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A Grid in Flux: Sound and Timing in Electronic Dance Music

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Abstract

Researchers have argued that temporal microdeviations from the metric grid, such as those produced by musicians in performance, are crucial to making a musical rhythm groovy and danceable. It is curious, then, that the music currently dominating the dance floor, “electronic dance music” or EDM, is typically characterized by grid-based rhythms. But is such a “mechanistic,” grid-based aesthetic necessarily devoid of microrhythmic nuance? In this article, we aim to show that the microrhythmic component of an engaging groove involves the manipulation of more than simply the onset locations of rhythmic events—the sonic features fundamentally contribute to shaping the groove as well. In particular, we seek to demonstrate that EDM producers, with their preference for a grid-based microtiming aesthetic, are very sensitive to and adept at manipulating such sonic features for expressive effect. Drawing on interviews with EDM producers, we show that producers are often concerned with both sonic and temporal features, as well as their interactions. We argue that sonic features are crucial to shaping groove and feel at the micro level of rhythm. Moreover, such features also tend to introduce an indirect microtiming aspect to the grid-based aesthetic of EDM through the ways in which they shape timing at the perceptual level. AQ3

Keywords: electronic dance musicgrooverhythmmicrorhythmtimingsound

Researchers have argued that temporal microdeviations from the metric grid, such as those produced by musicians in performance, are crucial to making a musical rhythm groovy and danceable. It is curious, then, that the music currently dominating the dance floor, "electronic dance music" or EDM, is typically characterized by grid-based rhythms.[1] Such on-the-grid rhythms are often heard as mechanistic, and, according to Mark Butler, EDM often aspires to literally sound like a machine: "Techno and other genres 'sound like' machines by presenting us with musical patterns that act like machines, and by cultivating aesthetic qualities that we associate with machines (such as precision, speed, and the like)."[2] But is such a "mechanistic," grid-based aesthetic necessarily devoid of microrhythmic nuance? In this article, we aim to show that the microrhythmic component of an engaging groove involves the manipulation of more than simply the onset locations of rhythmic events —the sonic features fundamentally contribute to shaping the groove as well. In particular, we seek to demonstrate that EDM producers, with their preference for a grid-based microtiming aesthetic, are sensitive to and adept at manipulating such sonic features for expressive effect.

Groove is a concept that is commonly used among musicians and fans of African-American-derived musical styles focused on rhythm to describe the perception and production of, quoting Merriam-Webster, a "pronounced, enjoyable rhythm."[3] As a noun, it is used to identify a particular rhythmic pattern, including the typical performative rendition of this pattern, e.g., swing groove, funk groove, etc. In addition, the adjective "groovy" is used normatively to describe an aesthetically successful and pleasurable groove (experience), where pleasurable is often understood as inducing an urge to move or dance. At a general level, we want to contribute to an understanding of both groove and grooviness that takes into account the importance of intersections between sonic and temporal parameters at the micro level of rhythm.

The article is based on four semi-structured interviews with expert EDM producers about their practice related to sound, timing, and sound-timing interactions. The producers we interviewed provided us with multitracks and project files for recordings they considered representative of their music. Multitracks allow us to analyze microrhythm in great depth because we are able to examine the timing and sound manipulation of the separate layers and events. Guided by the results of our interviews, we focus in particular on the positioning of sound onsets and on the manipulation of their amplitude envelope (i.e., the shape resulting from the amplitude of a sound from its onset to its offset) and intensity. Our argument with regard to the importance of the sonic features of groove is twofold. First, we argue that sonic features are crucial to shaping groove and feel at the micro level of rhythm. In our interviews, we find producers to be concerned with both sonic and temporal features, as well as their interactions. Second, we argue that sonic features can introduce an indirect microtiming aspect to the grid-based aesthetic of EDM by shaping the *perception* of timing.

THE ROLE OF MICROTIMING IN RHYTHM AND GROOVE

The different understandings of groove circulating among musicians and in the scholarly discourse tend to belong to three main categories: (1) groove as pattern and performance; (2) groove as pleasure and "wanting to move"; and (3) groove as a state of being. According to Guilherme S. Câmara and Anne Danielsen, the concept of groove comprises all these three related aspects, that is, rhythmic properties, pleasure, and embodiment.[4] With respect to rhythmic properties, researchers of musical rhythm have, in recent decades, devoted increasing attention to microrhythmic aspects of music that are generally ignored by conventional notational systems and structural music analysis.[5] The theoretical starting point underlying this interest is that rhythm as an *experiential* phenomenon resides in the meeting of sound and listener and contains both its relevant structuring patterns *and* the potential for the significant or expressive variation of these patterns.[6] Specifically, we understand rhythm to consist of an interaction between the listener's structuring schemes—which are derived from the music as well as a combination of general perceptual processes and individual pre-understandings—and the actual sounding rhythmic events.

Much attention has been given to microtiming nuances, which have been identified in theoretical, musicological, and ethnographic work as crucial to achieving the desired groove or rhythmic "feel" of certain types of music.[7] Some researchers have gone so far as to argue that temporal microdeviations from the metrical grid are crucial for developing musical groove, independent of style. For example, in one of his classic essays on swing and feel in music, in which he coins the often-referenced concept of "participatory discrepancies," Charles Keil states that for music to be "personally involving and socially valuable" it must be "'out of time' and 'out of tune.'"[8] Several scholars have followed up this claim with empirical studies. Josef A. Prögler had musicians perform a jazz groove and uncovered the existence of onset asynchronies between drums and bass.[9] Matthew W. Butterfield, on the other hand, studied *perceptual* effects of the minute participatory discrepancies that, according to Keil, produce the vital drive of a groove.[10] He concluded that those discrepancies alone were not enough to produce swing in jazz—a particular structure was also required. Generally, we receive the scholarship on temporal positioning as being somewhat narrowly focused on whether the *onset* of a sound occurs early, late, or on time in relation to a virtual reference structure (conceptualized as a series of isochronous points in time), and we propose here to widen the perspective on what timing is.

