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Musical Rhythm for Linguists: A Response to Justin London

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ABSTRACT: Musical timing is a rich, complex phenomenon which changes across cultures, periods and styles and requires highly explicit terminology in order to communicate clearly between music theorists, psychologists, neuroscientists, performers and indeed with linguists. Here I respond to Justin London's opening paper by outlining and expanding upon his key points and raising additional questions regarding the neural basis and the functional role of musical timing.

KEYWORDS: *beat, rhythm, meter, pulse, shared experience*

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JUSTIN LONDON'S paper, *Three Things Linguists Need to Know About Rhythm and Time in Music* sets out London's key points that 1) it is important to distinguish between rhythmic grouping and musical meter, 2) rhythm perception is not passive, but an active process, strongly influenced by prior experience and 3) musical timing has different features at different timescales. Here I will briefly discuss each point in turn and then pose two questions for future research in this area.

MUSICAL METER AND RHYTHMIC GROUPING

London's first point is that rhythmic grouping is fundamentally different from a sense of underlying musical meter. Rhythm perception is essentially based on duration perception, that is, on the perception and grouping of the physical, acoustic, temporal properties of individual notes and collections of notes. Such groupings vary widely and often characterize an individual piece of music or a musical style (such as Beethoven's 5th symphony, or jazz syncopations). Rather differently, meter perception is based on the sense of cycles of an underlying 'beat', in which the beat is periodic and conceptually isochronous, like the ticking of a clock. Metrical organization is usually constant throughout a piece of music and much Western music is organized in either 'duple' or 'triple' time (two or three beats in a cycle).

One important point to raise here for linguists is the relationship between 'beat' and musical 'meter'. The beat is the basic temporal unit of almost all musical styles, forming a regular, conceptually isochronous temporal reference point around which musical notes can be organized. Musical meter is a higher level of temporal organization involving a repeating pattern of two or more beats, and could thus even be described as the 'grouping' of beats, in a similar way that London describes rhythm as the 'grouping' of durations.

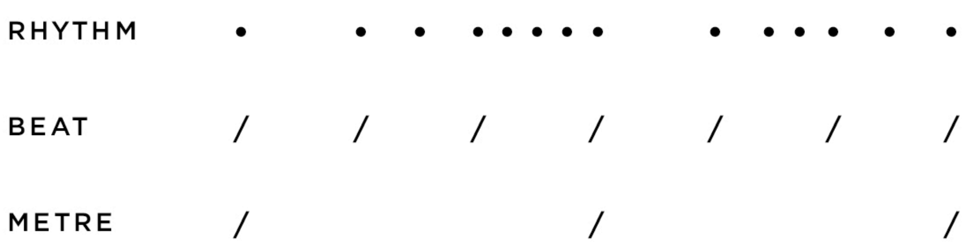

Fig. 1. Figure to show the relationship between a rhythmic pattern, the underlying beat, and the metrical organization of the beat.

While a steady beat (often referred to as the 'pulse') is a ubiquitous feature of most music around the world, metrical organisation seems to be more culturally specific, from the 2-beat marches and 3-beat waltzes of Western classical music to 5- and 7- beat dance rhythms in Greece, longer rhythm cycles in India and extended 'form numbers' and interlocking downbeats in Uganda and other parts of Africa (Cooke, 1990). Thus, while the *entrainment* level in music (the periodicity at which one might dance, clap, or tap a foot) is often linked with metrical level, it can also be strongly linked with the beat level, depending on the musical style. As London notes, the entrainment level is important and somewhat unique in musical behavior, since it allows for the synchronized attention and shared experience of large groups of people (Overy & Molnar-Szakacs, 2009).

RHYTHM PERCEPTION AS AN ACTIVE PROCESS

London's second point is that the perception of musical rhythm does not depend solely on the rhythmic organization itself, but also on the human mind that perceives the rhythm. That is, in order to make sense of incoming auditory information, the mind will 'actively' group notes into meaningful structures in ways that are highly influenced by an individual's prior experience, such as cultural exposure and musical training. Linguists may be particularly interested in research showing that an individual's native language can influence the way in which musical rhythms are grouped and perceived (Iverson et al., 2008), while it has also been shown that prior movement experiences (such as 'bouncing' in duple or triple time) can affect rhythm perception preferences in babies as young as 7 months (Philips-Silver & Trainor, 2008).

Such evidence links well with current theories of the human brain as a "hierarchical predictive coding" machine (e.g., Friston, 2005) and with work in the philosophy of mind regarding prediction and embodied cognition (e.g. Clark, 1997). That is, our prior internal models can be considered to have a crucial role in our interpretation of incoming rhythmic information, to the extent that the musical timing systems of unknown cultures can be difficult to perceive, as London outlines. It has been shown that the rhythmic expectation created by internal models is strong enough for the EEG neural response to an expected (Snyder & Large, 2005), or imagined (Schaefer et al., 2011) beat or metrical stress to be similar to that of the neural response to a real acoustic event. There is also evidence that the precision of such prediction abilities varies across individuals and is quite stable across time, affecting interpersonal coordination during musical tasks (Pecenka & Keller, 2011). Again, as London notes, this predictive aspect of rhythm perception allows for parallel entrainment and meaningful shared musical listening experiences amongst those who are familiar with a particular musical style.

