10 Rhythm and the Body

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Rhythm involves the production and perception of regularly timed events. It is inextricably tied to body movement and an embodied sense of interpersonal coordination in social and musical contexts that triggers reward centers in our brains, suggesting evolutionary function.

Rhythm is ubiquitous. Many phenomena in nature have rhythmic qualities, occurring on highly variable timescales, and for many different reasons. Natural systems in living organisms are no exception. Our hearts beat in periodic intervals, our breathing functions in regular cycles, and basic body motions such as walking require a complicated rhythmic coordination between interacting motor systems. For living beings, rhythm is embodied, meaning that it emanates from bodily experience, and manifests itself in both body movement patterns and our perceptual sensitivities. Many of us cannot help but move along to a rhythmic sound, especially when it is in the context of music. Recognizing the role of the body in rhythmic phenomena constitutes a crucial turn in our understanding of the importance of rhythm in human experience, as well as the evolution of many human behaviors.

The word "rhythm" is derived from the Greek *rhiem*, meaning "to flow." The notion of flow is a central conceptual basis for recent work in the psychology of rhythm and music, and studies of how musicians "get in the groove." But the idea of flowing rhythmically extends well beyond music: We get in the flow with others in conversation, or with ourselves in our work, and with our lives in the broadest sense. The underlying conceptual metaphor of flowing is rooted in our physical experiences of moving through the world and understanding that movement as a kind of journey. This metaphorical understanding is revealed in how people talk about many aspects of life in these terms, including quite importantly, how it feels to get in the groove, or flow with others. Flowing is intrinsically rewarding, and various kinds of embodied descriptions are indicative of the deep interactions between sensorimotor systems, perceptually guided action, and cognitive structure.

Most generally, rhythm refers to specific kinds of timing phenomena that can be described in terms of relationships between events. Rhythmic events can be *isochronic* (equally timed intervals) or *heterochronic* (variably timed intervals), sometimes with quite complex, hierarchical structures. Although laypeople and scholars alike often use the term rhythmic coordination in somewhat loose ways, the idea of entrainment is actually quite specific (see Phillips-Silver et al., 2010, for a review). Entrainment is the coupling of independent *oscillators* made possible by an energy transfer between them. An oscillator is any system that produces periodic output, such as a pendulum or metronome. Imagine two metronomes rocking back and forth separately, at two different beats per minute (BPM). They will not spontaneously assume the same period, of course, unless they are positioned in a way where their movement can have mutual physical effects on one another. For instance, if they are on a wood board, which is set on a sturdy surface, there will be no way for the motion of the swinging pendulum arms to move the board, and thus affect the other metronome(s). But if they are placed on a board with wheels, allowing it to move along with the motion of the metronomes, the movement of the pendulum arms will shift the board back and forth. This motion creates a means of energy transfer between the two metronomes, resulting in a feedback process that causes the two oscillators to become coupled, with the coupling dependent on the strength of the energetic connection. The independent oscillator settings (in BPM) can disrupt the entrainment, resulting in a continuously shifting phase relationship (itself potentially comprising a higher-order rhythmic structure). A web search of metronome synchronization will result in many visual examples.

Now imagine two bodies as the oscillators, and the link between perception and action as the means of energy transfer. What we hear (and see) can directly affect how we move our bodies; that is, auditory perception is attuned to isochronous sounds, and our bodies naturally engage with those sounds. From an embodiment perspective, we can understand rhythmic production and perception as situated activity that guides recurrent sensorimotor connectivity. Bodies generate rhythms through specialized motor programs, often with the help of culturally evolved technology, and drive perceptually guided action. Even passive listening to musical rhythms will activate motor areas of the brain. In many ways, rhythm processing in any animal provides a quintessential example of the relevance of embodied processes for understanding perception and action.

The link between rhythmic production and perception mediated through embodied processes can function in many social contexts. Social entrainment is present in a variety of species (e.g., synchronous chorusing in crickets and frogs), often in the service of territorial and mating behavior; however, many animals can be trained to entrain, with varying success. Researchers have studied parrots, sea lions, bonobos, and others showing how these animals can move contingently to a rhythmic stimulus. But none of these particular species have been observed to spontaneously engage in social entrainment with one another in nature. One proposed source of entrainment abilities is vocal learning. Being able to produce target vocal sounds generated by others requires specialized perception of useful acoustic features that interfaces with vocal motor machinery – a perception–action link. Put simply, vocal learning often requires that we connect, with precise timing, what we hear to how we move. Evidence from nonhuman animal research shows that spontaneous contingent movement to rhythmic sounds is typically performed by vocal learners, such as parrots. But with extensive training, non-vocal learners do it as well, though the underlying mechanisms are unknown. In one case, a California sea lion (not a vocal learner) has been shown to have learned quite well how to bob his head to the beat of human music. But closely related seal species are vocal learners, suggesting that latent abilities shared across genera or families could be at play. Evolutionary processes conserve structure, and thus, mechanisms can potentially be triggered by certain input despite their absence in the behavioral repertoire of the animal. The vocal learning hypothesis does a fairly good job of explaining why rhythm entrainment exists in many animals who do not show spontaneous social entrainment, but more work is needed (see Ravignani et al., 2014, for a review).

