an important step toward understanding the extra musical benefits of music instruction in public school settings. Further systematic research is, however, needed to investigate how music education relates to other academic areas. In addition, research exploring the effects of music instruction on cognition development can contribute to the academic and social welfare of children (Rauscher and Zupan, 2000).

5. CONCLUSION

This study suggests that learning music is an important developmental activity in tonal (Thai) speaker children's spatial ability. The Matching part and figure and the Spatial view post-test scores of children in the singing group were significantly higher than those of controls group. This suggests that training in a singing may influence the neural circuitry involved in judging spatial ability and temporal duration.

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