In consideration of the embodiment aspect of groove, a large study by Petr Janata and colleagues, using multiple methods and a wide variety of popular music styles, confirmed that the concept of groove is widely appreciated and is, in experiential terms, often understood as a pleasurable drive toward action.[11] Furthermore, they found that high-groove stimuli elicit spontaneous rhythmic movements, and that the degree of experienced groove is inversely related to the difficulty experienced in tapping along to the music.[12] Several rating studies of the relationship between microtiming and the

extent to which one feels an urge to move to the music have also been conducted, though they have yielded conflicting results. Some find no effect of microtiming asynchronies on groove ratings.[13] Others find that moderate and/or style-relevant microtiming is rated as high as on-the-grid grooves.[14] Researchers have also found that more microtiming generates more mental effort in performance and perception, as well as more motion response.[15]

EDM, which generally adheres to a grid-based aesthetic in terms of articulating the metrical orientation or moorings of the rhythm, counters the claim that "out-of-time"-ness is the key to making a groove interesting and danceable in that it is a vastly popular genre and is among the foremost musical styles associated with making people move and dance.[16] EDM scholars have thus revisited Keil's observation by pointing to other musical features that are significant to the groove experience of EDM. Some stress the importance of structural and dynamic changes, including the "break routine" or "breakdown," "build-up," and "drop."[17] Others have pointed to the impactful presence of syncopation and structural cross-rhythms such as the familiar 4:3 pattern, or four beats of an alternative pulse over three beats of the main pulse.[18] Still, the presence of this pattern is not enough to generate an interesting groove: a rendition of the 4:3 pattern using clicks, for example, would not be experienced as groovy. This observation points to the fact that the choice of sounds and instruments, as well as the sonic treatment of these sounds, also contributes to groove. Keil touched upon this possibility in his early writings on participatory discrepancies, when he discussed how "the vital drive" of a groove may be generated through the "attacks" of the rhythm section—that is, "the type of contact the player makes with his instrument in the initial production of a note."[19] Forty years later, Fernando Benadon, in an article addressing jazz swing as an interplay of rhythm, melody, and harmony, pointed to the still widespread tendency to neglect "the interaction between the pitch and time domains" in research into microrhythm.[20] Regarding empirical investigations of the audio features underlying perceived groove, there has been some research into the effect of loudness on groove.[21]

We propose to expand the study of microrhythm to include sound-related aspects of rhythmic events, such as amplitude envelope (temporal shape), intensity, and timbre, as they profoundly affect the feel of the groove and have implications for its appeal to bodily movement or engagement. Furthermore, we aim to show how the shaping of sound introduces "indirect" effects on timing: recent research into the perception of the timing of musical sounds has shown that sonic factors ultimately influence our perception of timing in music at the micro level, even though they are not necessarily identified as timing variations as such.[22] Drawing on interviews with established EDM producers, we ask what microrhythmic musical features they regard as significant when creating their grooves, how they understand the relationship and possible interaction between the temporal and sonic features of groove, and how they choose and manipulate sounds to shape the micro level of rhythm. We also analyze the relationship between sound and timing via a selection of the interviewed producers' music project files, which we approach using results from experimental perception studies on the relationship

between sound and timing.

METHOD: SELECTION OF INTERVIEWEES AND PROJECT FILES

We interviewed several distinguished Norwegian EDM producers in order to explore the discourse and practice related to sound, timing, and sound-timing interactions with experts in the genre. Instead of providing generalizable insight across EDM, we sought to engage with various approaches to groove within the genre and sought out leading producers representing different subgenres of EDM to articulate those approaches. We carried out the in-person interviews in 2017 and 2018, in which we were particularly interested in their perspectives on what a good groove is, and the importance of timing, sound, and sound-timing interactions, respectively. We then used a thematic analysis approach on the data—one that acknowledges that the "themes" of the interview guide may not be the same as the themes revealed by the patterning of responses across the data set.[23]

The producers provided us with their music project files, which allowed us to analyze the impact of individual sounds upon the perceived timing.[24] Our analytical approach involved aurally and visually comparing a given track with and without its applied processing effects or quantization. (We sometimes added quantization as well to test the perceptibility of timing deviations from the grid.[25]) Furthermore, this approach allowed us to examine the extent to which the producers' comments corresponded to a sonic analysis of the music.

The research presented in this article is based on interviews with the following producers: David Atarodiyan and Truls Dyrstad from the duo TRXD, Charlotte Bendiks, Espen Berg from the duo Seeb, and Per Martinsen (a.k.a. Mental Overdrive).

- TRXD, which signed with Warner Music Norway in 2016 and is currently signed with Sony Music Entertainment Norway, is an EDM duo that has had several hits in Norway in the past few years and has also gained international attention from the US magazine *Billboard*, among other outlets. TRXD's music represents electropop; while starting out making "tropical house"-inspired music, they soon evolved into a more urban pop-inspired sound, with track tempi ranging from 70 to 100 beats-per-minute (bpm), and with rhythmic patterns inspired as much by R&B and modern hip-hop and trap music as by the more conventional four-on-the-floor aesthetic of dance music. We analyze their hit "Jealous" (feat. Harper) from 2018.[26]
- Charlotte Bendiks has been active as a DJ since the mid-2000s. She plays her DJ sets

at nightclubs worldwide and has also released four albums and EPs. Bendiks's music represents classic house—characterized by a groove with a repetitive four-on-the-floor kick drum pattern and off-beat hi-hats, melodic synthesizers, and deep basslines, often with a tempo between 120 and 130 bpm—but with a minimalistic, lo-fi, and do-it-yourself (DIY) ~~DIY~~ approach. Drawing inspiration from house, trance, Detroit techno, nu-disco, Latin percussion, and African grooves, she calls her style "body music": "The idea of body music is a feeling—an idea that music is as much a physical experience as it is audio." We analyze her remix of Rudow's "Manifesting the Unreal" from 2018.[27]

- As part of the duo Seeb, Espen Berg is an established producer who has played an important role in the development of the Norwegian EDM scene. He has also contributed to several Norwegian pop and rock acts and has made remixes for distinguished international artists (including Coldplay, Ed Sheeran, and Taylor Swift, among others). Seeb's music represents tropical house, although its moody and melancholic sound distinguishes it from other tropical house acts, which favor cheerier harmonies. Drawing on both trance and progressive house, but with a more relaxed tempo (usually between 100 and 115 bpm), tropical house is characterized by a four-to-the-floor kick drum pattern, simple and memorable melodic phrases, rich synth pads and edgy lead synths, and "tropical" (to Western ears) instruments, such as pan flutes, horns, marimbas, and steel drums. We analyze Seeb's remix of Mike Posner's "I Took a Pill in Ibiza" from 2015.[28]
- Per Martinsen is an award-winning veteran DJ and producer and an influential figure in the Scandinavian electronica/techno scene for over three decades. Under the moniker Mental Overdrive, he has released eight albums, an assortment of singles and EPs, and two compilations. He is also part of the more ambient pop-oriented duo Frost, together with Aggie Peterson. Martinsen's music represents club-oriented old-school techno, or so-called Detroit techno, which is characterized by a minimal, melancholic, and soulful atmosphere and the characteristic sounds and precise, mechanistic rhythms of drum machines commonly used within this scene, such as Roland's TR808 and TR909. We

analyze his Mental Overdrive track “It’s All Good” from 2017.[29]

Although these producers are at different stages in their careers and represent different subgenres, they are all internationally distinguished producers with substantial experience, and music is their primary source of income. They are all based in Norway, where we carried out this research, but their music is released, toured, and consumed internationally.

