Effects of Early Musical Training on Musical and Linguistic Syntactic Abilities

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Music and language are distinct auditory domains serving different communicative uses. These differences may be less apparent in infants, and similar learning mechanisms may be applied in the syntactic development of both domains. By using a harmonic priming paradigm, this study revealed that 4- to 5-year-old children have implicit knowledge of Western harmony. Musical training affected response times and accuracy in a timbre identification task, but not the magnitude of the harmonic priming effect. Children with musical training showed enhanced language abilities, particularly in morphologic rule formation and memory for words.

Key words: **development; harmonic priming; language; syntax; plasticity**

Introduction

Music and language are considered as distinct auditory domains sharing many features but serving different communicative functions. These differences may be less apparent in infants, and a single learning mechanism may be applied to both domains.[1] Syntax can be defined as a set of rules governing the combination of discrete elements into sequences at multiple hierarchical levels.[2] Culture-specific knowledge about the syntactic rules of a linguistic or musical system are implicitly acquired through everyday experiences.[3] However, we do not know whether there are similar developmental underpinnings in the acquisition of syntactic knowledge in language and music. Studies examining the relationship between musical training and language abilities expand our knowledge about issues related to modularity, plasticity, and learning strategies of the developing brain.

Patel proposed a sharing of neural resources in the processing of linguistic and musical syntax.[4] Supporting this theory, behavioral[5] and electrophysiological[6] evidence was found for overlapping cognitive resources in adults and in 5-year-old children with specific language impairment.[7] Studies also revealed structural and functional brain differences in adult musicians.[8] One year of musical training affected auditory cortical-evoked fields in response to violin tones in 4- to 6-year-olds,[9] and 5- to 7-year-olds showed functional changes during a melody and rhythm discrimination task,[10] but only trends of transfer effects. In children, musical training has been positively associated with prosodic[11] and pronunciation[12] abilities, phonological awareness,[13] reading[13] and mathematical skills[14] as well as general IQ.[15] Children who decided to start musical training did not significantly differ in their neural, motor, cognitive, or musical abilities from those who showed no interest in music.[16] However, correlations between phonological awareness, musical perceptual skills, and nonverbal reasoning were observed.

The enculturation to Western music proceeds from sensitivity to consonance to the knowledge of key membership and finally to

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the knowledge of harmony.[3] Neurophysiological evidence suggests implicit harmonic syntactic knowledge in 5- to 7-year-olds.[17] By applying harmonic priming paradigms, it was shown that 6-year-olds without music lessons have implicit knowledge of Western harmony.[18] Musical training had no effect on response times in a timbre identification task in 8- and 11-year-olds. In a consonance identification task, response times did not differ between musically trained and untrained 8-year-olds. In 11-year-olds, trained children responded faster to the expected target chords. Musical training made performance accuracy insensitive to harmonic priming manipulation. In summary, musical training has not reliably decreased response times and enhanced accuracy in school children in the harmonic priming paradigms employed so far. What is the effect of early musical training on the performance in a harmonic-priming task and on linguistic abilities in preschool children?

Methods

Participants were 31 German-speaking children, 11 boys and 20 girls, with a mean age of 4 years and 11 months (SD = 3 months) and different birth orders. Parents had a wide range of educational, socioeconomic, and musical backgrounds. Thirteen children attended an early musical training course (Orff instruments) once a week (mean = 4.8 months). Linguistic abilities were screened using Grimm's SETK 3–5.[19] A harmonic priming paradigm[20] was applied: the priming and no-priming conditions consisted of three chords. The primes were two chords (Shepard tones), either following a IV-V (priming) or a ^{b}VI-^{b}III (no-priming) progression. The target was always the tonic, a three-note chord in root position, either played in a piano or trumpet timbre (timbre identification task). Between the 36 trials, 12 Shepard tones were played in order to avoid carry-over effects.

Results

In the priming study, the dependent variables were response time and accuracy. Response times 3 standard deviations away from each child's mean of correct responses were not considered. In preliminary analyses, paired *t*-tests confirmed that children responded faster to the priming condition in piano timbre, both for children with musical training, $t(11) = 2.17$,

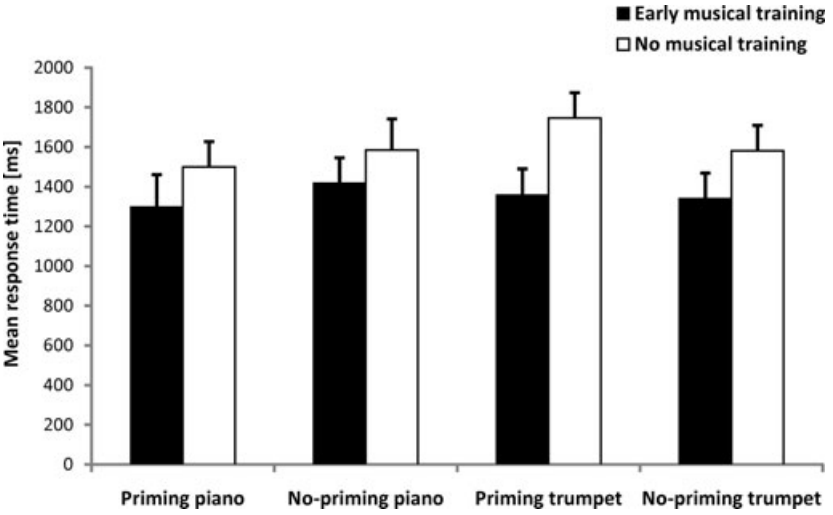

Figure 1. Mean correct response times as a function of the target chord to the prime context, the target instrument, and musical training.

