Research Proposal

Studying musical interaction: A new experimental paradigm for investigating pitch matching and correction mechanisms in music.

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Sensorimotor Harmonisation – A Missing Experimental Paradigm

In absolute terms we have impressive capabilities and potential to match perceived pitches. Sundberg (1987), for example, showed that trained singers can match a 440Hz reference tone with an accuracy of 1Hz (≈ 4 cents). Almost entirely unexplored, however, are the processes with which we maintain and embody continuing pitch relations in music. Even in the simplest scenario of interactively matching a single sustained pitch we must necessarily be constantly correcting for efferent and afferent variances. One valuable exception to the general lack of experimental evidence is Grell et al. (2009). In this study choir singers were recruited to produce an F#4 (370 Hz) to complete a major chord with an external D4 (293.7 Hz) and A4 (440 Hz). Rising or descending shifts of quarter or semitones were introduced at varying points of a 5 sec sustained chord and were corrected for by the choristers. The authors reported that the singers responded in the range of 197– 259ms depending on direction and size of the pitch shifts, as well as on skill and anesthetization. However, observations from individual participants also indicated a fast but imprecise reflex reaction (presumably subliminal) at 50ms and some slow reactions, presumably under a degree of volitional control, at 723ms and 1290ms. These and many more details of how we achieve and maintain coordination of pitch frequencies remain to be confirmed, explored, and illuminated further. Additionally, a substantial limitation of this study, in terms of its interpretative scope, is that the task was relatively complex and required musically trained participants.

I would suggest that much could be realised from an analogous experimental design to the 'sensorimotor synchronisation' isochronous tapping task (Stevens, 1886/8) used in rhythm and timing research. This seemingly simple paradigm has spawned a vast body of research that has informed our psychological and neuroscientific understanding of music, movement, action-perception coupling, attention, volition, interaction, sociality, empathy, co-operation, liminal and subliminal action, and group synchronization. I am therefore proposing some original pilot studies in which participants will be required to match a sustained external frequency (pitch) with a slider similar to that used in Hutchins and Peretz (2013). Other production methods to be explored could include producing a tone by drawing a line on a simple touchscreen device, using a tensile string, and, of course, singing. The latter would naturally have the broadest interpretative scope and relevance but would also, given the degrees of variance and vibrato in singing, present the greater methodological and analytical challenge. Shifts in the range of 1-50 cents (i.e. up to a quartertone[1]) to the target tone would be introduced and the first inquiry would be to identify thresholds for compensation and corresponding correction latency. Pitch processing thresholds are perceptually well understood (see Stainsby & Cross, 2016). However, correspondingly to the tapping paradigm, it seems likely that embodied correction will occur even below liminal thresholds. On the basis of investigations with the voice feedback frequency shift paradigm on auditory control of voice F0 (e.g. Donath et al., 2003; see Larson, 2016) we can make some further initial suppositions and hypotheses. For example it seems plausible that involuntary responses to perturbations will similarly occur at a short latency of circa 100-150 milliseconds. In contrast a second response at a longer latency of circa 250-600 milliseconds may likely be imbued with awareness and be subject to attentional manipulations. If this were to be the case we could perhaps surmise that the latter, being necessarily based on a more sustained pitch target, reflects a specifically musical pitch correction process. It is probably wise to resist temptations to think too far ahead. However, I would like to stress that, assuming initial success in the pilot studies, this paradigm would be open to much extension. We could productively investigate, for example, different frequency relations and thresholds in the level of the shift at which corrections incur conscious awareness and/or are subject to manipulations of attention and volitional control. It would also be interesting to explore the human-human interactional dynamics of the task, associations of this ostensibly simple task to issues such as empathy, prosociality, and cooperation, and the neuroscientific correlates.

A further benefit of this research could be that it would provide a necessary analytic control for claims of "tonal synchrony" or "pitch-synchrony" in linguistic and parent-infant communication (e.g. Robledo et al., 2016; VanPuyvelde et al., 2015). As such it could have important implications for comparative perspectives on music and language. My psychophysiological study of pitch perception and pitch production in humans and other animals (PhD Thesis, Chapter 3 [available on request]) suggests further that this missing experimental paradigm could impact upon our broader understandings of music in evolution, social interaction in music, perception-action coupling, volitional control of vocalisation, and the psychology of musical harmony.

[1] It would also be interesting to explore wider intervals but I am suggesting this range initially to keep the task focused on tuning issues that may occur naturally in music performance rather than degrees of change that would more likely be processed as a discrete intervallic change.