MUSICAL TIMING AT DIFFERENT TIMESCALES

Finally, London raises the point that musical timing has very different features and qualities at different time scales, which co-occur in an ongoing musical timeframe. For example, fast notes, or rather, short intervals (the time between note onsets) within the range of 100-300 ms are not usually perceived as individual events, but are grouped together and conceived of in terms of their collectivity within a specific time-frame, such as five notes within the beat (Fraisse, 1982), while very slow notes (or long time intervals) over the range of around 1500 ms are rather perceived as individual events than as part of a rhythmic pattern (Woodrow, 1932).

Linguists may find it interesting to consider these temporal scales in relation to similar temporal scales within language, which of course relies on the same acoustical features of sound (timbre, pitch, volume and duration) in order to build up structure and meaning. From the timbre of a musical instrument to a musical note, musical motif, musical phrase and an entire musical piece, language can be compared at the timescale of the formant, the consonant, the syllable, the word, phrase, sentence and indeed conversation, poem or novel. Cognitive performance at these timescales may also be correlated, for example performance on syllable segmentation tasks has been found to correspond with rhythm pattern perception abilities (Overy et al., 2003; Thomson et al., 2006).

However, as London exemplifies with an extract from *Eleanor Rigby*, strict hierarchical levels of temporal organization (such as the beat and the meter) allow for several kinds of rhythmic timing to occur simultaneously during a piece of music, often played on different instruments, and sometimes even simply implied by the musical organization of pitch distances in a single melodic line (e.g., in Bach's *Cello Suite no. 1*). In addition, a particular feature of musical timing is the role of expressive timing, that is, the deviation from absolute isochrony during performance. A computer-generated, perfectly temporally accurate performance sounds boring, inexpressive and 'in-human', while a performance that deviates from a strict tempo according to accepted conventions of expressive timing and *rubato*, is considered more emotionally expressive (Clarke, 1989) and indeed more 'musical'. Thus, it might be suggested that, in the same way that the temporal dynamics of speech can convey emotion (Scherer, 1995), the temporal dynamics of music also communicate emotional meaning, via rubato, tempo, pauses, syncopations, expectations and violations of expectancy.

DO DIFFERENT TEMPORAL LEVELS ENGAGE DIFFERENT NEURAL REGIONS?

London's stimulating paper leaves me with two key questions for future research in this area. Since the advent of brain imaging technology in the 1990s, the field of music neuroscience has been dominated by questions of melody, harmony and musical training, but more recently, rhythm and timing is starting to command more attention within both EEG/MEG research and fMRI research (e.g., Chapin et al. 2010; Chen et al., 2008; Grahn & Brett, 2007; Overy & Turner, 2009; Schaefer et al., 2011). It seems clear now that a range of neural regions are involved in musical timing tasks in addition to the auditory cortex, from the cerebellum and basal ganglia to the pre-motor cortex, SMA and IFG (see Grahn, 2009), depending on the specific type of musical task involved. My question is thus: do the specific temporal levels identified by London (less than 300ms, 300-1500 and more than 1500ms) engage specific neural networks? Does such neural organization give any clues as to how different temporal layers can be integrated into one perceptual present during musical listening? And are such networks similar to the way in which these temporal levels are engaged during language tasks?

WHAT IS RHYTHM FOR?

Finally, I am interested in turning to the question of the actual function of rhythmic timing. That is, what function does musical rhythm have in human intelligence and human behavior? Is it simply for fun – a cultural artistic object and a form of self-expression with which we can spend our leisure time (Pinker, 1997)? Or does rhythm have some developmental or evolutionary value, from the development of perceptual, cognitive, motor and language skills to social bonding (Cross, 1999; Malloch & Trevarthen, 2009; Merker, 2009; Mithen, 2005)?

Music is a highly social human behavior, strongly linked with relationship building and play, especially during childhood (see Campbell, 1998; Kirschner & Tomasello 2010; Overy, 2012). Music is also a very physical behavior, involving motor actions such as hitting and plucking or motor responses such as dancing, tapping and clapping. In addition, music is often highly emotional, leading to strong preferences and powerful affective experiences (Salimpoor et al., 2011). Rhythm inevitably plays a role in these aspects of musical behavior, and indeed often becomes a focus for speech therapists, movement therapists and music therapists who wish to provide rehabilitation of some kind using music as a tool (Thaut & Aribu, 2010). It thus seems likely that musical rhythm and timing have a range of functions and possible applications to be further delineated and integrated in future research, including in relation to linguistics and applied linguistics.

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