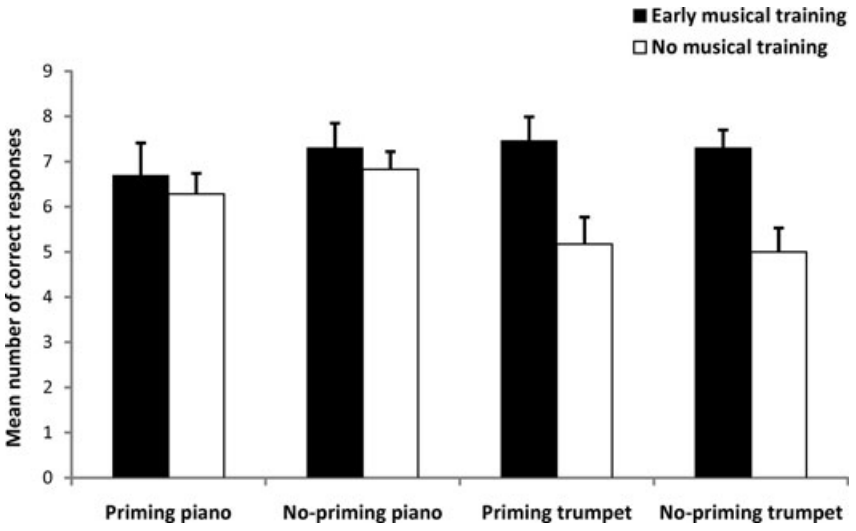

Figure 2. Mean number of correct responses as a function of the target chord to the prime context, the target instrument, and musical training.

$P = 0.05$ (by 121 ms), and for those without musical training, $t(16) = 2.27$, $P < 0.05$ (by 153 ms). The magnitude of the priming effect did not differ between trained and untrained children, $t(25) = 0.60$, $P > 0.10$. In the condition with trumpet timbre, musically trained children did not differ in their responses to priming and no-priming conditions, whereas untrained children responded faster to the no-priming condition, $t(15) = 2.74$, $P < 0.05$ (by 195 ms).

A repeated-measures ANOVA with priming and timbre as within-subject factors and musical training as between-subjects factor (Fig. 1) revealed a marginal interaction between priming and musical training, $F(1,25) = 3.04$, $P < 0.10$, and a significant interaction between priming and timbre, $F(1,25) = 9.68$, $P < 0.01$. No main effect for musical training was found, $F(1,25) = 1.78$, $P > 0.10$, although trained children tended to answer faster. A similar ANOVA on accuracy (Fig. 2) showed a significant interaction between timbre and musical training, $F(1,29) = 4.52$, $P < 0.05$, and a significant interaction between priming and timbre, $F(1,29) = 4.27$, $P < 0.05$. A significant main effect of musical training was observed, $F(1,29) = 6.19$, $P < 0.05$. However, children of both groups did not respond more accurately to the expected target chords in the priming condition.

In the language development test, musical training was significantly associated with better performance in the subtests on morphologic rule formation, $t(28) = 2.94$, $P < 0.01$, and memory for words, $t(28) = 3.23$, $P < 0.01$. Trends of better performance were found for phonological working memory, $t(28) = 1.80$, $P < 0.10$, and sentence memory, $t(28) = 1.89$, $P < 0.10$, but not for the subtest on sentence comprehension, $t(28) = 0.50$, $P > 0.10$.

Conclusions

These data replicated and extended recent findings[18] that preschoolers possess implicit knowledge of Western harmony regardless of early musical training, supporting the theory that musical training is not a prerequisite for musical enculturation. Harmonic priming effects, measured by response times, were only present for targets in piano timbre, which may be because the targets in trumpet timbre sounded similar to the primes. The size of the priming effect did not differ

between trained and untrained children.[21] Response accuracy did not follow the predicted pattern in trained and untrained children in both timbral conditions.[18] Early musical training and experience enhances auditory cortical development,[22] which may explain the (nonsignificantly) faster but significantly more accurate timbre identification in trained children. These children also performed better in the language development test, particularly in morphologic rule formation and memory for words. Tendencies for increased phonological working and sentence memory were also found. These language abilities are crucial to syntactic development, and a positive relationship with musical training could be related either to innate determinants or transfer effects. Behavioral long-term studies with younger children may offer fruitful complements to neurophysiological findings on syntactic development.

Conflicts of Interest

The author declares no conflicts of interest.

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