Our research reveals that the producers adopt different approaches to creating grooves, not only in terms of techniques for shaping the groove but also in terms of the initial production process. Bendiks and Martinsen prefer a live approach, combined with post-editing of the recorded sounds. First, they improvise, playing analog synthesizers and physical instruments over sounds triggered from drum machines and samplers; then, they turn to Ableton Live (a DAW system) to select, edit, and mix the parts of their recordings that are suitable for release.[30] An important aspect of such an approach (they explained) is to intuitively create on the spur of the moment without being overly self-critical; they feel that this “live playfulness” is easier to achieve without the initial visual feedback from the screen of a sequencer program. TRXD, on the other hand, appreciates the surgical approach that the DAW program’s graphical user interface enables, in terms of manually inserting, editing, and shifting the time placement of audio clips. According to TRXD, “By looking at the bar lines, we’ve learned how to place the elements in order to achieve a certain groove.” Seeb seems to use a combination of these two approaches to elicit a humanized, flawed, and nonquantized timing while simultaneously meticulously quantizing other parts of the track to produce a certain feel. These different procedures, as well as the subgenres in which they operate, play an important role in the producers’ approaches to shaping sound and timing, which we return to in our analytic discussions below.

SHAPING THE GROOVE—THE TOOL KITS OF EDM PRODUCERS

In the following discussion, we report from the interviews with our selected EDM producers and analyze the producers’ multitracks. The section is organized according to the primary techniques that emerged from the interviews. Given the presumed on-the-grid aesthetic of EDM, we are particularly interested in the extent to which our interviewees consciously work with micro-level timing and to what extent they shape timing through sound. Because timing deviations in a series of otherwise isochronous sounds are often perceived as dynamic accents, we are also interested in the relationship between timing and sound features such as intensity, timbre, and amplitude envelope.[31]

We first present techniques for manipulating the temporal positioning of ~~a~~ sounds, including precise and sloppy playing, the careful positioning of sounds, swing quantization, regular quantization, and phrase offset (also known as track delay). Next, we zoom in on techniques used to shape timing through manipulating sonic aspects, including the amplitude envelope and overall intensity of the sounds.[32] Here, we focus in particular on the signal-processing effects equalization and filtering (to

modify the frequency distribution) and sidechain compression (to modify the dynamics).[33] The aim of our analyses is to illuminate how these sonic effects contribute to the subtleties of groove.

"Sloppy" Playing

Our selected EDM producers understand the*combination* of on- and off-the-grid sounds as critical to achieving a good groove. When asked about the extent to which she is concerned with the timing of sounds, Bendiks, for example, answered that feel and timing are alpha and omega to her music and that she is concerned with preventing the rhythms from becoming too "static." She therefore avoids slotting the timing of all of the sonic events into the grid in a quantized fashion. This dictate aligns with her more general preference for grooves that do not feel too "rigid" or polished—grooves that, according to her, tend to dull the creative spark of the music. With access to her Ableton Live project files and a multitrack of her remix of Rudow's "Manifesting the Unreal," we were able to take a closer look at some of her means of achieving this misalignment. Bendiks's remix of "Manifesting the Unreal" is characteristic of her minimalistic house music and features repetitive rhythmic drum-and-bass patterns with sparse melodic and harmonic elements. One significant element contributing to the feel of "flawed" timing in this track is the unquantized and drone-like synth bass, which consists of a two-bar looped sequence that is depicted in Example 1a and can be heard in Example 1b.[34] Here, Bendiks has preserved her intentionally loose timing instead of using the quantize feature to correct any deviations from the metrical grid, resulting in a loop containing bass strokes that lag by as much as seventy milliseconds (which is, in this tempo, close to a thirty-second note). This level of delay is clearly above the threshold for an audible timing asynchrony in this tempo and context.[35]

In "Manifesting the Unreal," Bendiks also records three tracks of herself playing the djembe drum. In two of them, she performs the same rhythmic pattern; in the third, she only swipes the surface of the drum skin. She then layers these three takes atop one another, so that the onsets of the different hits are inconsistent in relation to the grid. This creates small audible asynchronies that are experienced as a series of "flams"—that is, two separate sounds played very close together to function as one slightly longer note or, in this case, as a rhythmic inconsistency. Bendiks explains that, in order to avoid a static feel (which is more appreciated in techno than in -house music), she often uses such hand-played percussion instruments in her music, which she records herself before looping the resulting rhythms in Ableton Live. Because she is not an accomplished percussionist, she adds, the recorded patterns rarely fall straight onto the grid. Even when she does play the patterns perfectly in time, she will often discard those takes, because they require more timing manipulation in the post-recording process in order to achieve her desired quality of groove relative to those in which the rhythm is not tight. In certain parts of the track, she also activates a delay effect on one of the djembe takes, creating discrete echoes with a delay length amounting to perfect sixteenth notes on every sound event on that take. Because the events that are triggering the delay are deviating from the metrical grid of

sixteenth notes, the delay trail continues to deviate from the metrical grid and thus further "muddles" the group of onsets, contributing to the general audibility of the "flawed" timing of the djembe takes.

It is not surprising that Bendiks endorses sloppy playing, given her lo-fi, DIY approach to house, but this technique was mentioned by Berg and Eriksrud from Seeb as well, who employ similar strategies to achieve a "human" or flawed timing in their production of tropical house. They explain that they prefer to play most of the instrumental parts themselves rather than programming them on the screen, adding that they always try to leave some of the parts unquantized—that is, as Berg put it, "as tight as possible, but human." They also claim that, for certain parts of the tracks—particularly in the "drop" sections—they often restrict themselves to playing only with their nondominant hand.[36] In line with Bendiks, their rationale for this approach is that both the machine's timing and the timing of their dominant hands are too perfect or too accomplished and "trained," so playing the parts with their weak hands lends more personality to the sounding patterns.

This intentional avoidance of the sequencer's quantization function in favor of a "human feel" represents not only a strategy among the producers we interviewed but also a fairly widespread tendency across the various genres of digital music-making.[37] The sounding results of such an approach vary according to factors such as the type of genre and song, the context, the tempo, the instrument, and the magnitude of the "flawed" timing in the played phrase, as we will further demonstrate below. While we have focused on performed sounds in this section, the next sections will address how the EDM producers work with recorded or prefabricated sounds—that is, musical segments stored and accessed within the sequencer program.

Blend and Nudge: The Careful Positioning of Sounds

When represented as waveforms or MIDI notes on the computer screen or digital instrument, sounds can be trimmed, stretched, and moved by the producers in relation to the grid and the other sounds in the given track. In the process of crafting a contemporary EDM track, several types of temporal micro-manipulation can be done, and all of the producers we interviewed explain that they devote a lot of time and attention to the careful temporal positioning of sounds when in this post-recording mode. In their descriptions, they focus in particular on two different approaches: blending sounds by layering them atop one another (also referred to as "compound sounds") and shifting the temporal relationships between sound events in different ways (so-called "nudging").

