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Your Brain Has Got Rhythm Even If You Don't

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Before writing this story, I had never heard the song "Pills" by Bo Diddly, but once I listened to it, I couldn't help but snap my fingers. I needed a refresher course on beat and meter to figure out the rhythmic organization of the song, but as it turns out, my brain automatically knew the difference. New research suggests that while listening to music — whether Pills or a new U2 track — your brain is actively tracking the beat and how it is organized. Researchers found that while simple distractions can throw your brain off-track, your brain can still help you tap along to the basic beat.

Scientists know that the brain tracks musical beat through a process called "neural entrainment." But most previous studies have used simple auditory stimuli — such as tone sequences — to test this phenomenon. Nina Kraus of the Auditory Neuroscience Laboratory at Northwestern University, with post-doctoral researcher Adam Tierney, wanted to observe neural entrainment when people listened to real-world music.

In their new study, the researchers presented participants with the song "Pills" superimposed with a bassoon sound, and then measured their brain's electrical response using electroencephalography (EEG). The bassoon overlay was either lined up with the beat of the song or shifted off beat. The idea was to see how the brain responded to a disruption in the rhythm of the song and to hopefully observe the neural entrainment with real music.

As published in the *Journal of Cognitive Neuroscience*, Tierney and Kraus observed neural entrainment to the beat in both bassoon conditions. But those listening to the bassoon overlay off beat showed a distinct departure from the neural pattern found in the on-beat condition: At the first harmonic of the song, people listening to the bassoon off-beat showed a reduced neural response, essentially becoming neurally off-track.

Kraus spoke with CNS about this new work and what it tells us about how our brains automatically track musical properties, such as beat and meter, and how it fits into the larger body of research about how our brains process music.

CNS: What exactly is neural entrainment? What are the neural oscillations that scientists have observed in response to music?

Kraus: Neural oscillations are slow increases and decreases in electrical activity. When picked up on the scalp by sensors they look a bit like a sine wave. Some of the earliest research examining brain-generated electricity using scalp sensors was on the oscillations that appear during sleep, which were used to distinguish the different stages of sleep. These sorts of slow oscillations have been shown to "entrain," or synchronize, to rhythmic stimuli. For example, if you start playing a participant a sound occurring twice a second and measure the electrical activity from their scalp

over a period of around 10 seconds, it is possible to pick up a brain signal occurring twice a second. More complex rhythmic sounds cause more complex mixes of brain signals.

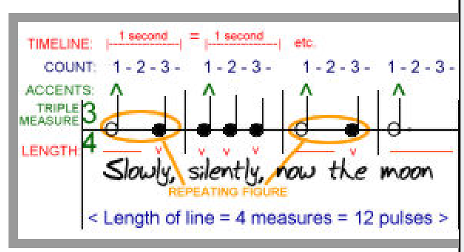
CNS: Why did you choose the song "Pills" by Bo Diddly? What made its sound qualities ideal for the experiment?

Kraus: We were looking for a song with a strong sense of rhythm — the sort of song you can't help but tap your foot to. However, many songs mark the beat with sudden changes in magnitude, in effect becoming louder whenever a beat arrives. We wanted to disentangle the effects of feeling the beat from the effects of hearing a spike in loudness. The song "Pills" features very little change in magnitude, but conveys a strong feeling of rhythm.

CNS: Why did past studies rely on simple sound stimuli rather than real-world songs to test neural entrainment? What are the challenges of working with real music?

Kraus: There's often a tradeoff in neuroscience between using simple stimuli over which scientists can have exact control and using more complex, real-world stimuli which capture more of the rich processing that takes place as we perceive and interact with the world. The challenge of working with real-world stimuli, such as actual music, is that it makes it harder to say exactly what feature of the stimulus is driving brain responses — that's what simpler stimuli are good at telling us. On the other hand, using real-world stimuli allows us a more direct way of generalizing from our findings to real-world listening.

CNS: What is the significance of your results for the tracking of musical beat versus meter?



Kraus: Our results suggest that there is a distinction between the tracking of the beat — the underlying pulse which helps organize movement to music, from foot tapping to dancing — and the tracking of meter — the rhythmic subdivisions that take place on a faster scale. This idea is supported by research on patients with brain damage which has shown that patients with damage to certain brain areas can tap to a metronome but cannot distinguish a march from a waltz.

CNS: So is that why neural entrainment was absent only for the first harmonic when the beat was off but not otherwise diminished for the off-beat condition?

Kraus: Yes, this result suggests that the tracking of slow rhythms in music — such as the beat of a song — is strong, automatic, and resistant to disruption by conflicting information. Finer-scale rhythmic information, on the other hand, is harder to follow when there are rhythmic distractions.

CNS: What would you like people to most understand about this research?

Kraus: Music might seem complex and hard to understand if you haven't taken music classes or learned an instrument, but your brain is great at taking an intricate song with a dozen things happening at once and figuring out what its simplest, most important elements are. Your brain figures out where the song's pulse is, and divides the time between pulses into "stronger" and "weaker" notes. You don't even really notice that your brain is doing this until something happens to make this process break down: by playing a sound at just the wrong time we can make the rhythm of the piece sound odd and even upsetting, and we can show that the brain's ability to pick out certain rhythmic patterns in the music is disrupted.

CNS: This experiment was with high school students with little musical experience. Do you think the results will differ with people with more musical experience based on other research you have conducted?

Kraus: I don't know, but it'd be fascinating to find out! One possibility is that musicians would be better at hearing the off-beat sounds and music as two perceptual "streams," and therefore they might show less disrupted rhythmic tracking in the off-the-beat condition.

CNS: How does this work fit into the bigger picture of cognitive neuroscience research on music?

Kraus: Prior work has suggested that the brain locks onto rhythms by, essentially, synchronizing with them. Our results support this theory, and provide a mechanism by which rhythms in sound are reinforced biologically that is, by generating the first harmonic of the beat. This reinforcement mechanism is disrupted if conflicting rhythmic information is present. It is commonly thought that synchronization of sound with brain rhythms reflects a waxing and waning of attention; that is, listeners pay more attention to sounds occurring on the beat. Another automatic sound processing mechanism may also be at play, as our participants were not instructed to pay attention to the song.

CNS: What are the next steps for this research? What is your ultimate goal?

Kraus: A long-term goal is to understand how rhythm contributes to speech processing. Speech contains many rhythmic regularities; in English, for example, stressed syllables tend to alternate and to be longer than unstressed syllables. Rhythm helps us know where relevant information stops and starts. Listening to one's conversational partner requires focusing on the patterns they're producing and tuning out background distractions, so tracking rhythm despite conflicting information may in fact be a vital skill. This may be why rhythmic abilities track with language skills such as reading.

One next step is to look at how different facets of rhythm "intelligence" such as remembering rhythmic patterns, synchronizing to sounds, and hearing the beat of music relate to each other. Are individuals good at certain aspects of rhythm processing and not others? And what aspects of rhythm tracking relate to everyday language skills?

-Lisa M.P. Munoz

The paper, "**Neural Entrainment to the Rhythmic Structure of Music**" by Adam Tierney and Nina Kraus, was published online on August 29, 2014, in the *Journal of Cognitive Neuroscience*.

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