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Effects of Music Perception and Imagery on Sensorimotor Synchronization with Complex Timing Patterns

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There is a close relationship between music perception and action. Music unfolds in time, and listeners often move along in synchrony. Western classical music may give rise to experiences of inner movement while overt movement is suppressed. The rate at which this music unfolds often varies continuously; this is expressive timing, which is especially associated with motion.¹ A particular musical structure tends to favor a particular, typical expressive timing pattern (ETP). However, ETPs of individual artists sometimes deviate considerably from this norm.²

The present study investigated whether overt movement (finger tapping) in synchrony with an ETP is facilitated when the ETP is carried by music rather than just by a sequence of clicks, and whether this facilitation is greater when the ETP is typical of the music rather than atypical. The study further examined whether such facilitation occurs when the music is merely imagined. Musically inappropriate timing patterns (TPs), for which no facilitation was expected, served as comparison.

Two experiments both used the opening of Chopin's Etude in E Major, op. 10, no. 3, as the musical excerpt. Each experiment included three conditions requiring synchronized finger tapping: (1) with a sequence of clicks, (2) with clicks accompanied by music, and (3) with clicks while only imagining the music, in that order. The ETPs (T0, T1, T2, T4) were derived from a principal components analysis of 115 expert performances.²

In experiment 1, there were 5 TPs: isochronous, T1 (fairly typical), T2 (atypical), T4 (atypical), and R1 (random). The design was blocked by condition, and each TP was presented 10 times in succession in each condition. In experiment 2, there were 9 TPs: isochronous, T0 (highly typical), T1, T2, T4, as well as T0', T1', T2', T4' (phase-shifted versions misaligned with the musical structure). The design was blocked by TP. Each TP was presented 20 times in succession, two times for practice (clicks only) and then six times per condition, without breaks. In both experiments, the isochronous TP was presented first as practice; the other TPs followed in a coun-

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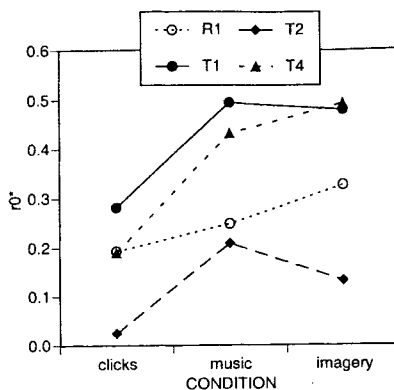


FIGURE 1. Results of experiment 1.

terbalanced order. Twelve musically trained undergraduate students participated in each experiment.

The measure of synchronization accuracy for the anisochronous TPs was the *prediction index*, $r0^* = (r0 - ac1) / (1 - ac1)$, where $r0$ was the correlation between the TP's interonset intervals and the intertap intervals, and $ac1$ was the TP's lag-1 autocorrelation. The $ac1$ set a lower limit to $r0$ because lag-1 tracking typically occurs when synchronization with an unpredictable TP is attempted.³

FIGURE 1 shows the average $r0^*$ indices for each TP in each condition of experiment 1. Since the conditions were in a fixed order, there was a gradual improvement due to practice for all TPs. However, performance improved more for the ETps than for R1 between the click and music conditions, $F(3,33) = 3.2$, $p < 0.04$, regardless of ETP typicality. Conversely, comparing the music and imagery conditions, ETps suffered more from the absence of audible music than did R1, $F(3,33) = 4.9$, $p < .007$. Between the click and imagery conditions, there was likewise a significant interaction with TP, $F(3,33) = 4.1$, $p < 0.02$, suggesting a beneficial effect of imagery for at least one ETP (T4) relative to R1.

FIGURE 2 shows the results of experiment 2, in which each ETP could be compared to its phase-shifted version. In each case, synchronization accuracy improved more for the ETP than for its phase-shifted version between the click and music conditions, $F(1,11) = 24.0$, $p < 0.0006$. The opposite was true between the music and imagery conditions, $F(1,11) = 36.6$, $p < 0.0002$. However, the Version \times Condition interaction was nonsignificant between the click and imagery conditions. There were no triple interactions with TP.

These results provide convincing evidence that synchronization of a simple motor activity with an ETP is facilitated when the ETP is carried by an appropriate musical structure than when it is carried by an unstructured click sequence. Moreover, this facilitation occurred regardless of the typicality of the ETP, which supports the notion that radically different ETps, observed in expert performances,² can be compatible with the same musical structure. However, there was little evidence that musical imagery was an effective substitute for audible music.

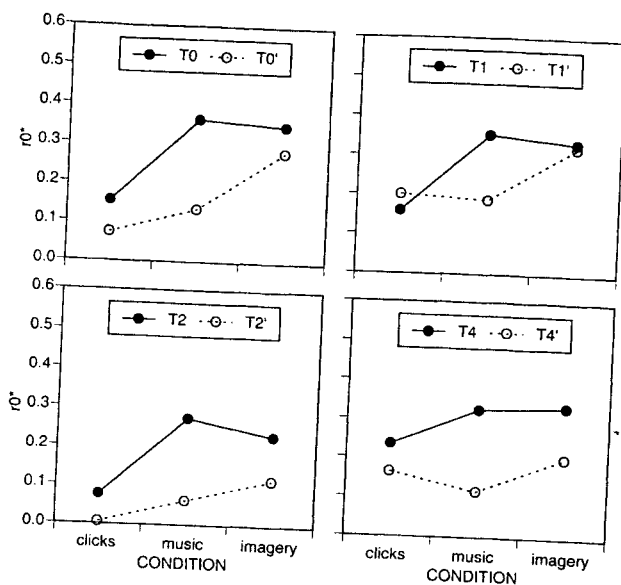


FIGURE 2. Results of experiment 2.

Nevertheless, imagery did have an interesting effect on synchronization with *isochronous* sequences in both experiments. The intertap intervals in the music condition showed small but systematic deviations from regularity, as observed previously.⁴ Thus, the musical structure influenced the timing of the synchronized action, without participants' awareness. The very same pattern of deviations, albeit somewhat reduced in magnitude, emerged in the imagery condition. This proves that participants did imagine the music and that imagined music can have involuntary effects on the timing of accompanying motor behavior. These effects, however, may be unrelated to the ability to predict ETPs.

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