Layering is a much-used technique in popular music production, the intent of which is to combine (or stack) two or more sounds that have similar functions, such as two different kick drums, in order to create a compound sound that is more interesting and richer than the original sounds were on their own. Layering sounds is often complex and involves carefully choosing and mixing different sounds together, distributing dominant frequency areas and timbral features between or among the layers

while carefully positioning their temporal onsets in relation to one another to avoid masking or clashing frequencies. TRXD's Atarodiyan and Dyrstad describe how they often create compound drum sounds that consist of several discrete samples positioned around the beat. For example, a snare drum with a lot of punch and energy in the low-frequency area might be positioned slightly behind the beat, then combined with a pitched-up snare drum or a bright clap sound placed slightly ahead of the beat to produce a "fatter" or richer aggregate sound.

Examples of layered sounds can be found in Seeb's remix of Mike Posner's "I Took a Pill in Ibiza."[38] The project file for "I Took a Pill in Ibiza" reveals the way in which they stack a tambourine sound slightly behind the hi-hat sound in order to make the result "bigger." It also features a clap sound that comes across as coherent but actually consists of two different clap sounds and two different samples of fingers snapping, each of which consists of several snaps in turn. As shown in Example 2a and heard in Example 2b, this compound sound has a duration of forty-five to fifty milliseconds.

The temporal asynchronies between the sounds producing the compound sound are relatively minor and, in most cases, likely not even to register as such. In the case of the finger snaps/claps sound, for example, one hears this as one coherent sound, but the flam effect distributes the energy and focal point of this sound away from a point-like exact positioning on the grid. Such layering contributes to the overall feel of the song: the exact temporal locations of such compound sounds become less obvious to the listener and the gestural shapes come forward as more rounded.[39]

Apart from layering similar sounds into a compound sound, the producers also describe aligning disparate sounds in opposition to one another. Bendiks notes that she devotes a lot of time to manually moving sounds mere milliseconds behind or ahead of the grid to create her "unpolished roughness" or particular feel for the groove. Relying on her experience as a DJ, in this case, she works with two or three isolated sound loops at a time, shuffling them around intuitively against each other on the grid until the (imperfect) entirety grooves perfectly. Even when she is working with prefabricated percussive loops—that is, a loop consisting of several individual sounds in a preset pattern—she often moves the individual sounds in the pattern by a certain number of milliseconds to free them from the "perfect" timing that such loops often display. Berg from Seeb recalls first encountering this technique of aligning disparate sounds in opposition to one another in his time as a house music producer in the 1990s, when drummers playing a four-to-the-floor disco beat would instinctively strike the snare a little ahead of the beat expressed by the kick to give the groove a better flow. Adopting this logic, Berg and Eriksrud occasionally use this technique with Seeb as well, manually moving sounds ahead of or behind the beat to give their rhythm the "right" overall feel.

Still, Berg insists, although many sounds may be slightly off the grid, some sounds, including the kick drum, should consistently accentuate the grid instead. The resulting contrast between sounds on the grid and sounds audibly off the grid is experienced as a combination of tight and "loose" timing, and,

as Berg explains: “It is the combination of tight and loose sounds that makes Seeb’s music groove.” A similar ideal is evident in the project file for TRXD’s “Jealous” (feat. Harper), to which we will return shortly. Here, the multitrack reveals that the kick and most of the percussive elements were placed on the beat, whereas selected gestures such as snare rolls were moved slightly behind it.

The producers all describe the process of positioning the sounds’ respective onsets in relation to one another in different ways as intuitive—as something that is done until it “feels” right. As a stylistic feature, then, it differs from track to track, depending on parameters such as the sonic content, tempo, and overall context, including the subgenre in which they operate. Again, as was the case with the blending of similar sounds, the result here might be perceived as a compound sound rather than as clear-cut, audible asynchronies between discrete events. This arraying of individual sounds around the beat produces what Danielsen calls a “beat bin”—that is, two or more temporally distributed rhythmic events that merge in perception to become one beat.[40]

This meticulous adjustment of the microtemporal placement of sound events is considered both a necessity and a creative strategy by three of our four interviewees; the exception is Martinsen who represents the more grid-based subgenre techno. The others, however, emphasize that such adjustments require a certain level of experience and flair from the producer to get right. The fact that this is regarded as crucial to achieving the desired quality of the groove highlights the way in which EDM grooves, while often grid*oriented*, are considered by their producers to be something much more animated than what has previously been suggested in the academic and journalistic discourse.

Swing Quantization and Phrase Offset

Berg from Seeb explains that he has been concerned with microtiming since he started programming house in the 1990s. When he and Eriksrud first began to transition to EDM and the work of remixing, they spent an entire day analyzing successful tracks in the tropical house genre. They soon realized that what enticed them about this style was its distinct rhythmic aspects; they noticed, in particular, that many of the tracks featured a rhythmic feel somewhere between triplets and straight sixteenth-notes. That is, whereas some sounds were located at precise eighth-note or sixteenth-note subdivisions, others had been systematically pushed toward triplets using the quantization swing-percentage tool. The ability to swing-quantize originated with the digital drum machines invented by Roger Linn in the early 1980s and allows a drum programmer to automatically place the sonic events triggered by a drum machine sequencer somewhere between a straight eighth-note or sixteenth-note pattern and a fully swung pattern.[41] On a Linn machine—either the original LM-1 (1979) or the Akai MPC 60 and 3000 series drum machines (which were also partly constructed by Roger Linn)—the ratio of applied swing is set as a percentage, a model since adopted by most digital sequencers, including Ableton Live, the DAW used by Seeb. Here, zero percent swing represents a straight sixteenth-note pattern and 100 percent represents a triplet-based shuffle beat. Berg and Eriksrud

realized that swing quantization—one with a quite specific swing ratio—was crucial to achieve the characteristic tropical house groove, especially when this was combined with polyrhythmic patterns. They ended up with a rhythmic template in which some of the subdivisions were swing-quantized (moved toward a triplet-based shuffle beat) within a certain "pocket" of roughly 22 to 40 percent swing. They then brought this template into their creative process, using it to generate a certain rhythmic feel (although they tried not to be too restricted by the exact numbers that their research had produced).

Our analysis of multitrack recordings of Seeb's music demonstrates a striking deployment of swing quantization along the lines described by Berg. In the original Ableton Live project files for their remix of "I Took a Pill in Ibiza," an excerpt of which is shown in Example 3a and can be heard in Example 3 b, the tracks containing the plucked string sounds that create the main chord arrangement in the verse and drop are all swing-quantized so that the onsets of the notes on the second and fourth beats are twenty-three milliseconds behind the grid.