Rhythm in humans has been described as a suite of co-operating behavioral subskills, including *continuous* and *burst* body muscle movement (sometimes called *smooth* and *ballistic*), the action-perception link just described, and error correction mechanisms. Specific types of errors require tailored behavioral solutions. For example, adjusting your rhythmic behavior timing to synchronize with a beat that is the same tempo as your movement (e.g., stop momentarily and start on time) is a different problem from adjusting the interval between rhythmic events (i.e., change the BPM). Evidence suggests these kinds of corrections involve distinct cortical processes. The underlying control and implementation of error correction mechanisms interface in still unknown ways with subjective feelings of being in the groove. This sensorimotor coordination is facilitated by many factors, including the auditory structure of the rhythm, whether the target beat is generated by a live agent or a machine, and how easily one can imagine and produce entrained movement.

Consider the qualities of music and the contexts in which people are compelled to dance. We have to *feel* the beat and find a way to move our bodies contingently. For instance, people tend to move their upper body, especially their head, to salient low frequency features in rhythms (e.g., a kick drum), while moving their torso and hands to more high-frequency components. But simple isochrony often does not induce a groove; small variations in timing qualities, such as syncopation, where accents are shifted in unexpected ways, add complexity to rhythms that help capture embodied reactions to beats.

Rhythmic movement in humans is highly social, and it need not involve musical rhythm at all. We entrain our speech patterns and synchronize our body movements during conversation. Moreover, groups of interacting people can move together over long timescales that can contribute to an overall sense of flowing with a social partner. These kinds of coordinated phenomena seem to be related to nonverbal vocal behaviors. For example, laughing together can predict how coordinated people are in conversation, and the degree of coordination can be related to various measures of feelings of closeness and cooperation. Researchers examining interpersonal coordination in communication use sophisticated techniques incorporating dynamical systems analyses revealing synchrony on multiple timescales, all likely related to an overall subjective sense of being in the groove, or flowing. These perceptions are not linked to our deliberate movements; trying to consciously synch with another in conversation can have negative effects on the actual coordination. People are not typically able to describe verbally what is going on, but they can "feel" it. It is embodied, automatic, and likely an index of how well we might get along outside of the immediate communicative context.

The beat is felt subjectively in the body, and becoming entrained to an isochronous rhythm, especially with other individuals, is a pleasurable goal state that is associated with activity in reward centers of the brain. Moreover, how we encode rhythm is affected by our bodily experience. In one study, researchers bounced babies to an ambiguous auditory rhythm with bouncing accents on either a double or triple beat. They then played the recordings back to the infants days later and found that the babies preferred to listen to auditory analogs of versions that matched what they had been bounced to. The way the babies experienced the beat with their bodies had an impact on how they encoded the sound. Adults even seek out rhythm in noise that is not recognizable as music. In a study of how music preferences shape particular musical features, sound sequences were presented to listeners in pairs, and listeners had to choose which one they preferred. After many repeated exposures across listeners, preferred sounds were replicated with slight modification (emulating mutation), and dis-preferred sounds were removed (i.e., selected against). Over thousands of generations in this extremely simple evolutionary simulation, rhythmic beats emerged spontaneously. We deeply crave rhythm in the sounds we hear.

Research investigating the experience of musicians getting in the groove reveals that these experiences are multimodal and complex (see Levitin et al., 2018, for a review). One of the best signs for musicians that they are in the groove is when the coordinated playing becomes automatic and effortless, and there is a kind of locked performance. Musicians seek out these kinds of experiences, and many report a sustained groove as the height of musical pleasure as a performer. During playing, minor adjustments (i.e., error corrections) are typically needed as the collective performance unfolds in time. The groove emerges dynamically as these errors are resolved, and constant feedback between musicians is often helpful. These adjustments of course often happen mostly unconsciously, but can also involve verbal instruction, nonverbal signals, and musical indicators of success and failure. The direct connection to interpersonal interaction in conversation is fairly straightforward, as conversation is likely the primordial behavior from which culturally evolved musical interaction is derived.

If our ability to entrain is deeply rooted in our sensorimotor experience, and is intricately tied to basic communicative behavior, it is rather easy to understand why cultural processes have been attracted to it. We are highly motivated to engage in musical activity, whether as players, listeners, or dancers. The intense and universal motivation to participate in musical activity suggests social function. Music and other cultural practices that incorporate rhythm are successful because of our embodied predilections. But what social functions could this serve? One possibility is that rhythm provides a means by which groups of people can communicate their social coalitions. Isochronous beat structures allow groups to integrate complex musical and dancing activity in ways that reveal sophisticated and well-rehearsed coordination. The ethnographic record of traditional societies around the world shows clearly that musical performances are very common during initial encounters between distinct groups. These acts, in conjunction with other cultural behaviors, can help groups signal the quality of their relationships, including honest signaling of time spent investing in the performances and the strength of their coalition. Evolution could have favored rhythmic abilities in modern humans beyond those needed for vocal learning, resulting in one of a handful of musical behavioral adaptations that coevolved with cultural traditions.

Ongoing research is looking at many different aspects of this widespread phenomenon, including comparative work attempting to disentangle the evolutionary roots of entrainment and psychological research exploring the complexities of rhythmic coproduction and perception. The topic of rhythm is one that lies at the complex interface of biological and cultural evolution, and much remains to be discovered. We are just now getting in the groove.

For Sources and Further Reading

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