



**Temporal organisation of sound sequences:
Same processes in music, environmental scenes and speech ?**

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Our previous research has focused on how people hear musical and non-musical rhythms in order to identify the underlying psychological processes that make the perception of music such a fulfilling and satisfying activity. Music is typical of all forms of sustained activity over time, in that it can only be successfully perceived or performed if the individual events from which it is composed are perceptually integrated into larger units spread over time. Indeed, music has been defined as the art of organising events in time. As such, it provides an ideal opportunity to investigate the perceptual and cognitive temporal processes that overcome processing constraints and thus make such activity possible.

Following *Dynamic Attending Theory* (Jones & Boltz, 1989; Drake, Jones, Baruch, 2000), we consider that each individual is predisposed to analysing information that arrives at a particular rate or tempo. This rate, known as the *referent period* would be pre-wired, specific to each individual, and functioning from an early age. Events arriving close to this rate would be analysed preferentially. Music is highly structured over time, in that events are organised in a hierarchical structure with events nested within multiple hierarchical levels. The idea is that individuals focus preferentially on events occurring at the hierarchical level which is closest to their referent period. Attention will be focused spontaneously on events occurring at this *referent level*, processing will be optimum, and future events will be "expected" at this rate. Once listeners have "latched onto" this referent level, they may actively focus attention on other hierarchical levels, either faster or slower than the referent level. This process of *focal attending* requires considerable processing resources.

We have identified simple ways of measuring these three processes. The *referent period* may be measured by asking participants to tap in a regular fashion at the rate that seems most natural to them (spontaneous motor tempo). The *referent level* may be measured by asking them to listen to a musical sequence, and then to tap in time with the music in a regular fashion at the rate that they think "goes best with the music" (spontaneous synchronisation). *Focal attending* may be measured by asking listeners to synchronise at multiple hierarchical levels within a structured sequence such as music. The number of levels at which they are able to synchronise reflects the number of hierarchical levels to which they have access: the greater the number of accessible levels, the more structured their temporal hierarchical representation.

Several studies have examined changes in these processes with musical tuition, age and acculturation:

- Musicians have a slower referent period and referent level than non musicians, and they organise events at higher hierarchical levels (Drake, Penel, & Bigand, 2000). Thus, musical tuition enables a listener to organise events over longer time spans and within a more complex hierarchical structure.
- Both referent period and referent level slow with age, and there is a progressive increase in the number of hierarchical levels incorporated in the mental representation (Drake, Baruch, & Jones, 2000). As children get older, they are able to organise events over increasingly longer time spans and within a more complex hierarchical structure.
- Listeners tap slower, and at higher hierarchical levels, with music from their own culture than with music from an unfamiliar culture (Drake & Bertrand, 2001; Drake & Ben Heni, 2002 – comparisons between

French and Tunisian listeners synchronising with French and Tunisian music). The more familiar a listener is with a particular hierarchical structure, the greater their use of that structure.

We now extend our investigations into whether or not these processes function in a similar fashion with other types of structured sound sequences. Can the temporal processes identified in music perception and production be generalised to other types of sequences, in particular environmental scenes and speech? Two research projects are underway. The first examines the way in which listeners extract temporal regularity and hierarchical structure from *environmental auditory scenes*. Such sequences are usually less highly-structured than musical sequences. Evidence of the use of a referent level has been obtained, but there is very little evidence of organisation over longer time spans. The second research project in relation to *speech sequences* will be presented in detail. Listeners heard 30-second stories read in French, English and Japanese (as well as versions played backwards to remove structured linguistic content). Their task was, as with music, to tap in a regular fashion at the rate that seems most natural to them. The hypothesis was that the more familiar a person is with a particular temporal structure, the more highly-organised will be their representation. The referent level, as measured by the spontaneous synchronisation rate, should be higher (slower) for sequences with which they are most familiar. That is French-speaking subjects should tap slowest for the French sequences, at an intermediate rate for the English sequences and fastest for the Japanese and reversed sequences. Similarly, English-speaking subjects should tap slowest for the English sequences, at an intermediate rate for the French sequences and fastest for the Japanese and reversed sequences. The results confirm these predictions, even when mean syllable rate is taken into consideration. However, we have so far been unable to correlate these synchronisation rates with structural characteristics of the speech. [Financement - Cognitive, Déficiences de Traitement Temporel en Audition].

Drake, C., Penel, A., & Bigand, E. (2000) Tapping in time with mechanically and expressively performed music. *Music Perception* 18, 1-24.

Drake, C., Baruch, C., & Jones, M. (2000) The development of rhythmic attending in auditory sequence: attunement, reference period, focal attending. *Cognition* 77, 251-288.

Drake, C., & Bertrand, D. (2001) The quest for universals in temporal processing in music. *Annals of the New York Academy of Science* 17-27.