In relation to the basic four-on-the-floor kick-drum pattern of the track, the plucked synth could be interpreted as forming a 4:3 cross-rhythm. Whereas this syncopated pattern in itself introduces a certain rhythmic friction (and *pace*) to the track, the added effect of swing-quantizing the plucked sounds undermines any potential rigidity and instead produces, as Berg puts it, a "more laid-back and swaying groove experience." That is, the swing quantization of every other note in the plucked synth introduces a systematic alternation between tight and loose timing. Berg justifies such small temporal deviations from the grid as follows: "If all the sounds are hard quantized, it sounds very lifeless and boring. If you take one of our tracks and quantize everything to straight sixteenth notes, for instance, it'll lose a lot of what makes it work."

Swing quantization is not mentioned by the other interviewees, which indicates that this technique might be more common in some subgenres of EDM than others, including techno which usually favors a more rigid sounding rhythm. Yet, Martinsen, who represents this subgenre, mentions another way of working with microtiming, namely to rhythmically offset whole regions or sections of sounds—that is, to adjust the temporal placement, or start and end times, of sound *sequences* relative to the grid (as opposed to moving individual sounds). This technique, which is often called phrase offset or track delay, is conventionally used to "correct" the timing of a whole track in a mix by aligning it with the grid (and the other tracks) as a way to compensate for sloppy playing or recording latency issues. As several of the producers note, however, phrase offset or track delay may also be used as an expressive means of altering the rhythmic feel of a track by offsetting a sound sequence so that it is audibly behind or ahead of the beat. Although the sounding result can be similar to the effect derived from moving individual sounds off the grid or shuffling every other beat in a pattern, as discussed above, phrase offset or track delay also introduces consistency on a larger time scale, since the shift in time affects all of the sounds in the offset sequence. For example, if all of the sounds in the offset sequence

were initially hard quantized (so that they aligned with the grid), this technique will, according to Martinsen, add rhythmic friction to the track while retaining its "super quantized" machine aesthetic with "an immensely quantized clock running," as he puts it. The temporal intervals between each sound in the phrase here remain the same even as they are collectively skewed in relation to the rest of the rhythmic fabric.

Manipulating ~~IMING~~Timing ~~THROUGH~~Through Filters and Processing Effects

While Martinsen admits to sometimes using techniques for moving sounds temporally "off the grid" such as the phrase offset function, he continues to insist that he favors what he refers to as a "pure grid-based drum-machine aesthetic." He explains that when producing under the moniker Mental Overdrive, he makes most of his music by experimenting with analog drum machines, synthesizers, and effects on a modular setup without a computer. Although he then usually proceeds to record, arrange, and mix his sessions into more coherent tracks using a DAW such as Ableton Live, he likes to retain the rhythmic character of the drum machines in the end result. A grid-based aesthetic is very apparent in the drum tracks of "It's All Good," which were programmed on a classic Roland TR-808 drum machine. This machine features a step sequencer, which has a binary approach to drum programming that allows the musician to turn sounds on or off at the preset resolution of a bar divided into sixteen discrete steps with equal duration. In other words, this sequencer does not allow for any microtiming variations. The drums reveal no deviations from this metrical sixteenth-note grid, which implies that all of the drums in the track are quantized by the drum machine. Despite the fact that many of his tracks exhibit this strict on-the-grid aesthetic, however, Martinsen notes that he is nevertheless very concerned with timing at the micro level, which he manipulates through shaping the sounds themselves, not merely their relationship to the grid: "It is the small changes, the manipulation of details, that make the groove interesting and prevent it from being static," he explains. He often reshapes the sounds' amplitude envelopes by manipulating their attack or release phases through frequency filters, or he emphasizes certain parts of the envelope through changing its intensity dynamics. According to Martinsen, a sudden low-pass filtration of a hi-hat that allows low frequencies and attenuates all higher frequencies, or an extension of the hi-hat strokes' durations (from "tsch tsch tsch" to "tsssjich tsssjich tsssjich"), will alter the groove completely, even if everything else in the groove remains the same.

Such manipulation is evident in the second hi-hat of "It's All Good," introduced at 1:26. The hi-hat has been processed with an automated resonant high-pass or band-pass filter (which allows frequencies within a certain range and attenuates frequencies outside that range) across all of the sounds in the hi-hat pattern over time. As the filter moves, it emphasizes not only various frequencies inherent to the original hi-hat sound but also the resonance of the sound itself, resulting in an eerie and stirring "singing" voice in the otherwise static hi-hat sound. While this filter-sweep obviously changes the timbral character of the sound, the locations of the hi-hat strokes are not perceived as deviating

from the metrical grid. Yet the minute change in the intensity dynamics of the hi-hat sound over time still has a significant impact on the groove, in terms of shaping the physical duration of its envelope along with its intensity level. The attack and release phase of the sound is thus changed as a result of this filtration, which might in turn affect where its onset is perceived to be located as well. Overall, these small changes in the hi-hat animate the groove, subtly but clearly. This is one of several examples from the track that highlight how Martinsen's manipulation of the sounds' amplitude envelopes provides effective timbral and dynamic variation to an otherwise static rhythmic texture.

Several of the other producers also mentioned that they work with various processing effects to shape their grooves. For example, the TRXD members explain that they shape their grooves by manipulating the sounds' amplitude envelopes, as well as using equalizers for frequency manipulation, distortion for altering the distribution of harmonics, and reverb for spatialization. Among the sonic features that the producers mentioned most often as relevant to their shaping of grooves, however, is intensity dynamics. To Martinsen, the use of this processing effect is, in addition to track delay, the primary inroad to shaping the microtiming of his techno grooves, whereas to the other producers, this technique represents one among several strategies.

Manipulating ~~IMING~~Timing ~~THROUGH~~Through Intensity Dynamics

The producers all emphasize the importance of intensity dynamics for making a track groove, whether it involves balancing the relative volume between tracks within the overall production, varying the intensity level over time within a single phrase, or working with the dynamics of the individual sounds. To Martinsen, the dynamics of, and between, individual elements can be more important to a good groove than the sense of an "organic" timing or a "human touch" (meaning the nonquantized live recording with "sloppy" timing that retains the feel of a live performance, as described above): "Turn the volume a bit down, and then raise it again . . . lots of such tiny movements in the single elements change the groove completely." Two decibels in the *wrong* direction, according to Martinsen, can actually empty the groove of its vitality.

Martinsen is concerned with not only the static balance setting but also the experience of dynamic development or variation within a production (or within an individual sound in that production): "A good groove is, to me, an interplay between musical elements which somehow breathe together." He continues: "A poor groove is often reflected in an amplitude spectrum representing a flat volume envelope of the track as a whole."[42] An important aspect of his ideal of a "breathing" mix, as he calls it, is to allow enough room within a production for sounds to stand out when the track is played on a PA system in a club setting: "One of the most important things about groove is the gaps . . . If it [the track] is too busy, then the groove disappears, and you are left with a wall."

