The Role of Rhythm in Guiding Attending

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Much of the environment with which we interact is dynamic in that it changes in meaningfully ways over time. We see this in moving objects, body gestures, conversations, ambient sound patterns and in musical events. How is it that we keep in touch with such things as they unfold in time, monitoring them and anticipating nuances as well as major breakpoints in their structure?

One possibility that has been considered at Ohio State is that the dynamic structure of the events themselves provides a basis for guiding an inherently temporal attending activity (Jones, 1976; Jones & Boltz, 1989). We have assumed that attending is based on the joint activity of many attentional rhythms, or oscillators, of graded periods each of which is capable of locking-into, i.e., entraining to a corresponding periodicity embedded in dynamically patterned events. This entrainment enables real time attentional tracking as well as anticipatory responding; in addition, depending on the task and the particular model, it determines an individual's sensitivity to certain structural changes in the unfolding event. To be more concrete about this it helps to illustrate how we study attending in particular tasks.

Often we use a task where a person is presented with an auditory pattern of some sort in which we embed a structural change i.e, a target. The change might be a spectral alteration to one of the pitches comprising a melody, or it might be a lengthened time interval or a shifted tone within a rhythm. Sometimes the patterns themselves are polyrhythms. Polyrhythms are composed of sequences based on two different tone frequencies (high, low tones) that each trace out an isochronous sequence, but in which the respective rates, related by rational numbers, are dissonant (e.g., 3:2, 4:3, etc.). In other cases, the sequences may consist of rhythms formed by recurrent tones of a single frequency but with different intensities (loud, soft) and also patterned in duration to form rhythms such as short–short–long. A common strategy is to embed a structural change within one of two identical test regions within such sequences thereby permitting the use of a two alternative forced choice (2AFC) procedure. We arrange things so that in all of the events that we study in a given experiment the test regions where a target change occurs are identical. So, for instance, if we insert a time-change into a rhythmical pattern (e.g., a rhythm involving only short–short–short time intervals versus one involving short–short–long), the target time-change will always alter a short interval. In this way, we can study the effect of surrounding rhythmic contexts on listener's abilities to detect a small timing nuance.

In fact, if we focus only upon time-change detection tasks some of the recent work that Ed Large and I have been conducting provides one model that is possible out of this framework (Large & Jones, 1996). In this research, we aimed to address two related problems: 1. How do people who listen to rhythmically patterned sequences of the sort I have just described intuit the form of the rhythm, and hence detect a time deviation? and 2. How do people intuit the underlying rhythmic form even when the tempo or rate of the sequence modulates over time as it does in most dynamic events in our natural environment?

The model is a dynamical systems model, developed by Ed Large, which instantiates many of the assumptions I outlined earlier. It assumes that an oscillator carries a pulse of attentional energy that is maximal for some expected point in time within the period of an attentional oscillator. The oscillator is biased to entrain to time periods within an auditory event sequence that correspond to inter-tone time intervals that are near its stipulated period. Thus, longer or shorter time intervals are noticed as deviant to the extent that they violate these expectancies. A second feature of the model is its adaptability to tempo modulations: the period of any oscillator can adapt, via a phase/period resetting process (short-term learning), to track moderate temporal irregularities within a sequence. Finally, a two oscillator version of the model has the potential to explain how people intuit rhythmic form because each of the two attentional oscillators responds to a different (changing) periodicity within a given rhythmic pattern; nevertheless, together they reveal a coupling bias for a time-ratio of 2:1 (in this model).

We have been able to describe the time discrimination performance of average listeners in 2AFC tasks using a variety of patterns that contain different degrees of tempo (rate) modulations (Large & Jones, 1996). Likewise, in other patterns that vary in their rhythmic complexity we have nicely predicted systematic discrimination responses to simple versus complex rhythmic forms (Jones & Yee, 1996). In summary, the model illustrates how assumptions about the inherent rhythmicity of attending can address the two related problems that come up when we consider how people track dynamic events in their environment. It explains adaptability to tempo change and it explains sensitivity to underlying rhythmic forms.

References

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