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Sensorimotor synchronization and perception of timing: Effects of music training and task experience

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ABSTRACT

To assess individual differences in basic synchronization skills and in perceptual sensitivity to timing deviations, brief tests made up of isochronous auditory sequences containing phase shifts or tempo changes were administered to 31 college students (most of them with little or no music training) and nine highly trained musicians (graduate students of music performance). Musicians showed smaller asynchronies, lower tapping variability, and greater perceptual sensitivity than college students, on average. They also showed faster phase correction following a tempo change in the pacing sequence. Unexpectedly, however, phase correction following a simple phase shift was unusually quick in both groups, especially in college students. It emerged that some of the musicians, who had previous experience with laboratory synchronization tasks, showed a much slower corrective response to phase shifts than did the other musicians. When these others were retested after having gained some task experience, their phase correction was slower than previously. These results show (1) that instantaneous phase correction in response to phase perturbations is more common than was previously believed, and suggest that (2) gradual phase correction is not a shortcoming but reflects a reduction in the strength of sensorimotor coupling afforded by practice.

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1. Introduction

Sensorimotor synchronization is a skill that is especially important for musicians when they have to play in ensembles. However, even people without music training are generally able to tap in

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approximate synchrony with a metronome or with the beat of music. Synchronization requires either continuous entrainment or discrete error correction, of which two forms – phase correction and period correction – have been identified in tapping tasks (Mates, 1994; Repp & Keller, 2004; for a review, see Repp (2005b)). *Phase correction* is the largely automatic adjustment of the timing of each tap on the basis of previous temporal information. *Period correction* in addition changes the internally specified period of the rhythmic action and seems to be more under cognitive control. Conscious detection of a tempo change in the pacing sequence may be necessary for period correction, or at least enhances it (Repp, 2001b; Repp & Keller, 2004), whereas phase correction is independent of conscious detection of timing perturbations or asynchronies (Repp, 2000, 2001a).

Both error correction processes have typically been found to be gradual, not instantaneous: When an unexpected timing perturbation is introduced into a pacing sequence during synchronization, participants usually need to make several taps to adapt fully to the change in timing. The shift of the first tap following a perturbation, relative to its expected time of occurrence, has been termed the *phase correction response* (PCR) and varies linearly with perturbation magnitude as long as the perturbations are relatively small. Thus the mean PCR can be expressed as a proportion of perturbation magnitude, and it is typically well below 1 unless the sequence tempo is very slow (Repp, 2008a, 2008b) or period correction accompanies phase correction (Repp & Keller, 2004). Other methods of estimating the speed of phase correction (e.g., Repp & Keller, 2008; Semjen, Schulze, & Vorberg, 2000) have likewise led to the conclusion that phase correction is rarely instantaneous, and period correction appears to be even slower (Repp, 2001b; Repp & Keller, 2004).

Previous studies from the author's laboratory have nearly always used musically trained individuals who were regular participants in synchronization tasks. A focus on such "synchronization experts" can be justified by the special relevance synchronization skills have to music performance and by a desire to obtain clean data from highly motivated participants. As a consequence, however, less is known about the synchronization skills of those with little or no music training. Although some studies by other researchers have used participants with little or (frequently) unspecified music training, comparisons across studies are difficult because of methodological differences, and a direct comparison of musicians' and nonmusicians' synchronization performance has rarely been made. It seems reasonable to expect that nonmusicians would exhibit larger asynchronies between taps and pacing sounds, greater tapping variability, and slower error correction than musicians. One recent study (Repp & Doggett, 2007) indeed found higher variability and a larger negative mean asynchrony (anticipation tendency) in nonmusicians than in musicians (see also Franêk, Mates, Radil, Beck, & Pöppel, 1991; Gérard & Rosenfeld, 1995). However, effects of music training and/or of task experience on error correction processes have not yet been investigated directly.

The present study took advantage of a data set collected originally for a different purpose: to explore whether synchronization skills in college students are related to a measure of phonological fluency. That purpose will not be justified here; the results pertaining to it were modest and will be reported elsewhere, if at all. However, the availability of data from participants with (in most cases) little or no music training offered an opportunity to compare their synchronization performance to that of a small but readily available group of highly trained musicians in exactly the same tests. Some of these musicians had been regular participants in the author's research during the previous academic year, but most had just been recruited and thus were novices with regard to laboratory timing tasks, as were the college students. Thus, a comparison could be made that was largely unencumbered by possible effects of task experience. Such effects, if any, could be gauged by comparing the data for musicians with and without task experience, although the *N* was small. Within the group of college students, moreover, a comparison could be made between those without any music training and those with some training.

Three brief synchronization/perception tests were devised specifically for the purpose of assessing individual differences. The tests measured mean asynchronies and inter-tap intervals (ITIs), their variability, the speed of phase correction in response to phase shifts, the speed of phase and period correction in response to tempo changes, and also perceptual sensitivity to changes in timing and tempo. The hypothesis was simple: highly trained musicians were expected to be superior to less trained participants in all respects, and college students with music training were also expected to do better than those without any training. Possibly, musicians with extensive task experience would also do better

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