An effective means of shaping the dynamics of a production or an individual sound is dynamic range

compression. The compressor responds to and reduces the amplitude level of an audio signal that exceeds a set threshold by an amount selected with an attenuation ratio. Working as a complex volume controller, then, the compressor shortens the distance between a signal's peaks and valleys, thus reducing its dynamic range. The set attack and release times determine when the compressor starts and stops working, and, together with the threshold level and ratio, allow the producers to "remodel" the amplitude envelope of a sound over time.

Sidechain "Pumping"

All of the producers we interviewed say that they make moderate use of the common compression technique called sidechain compression or sidechaining.[43] In music production, sidechain compression is often used to create space for the various sounds in the mix, and to foreground sounds within the low-frequency and sub-bass area. For example, the frequency range of a deep kick drum might be masked by a synth bass or other low-frequency sounds that are occurring simultaneously. By using the kick drum as the trigger signal to a compressor that controls the amplitude of the other sounds, the interfering frequencies will be dynamically reduced (or "ducked") until the release control of the compressor allows them to reenter the mix.

Sidechain compression can, however, also be used more experimentally and overtly. The most obvious impact associated with the overt use of sidechain compression is the so-called pumping effect, or the audible and rhythmic changes in level caused by the compressor alternately attenuating and releasing a signal. Its most familiar iteration arises when the release time is set to a relatively long duration, thus causing an offset volume swell following the attenuation caused by the trigger signal. This technique is particularly emphasized by the TRXD duo and Berg from Seeb.

Berg explains that the way he and his Seeb partner, Eriksrud, often deploy sidechain compression is by trying to set the release of the compressor in temporal accordance with one or more of the off-the-grid patterns already established in the given track. When set just right, the dynamic off-beat swells resulting from the use of sidechain compression coincide with other rhythmic events and thus "work together towards emphasizing a slightly off-the-grid timing pattern," Berg explains. This is evident in their "I Took a Pill in Ibiza" project, for example, in which they have applied sidechain compression to most of the tracks in the mix. This includes all of those in the aforementioned "plucked" parts, which are visualized in Example 4a and can be heard in Example 4b. Whereas the use of swing quantization on these parts already influences the groovy feel of the track, the reshaping of the sounds' amplitude envelopes—the result of the sidechain compression kicking in on each quarter note (triggered, in this case, by the kick drum)—leads to a far more accentuated and rhythmically tilted flow. In its pre-processed state, the plucked synth has both a sharp attack and a tail of reverb to it, both of which are reshaped by the dynamics processing. This alteration is clear when we listen to the sequence between 0:10 and 0:29 seconds and compare the waveform with and without sidechain compression.

Twenty seconds into the track, the plucked synth takes on a different timing and energy when the sidechain compression is triggered by an inaudible trigger signal. This signal mimics the four-to-the-floor kick-drum pattern, so even though it is not audible at this point (it is introduced at 0:57), the kick drum is clearly felt due to the regular pumping sensation of the sidechained sounds. The envelopes of the plucks in the pattern, in turn, are shaped by the compressor in different ways due to their placement in relation to the trigger signal. In addition, because of the track's relatively slow tempo, listeners are likely to be quite sensitized to the particular ways in which sidechain compression produces microrhythmic variations (the plucked pattern is presented without sidechain compression before this sidechained version is introduced), and to the rhythmic tensions between the various sounds in the mix. This use of sidechain compression thus results in a distinct rhythmic effect whereby the attack of every note coinciding with the trigger signal is first attenuated and then released, in effect depriving those notes of their natural attack phases and the percussive "plucked" character of the sound; see the red rectangle in Example 4a. Sounds that appear right before the trigger signal, meanwhile, are abruptly cut off, including the tail of the reverb, allowing them to stand out from the rest of the pattern; see the blue rectangle in Example 4a. This rhythmic pattern was already dynamic even when it was uncompressed, but now, when processed by the compressor, its second, third, and fourth beats stand out as clear dynamic accents.

Atarodiyan and Dyrstad from TRXD explain that they also use sidechain compression to create dynamic variation. To them, sidechain compression is crucial to the feel of their music, because its subtle but effective dynamic swells in amplitude envelopes introduce what they described as a particular "bounce" to the groove. They further explain that their kick-drum patterns are often syncopated in line with urban and contemporary R&B rather than the typical four-to-the-floor beat of house and techno. Triggering sidechain compression with a syncopated kick-drum pattern rather than a regular quarter-note pattern introduces rhythmic variations in the volume swells that follow the attenuation, adding more complexity to the groove. Atarodiyan points out that a simple sustained bass note can be made groovy by processing it with sidechain compression triggered by a syncopated kick-drum pattern. The multitrack of their track "Jealous" (feat. Harper) bears this out. At the start of the first verse, a percussive bass synth attack is positioned right on the beat. When the kick drum is introduced, however, it triggers the sidechain compression and suppresses the initial transients of this bass sound, changing its character immediately. Because the bass and kick drum follow the same rhythmic pattern in this verse, the attack of every bass note is transformed from a percussive onset to a subtle volume swell, resulting in a sound more akin to a sustained bass pad. As a consequence, the perceived timing of this sound is also shifted slightly behind the beat.

In the chorus, on the other hand, the bass shifts to an eighth-note rhythm even as the kick drum continues to trigger sidechain compression following the same pattern as before. This introduces rhythmic complexity in the way in which the sidechain compression both mirrors the kick-drum pattern and creates a new accent pattern, as illustrated in Example 5a and heard in Example 5b.

Whereas the bass strokes that coincide with the kick drum are deprived of their natural attack points—see the red rectangle in Example 5a—the bass strokes between the kick drum hits are not and therefore become off-beat accents. The only stroke left to articulate the pulse without being compressed is the fourth beat; see the green rectangle in Example 5a. In all, this sudden shift in emphasis and accentuation creates a syncopated and dynamic feel, despite the fact that the original MIDI pattern of the bass part is programmed as a dynamically flat line based on quantized eighth notes.

The hi-hat in this track, visualized in Example 6a and heard in Example 6b, is similarly programmed consistently in a strict grid of eighth, sixteenth, and thirty-second notes without dynamic accents. To create dynamic variation in the pattern, a subtle amount of sidechain compression is triggered by the kick drum, which leads to a decrease in the amplitude of every hi-hat stroke that coincides with the kick. As a consequence, the kick and the hi-hat become complementary rhythmic layers—that is, the pronounced strokes in the hi-hat pattern fall in the gaps between the kick-drum strokes. This sidechain compression of the hi-hat contributes to a new pattern that presents as both more dynamic and more dialogical.[44]

TIMING AS SOUND—SOUND AS TIMING

The interviews and analyses above demonstrate that deviation from the grid is important to EDM producers. The producers' concern about the relative rigidity of the music is an interesting finding in the context of a genre otherwise thought to be extremely grid based. The actual deviations themselves remain minute, though, especially in relation to those found in other groove-based genres. They are mostly within the range of thirty milliseconds or so, which raises important questions about how these variations are actually experienced, and to what degree they affect the quality of the groove. We conclude that they have effect at different levels: whereas some of the analyzed temporal deviations in the EDM tracks audibly undercut the grid, others are not heard as a specific change in timing but rather as a change in overall feel. And if they are very minute indeed, they might even be heard as primarily a dynamic or timbral change—that is, as sound.

Just as timing manipulation can be heard primarily as a change in sound, sonic manipulation can be heard primarily as a change in timing. As is reported above, the producers see sound and timing as intrinsically related, and sound choice and sound manipulation as important to the final result. The producers' emphasis on shaping the sounds and their relationships in the right way recalls the results of several perceptual experiments wherein sound and timing were found to be intrinsically related in various ways. In particular, the scholarly practice of equating onset timing with the perceptual location of rhythmic events has been challenged by research into the perceived timing of auditory events. Both in music and in speech, the shape of the attack phase of a sound, for example, is one important influence upon its perceived timing.[45] This reciprocal relation between temporal and frequency-related

aspects of sound at the micro level of rhythm means that altering sonic features may cause a change in the perceived timing, and vice versa. Moreover, below a certain threshold—one that will vary considerably with context, including tempo and genre expectations[46]—it is indeed impossible to distinguish between the two. This more "holistic" way of hearing and manipulating microrhythm sheds new light upon groove creativity in the EDM genre.

Our interviews revealed that EDM producers have several strategies for achieving the subtle rhythmic friction needed for an EDM track to groove and point to the often-overlooked microrhythmic complexity of EDM grooves. In general, making parts of their music *looser* timing-wise represented a clear priority for these producers. They did so in a variety of ways: recording manually played audio and MIDI parts, sometimes with intentionally flawed timing, and abstaining from correcting them with quantize functions; manually moving the placement of individual sounds in a sequencer program slightly off the grid, or distributing compound sounds around the grid; applying swing quantization; using phase offset/track delay or similar functions to move a sound sequence or an entire track slightly forward or backward; and manipulating sounds' envelopes, including their attack times as well as their intensity and dynamics, by using filters, volume faders, and sidechain compression.

Some of the approaches to shaping the groove discussed above were mentioned by several producers, whereas others were highlighted by only a few. It appears that certain techniques are more common in some subgenres of EDM than in others. Swing quantization, for instance, might shape most tropical house grooves but relatively few old-school techno grooves, and producers working with techno grooves might be less concerned with sloppy playing and careful positioning of sounds than producers making tropical house, house, and electropop. However, such a conclusion would require a closer inspection of music by several artists within a given genre and/or more interview data from those artists. What the present findings clearly show, though, is that EDM producers *across* different subgenres regard sound and timing as intrinsically related and emphasize the importance of shaping timing through sound. In short, though EDM may indeed be grid based, the articulation of the grid is in flux.

It would be hasty, however, to conclude that a good groove *requires* such timing manipulation. What we have demonstrated, instead, is that EDM producers are very concerned with both timing and sonic variations, and that they actively shape them through a range of operations. We have also learned that producers find it hard to distinguish between these two aspects—sound and timing are almost perceptually inseparable in this genre, and both contribute to energizing EDM grooves.

The producers we interviewed often used metaphors involving living organisms when describing their ideal grooves, such as, a "breathing" mix, "body music," or an "energetic" or "sexy groove."[47] Such descriptions represent a marked departure from robotlike dance music produced by means of early drum machines and sequencers with limited micro-level flexibility, such as the legendary Kraftwerk

albums *Man-Machine* (1978) and *Computer World* (1981). The use of such metaphors could, of course, be simply an attempt to humanize a genre that has often been used to exemplify the nonhuman standardization of (commercial) popular music. As Danielsen points out, the division between so-called human and machine aesthetics in rhythmic design within 1970s popular music probably still informs the abiding understanding of why rhythmic patterns consisting of grid-ordered events are experienced as lacking a human touch even when they are produced by a human and contribute to bodily movement on the dance floor.[48] Loose timing, in turn, tends to evoke associations with actual human performance, even when those patterns and variations have been generated by a computer. However, our interviewees' preference for references to the human body rather than to the machine, likely also testifies to the ways in which rhythmic properties, embodiment, and pleasure are interrelated components of groove (as pointed out above), and to the profound rhythmic complexity of contemporary EDM grooves exceeding the machinistic. This complexity cannot be reduced to discrepancies between a virtual reference structure and the actual onsets of sounds alone but must also be made to encompass the intrinsic and complex relationship between timing and sound, including the shape and intensity of the individual sounds.

1 In this article, EDM does not refer to any specifictechno-centric music style but works as an umbrella term encompassing several subcategories of stylistic differences, which is how the term has been used by scholars such as Butler (2006) and Taylor (2001).

2 Butler (2014, 188).

3 Merriam-Webster Dictionary Online (n.d.).

4 Câmara and Danielsen (2018).

5 See, for example, Danielsen (2006) and (2010); Johansson (2010); Kvifte (2007); Polak (2010); Polak and London (2014).

6 For research sharing this theoretical premise, see Bengtsson et al. (1969); Clarke (1989); Danielsen (2006); Desain and Honing (1989); Keil (1995); Kvifte (2004), London (2012).

7 See, for example, Ake (2002); Benadon (2006); Bengtsson and Gabrielsson (1983); Butterfield (2006) and (2011)~~(2011)~~; Câmara and Danielsen (2018); Danielsen (2006~~, 2012~~). {**Comment by Author:** Have tried entering Danielsen (2012) again to make the year appear blue (answering Q8), but nothing happens when I try. It should say Danielsen (2006) and (2012) with both in blue. }; Iyer (2002); Keil (1995); Kvifte (2004); and Monson (1996).

8 Keil (1987, 275).

9 Prögler (1995).

10 Butterfield (2010).

11 Janata et al. (2012).

12 Janata et al. (2012).

13 Butterfield (2010); Davies et al. (2013); Madison et al. (2011).

14 Matsushita and Nomura (2016); Senn et al. (2016); Skansaar et al. (2019).

15 Skansaar et al. (2019); Danielsen et al. (2015b); Kilchenmann and Senn (2015).

16 Rietveld (2018).

17 Dibben and Solberg (2018); Solberg (2014); Solberg and Jensenius (2017). Within the EDM context, "the drop" refers to the section of a track that, as described by Karthik Yadati et al., "occurs after a *build*, a building up of tension, and is followed by the re-introduction of the full bassline" (2014, 143). See also Nippard (2015).

18 See, for example, Butler (2006); Zeiner-Henriksen (2010b); Witek et al. (2014); and Sioros et al. (2014).

19 ~~Keil (1996, 341).~~ ~~(Keil, 1966)~~ (Keil, (1966, 341)

20 Benadon (2006, 73).

21 Stupacher et al. (2016).

22 Brøvig-Hanssen et al. (2020); Danielsen et al. (2019); Gordon (1987); Vos and Rasch (1981); Wright (2008); Zeiner-Henriksen (2010a).

23 Braun and Clarke (2006).

24 The chosen producers provided us with multitracks and project files for recordings that they consider to be representative of their music as well as interesting in relation to the groove. Coincidentally, these tracks fall within a limited bpm range: primarily 100 bpm except for TRXD's track, which, with its half-tempo feel, runs at 70 bpm. All but one, then, present the tempo that people tend to prefer when asked to tap at a comfortable speed. As Justin London argues, the durations of the quarter notes at that tempo "strongly give rise to a sense of beat and afford sensorimotor synchronization" (2012, 62). We will leave to a subsequent study the analysis of tracks at the slightly faster tempo that is typical of the trance and house subgenres of EDM.

25 Quantization is a feature in a digital sequencer that is often conceived of as a timing "correction"

function, since it eliminates imprecisions according to the sequencer program's metrical grid. Quantized rhythms are, as Butler puts it, "spaced with mathematically perfect evenness and consistency" (2014, 187–88).

26 TRXD's "Jealous" (feat. Harper) can be accessed at https://open.spotify.com/album/7ABu6SQQwNvzOTSE6gRUEu or https://www.youtube.com/watch?v=LDjym-aJpZg. The track features on the soundtrack of the Norwegian film*Battle* (2018), directed by Katarina Launing and written by Karsten Fullu and Maja Lunde.

27 Charlotte Bendiks's remix of Rudow's "Manifesting the Unreal" can be accessed at https://tiep.bandcamp.com/track/manifesting-the-unreal-charlotte-bendiks-manifest-this-mix or https://www.youtube.com/watch?v=I1eaFNAeFK4.

28 Seeb's remix of Mike Posner's "I Took a Pill in Ibiza" can be accessed at https://open.spotify.com/album/31VgmdtmYLMb31XhP3RPVc or https://www.youtube.com/watch?v=foE1mO2yM04.

29 Mental Overdrive's "It's All Good" can be accessed at https://mentaloverdrive.bandcamp.com/track/its-all-good or https://www.youtube.com/watch?v=VrvN1Rwulhc.

30 Robert Strachan defines DAWs (digital audio workstations) as "all-in-one applications installed on computers, which provide a visual interface and collection of functions whereby recording, sound generation, editing and mixing are able to be undertaken within a singular virtual environment" (2017, 7–8). As such, the DAW is a sequencer—an application software that can record, edit, and play back sounds—but one that is specifically computer based with the possibility of both audio recording and MIDI interface, and is usually more complex than the sequencer of early drum machines and synthesizers, for example. Examples of DAWS are Ableton Live, ProTools, and Logic.

31 Povel and Okkerman (1981); Tekman (2002).

32 Sound intensity also influences perceived timing, generally moving it either earlier or later in relation to actual onset. The direction varies with the musical context; see, for example, Danielsen et al. (2015a) ~~and~~, ~~(~~Câmara et al., (2020a), and ~~(~~Câmara et al., (2020b) ~~(Câmara et al., 2020) (Câmara et al., 2020) Câämara et al. (2020a, 2020b)~~. Perceptual experiments have also shown that sounds with dynamic accents are perceived as longer in duration than nonaccentuated sounds; see Tekman (2001); Waadeland (2006).

33 Sidechaining involves a compressor that uses two input signals instead of one: a main input signal and a sidechain input signal. When the latter signal, often referred to as the "trigger" signal, surpasses the threshold, it activates the compressor, which attenuates the amplitude of the main signal. When the

trigger signal falls below the threshold of the compressor, the main signal returns to its original level. The attack and release times of the compressor dictate how fast the onset and offset of this attenuation occurs.

34 Due to copyright concerns, all sound examples are remakes based on the original sound files shared by the producers.

35 Clarke (1989).

36 See footnote 17 for an explanation of "the drop."

37 See, for example, Brøvig-Hanssen and Danielsen (2016) and Danielsen (2019).

38 This track became the second most-streamed single worldwide on Spotify in 2016 and had a significant impact on the sound of EDM, especially with regard to its use of "vocal chops"—that is, fragmented vocal samples that are juxtaposed, rearranged, and re-pitched, and that often occur in the drop section of the song.

39 See Câmara and Danielsen (2018) and Danielsen et al. (2015b).

40 Danielsen (2010).

41 Swing as described here is in principle related to swing in jazz in that it introduces a pattern of subdivision units with unequal duration to the groove. However, the sonic result is often quite subtle and does not resemble a swing groove in the sense of jazz.

42 An amplitude spectrum is a visualization of the musical frequencies' amplitudes distributed over time (i.e., a loudness graph). A flat amplitude spectrum basically indicates that every frequency in the spectrum is set to be played at the same amplitude, without variation.

43 See footnote 33 for an explanation of this technique.

44 For further discussion of Seeb and TRXD's use of sidechain compression, and of the rhythmic effects of dynamic manipulation more generally, see Brøvig-Hanssen et al. (2020).

45 Danielsen et al. (2019); Gordon (1987); Vos and Rasch (1981); Wright (2008).

46 Clarke 1989.

47 For a discussion of organicist metaphors in analyses of music, see Solie (1980) and Walther-Hansen (2020).

48 Danielsen (2019, 596–98).

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7. **Query:** [AQ7] - : Please provide complete details for (Keil 1996 and Cämara etal. 2020a, 2020b) in the reference list or delete the citation from the text.

   Response: [*Author - Brovig-Hanssen: ragnhild.brovig-hanssen@imv.uio.no*]: Have added the references and cited them in the text. Keil 1966 in footnote 19, and Câmara et al. 2020a and 2020b in footnote 32. I had to create the references manually because the editor would not validate them despite providing correct doi, so it took some attempts. Hopefully it is correct now?

8. **Query:** [AQ8] - : There is no mention of (Butterfield 2011, Danielsen 2012) in the text. Please insert a citation in the text or delete the reference as appropriate.

   Response: [*Author - Brovig-Hanssen: ragnhild.brovig-hanssen@imv.uio.no*]: Both of these were already mentioned in footnote 7, but with the years not in blue but in grey. I think i managed to fix Butterfield (2011), but were unsuccessful in entering Danielsen 2012 again. See comment in footnote 7.

Comments

1. **Comments** [Author - 9/2/2021 6:15:20 PM]: Have tried entering Danielsen (2012) again to make the year appear blue (answering Q8), but nothing happens when I try. It should say Danielsen (2006) and (2012) with both in blue.