The Salience, Shapes, and Functions of Continuous Processes in Contemporary Electronic Dance Music

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Abstract

This dissertation examines the salience, shapes, and functions of continuous processes in contemporary electronic dance music (EDM), providing an analytical framework for discussing their structural and aesthetic roles in this repertoire. Continuous processes are musical gestures with continuous changes to musical parameters, rather than discrete, “step-by-step” ones. Examples include glissandos, crescendos, fade-ins, accelerandos, and filter sweeps. Most of the music discussed is from the 2010s, and from the large category of genres under the umbrella of house and trance. All the music referenced is available for listening through the supplemental files for this dissertation.

The dissertation develops a multifaceted approach to the analysis of continuous processes in EDM. First, continuous processes are categorized according to their length and parameter altered (chapters 2 and 3), then according to their shape as compared with mathematical functions (chapter 5), then according to their musical functions as providing orientation, disorientation, ornamentation, and/or intensification (chapter 6). Continuous processes often provide sonic instructions for dancers. For example, “uplifters” (ascending pitch slides) in buildup sections create a sense of tension in listeners, and an expectation that a highly-energetic main section is coming up. Conversely, “downlifters” signal that the energy of the track is decreasing and that dancers can take a break. Continuous processes can also have specific semiotic meanings, as is shown in the hermeneutic analyses of two tracks by Deadmau5 and The Chemical Brothers in chapter 7.

Throughout the dissertation, nine analytical guidelines for comparing continuous processes in terms of their salience are outlined gradually. These add another dimension to the analysis of continuous processes, making explicit the kinds of foreground-background parsing involved in listening and pointing towards how continuous changes saturate EDM with multiple levels of prominence.

Existing analytical scholarship on EDM has focused on discrete processes, especially the sudden addition or subtraction of sound layers. Certain types of continuous processes have been explored, but they have not previously been discussed systematically. This dissertation adds to existing scholarship by drawing attention to the many roles of continuous processes in EDM, and showing how they contribute to the emotional waves experienced when listening to this music.

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Chapter 1 – Introduction

Producers and fans of electronic dance music (EDM) describe the experience of listening to this repertoire as like riding emotional waves. The superstar producer Armin van Buuren, who works in the EDM genre of trance, says that "Trance music is all about release. It's about energy. It's about emotion… It's like a wave. You're a surfer."[1] Similarly, Rick Snoman, author of the seminal *Dance Music Manual*, says that all dance music "deals mostly in emotional waves, consisting of building and dropping the arrangement to generate an emotional state in the audience."[2] The narratives of contemporary EDM tracks are based on the fluctuations of sonic energy levels, the alternation of buildups and climaxes, and the oscillation between tension and release. What musical components participate in these narratives, creating varying degrees of tension in EDM?

Butler states that EDM listeners correlate tension and energy levels with texture changes.[3] Tension is highly linked with the withholding of the beat and specifically the kick drum. The presence or absence of this low drum sound, and its entrance or exit from the texture, is highly important in determining the function of different sections in the track and their tension levels.[4] Butler and Hawkins both also associate tension with metric irregularity and metrical dissonance.[5] Polyrhythms, syncopation, and displaced rhythms are all very important in EDM and contribute to its complexity and intensity

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[1] "MasterClass | Armin van Buuren Teaches Dance Music" (2018, lesson 17, 0:00–0:30).
[2] Snoman (2009, 269).
[3] Butler (2006, 221).
[4] Ibid. (91, 247).
[5] Butler (2001); Butler (2006, 138–175); Hawkins (2003, 92–94).

throughout various tracks. Another common technique that increases tension in “buildup” sections is the snare-drum “roll” or “fill,” when percussive sounds such as snare-drum hits become closer and closer together until it almost sounds like a drum roll.[6] All three of these techniques can be described as discrete processes, since they involve the sudden entrance or exit of a sound layer, or the repetition of discrete sounds in a stratified texture.[7] The snare-drum roll is an example of discrete acceleration, since the “speeding up” takes place in various stages of rhythmic diminution, such that the rhythmic values become twice as fast in each new stage.

However, *continuous* processes also contribute significantly to the increasing and decreasing of tension and energy levels in EDM tracks. By continuous processes I mean musical gestures produced with continuous changes to musical parameters.[8] Examples include pitch slides (glissandos), crescendos, fade-ins, accelerandos, filter sweeps (which continuously change the cutoff threshold of frequencies that are being filtered out of sounds), and timbre changes (accomplished through continuous manipulation of sound envelopes and/or frequency content).[9] This dissertation examines the salience, shapes, and functions of continuous processes in contemporary EDM, and provides an analytical framework for discussing their musical and aesthetic roles in this repertoire.

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[6] Snoman (2009, 252, 266–268); Solberg (2014, 70).
[7] Butler describes the importance of heterogeneous, stratified textures in EDM generally. Butler (2006, 93, 182, 224).
[8] I am using the word “processes” to describe these phenomena rather than “motions” because it describes both continuous and discrete techniques better as an umbrella term. However, “motions,” “gestures,” or “changes” are also useful words for the techniques I describe, especially continuous ones, and therefore I also use them occasionally.
[9] The most common way of altering the characteristics of a sound envelope to change timbre is through changing the ADSR (attack, decay, sustain, release) envelope for amplitude. The most common way of changing the frequency content of sounds is applying filters. Holmes (2012, 226–229).

I am using the word continuous rather than gradual to describe these processes because the term gradual is usually used with less specificity.[10] The precise definition of the word, based on its etymology, says that a gradual process occurs not only slowly, but by degrees. Continuous processes can occur slowly or quickly, but they have no gaps or breaks, just like continuous lines or curves in mathematics, whereas discrete processes occur in a step-by-step fashion, with clear dividing lines between each step. Other binary oppositions can also be invoked to describe distinctions between discrete and continuous phenomena, such as: quantitative vs. qualitative, digital vs. analog, combinatorial vs. holistic, particulate vs. wave-based, and lattice-based vs. morphological.[11] I have chosen the terms discrete and continuous for simplicity and clarity.

Figure 1-1 shows some visual representations for continuous and discrete processes. Both continuous processes and discrete ones are crucially important to the aesthetics of EDM. This dissertation focuses on continuous processes because they have been understudied in analytical scholarship on this repertoire, but I am not aiming to ignore or exclude discrete ones, such as scalar melodies, chord progressions, and the sudden addition or subtraction of new sounds into the mix.

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[10] I am also not using the term processes or gradual processes in the sense that Reich describes, as the gradual unfolding of entire pieces. Reich (2002).

[11] Middleton (1990, 215, 269); Wishart (1996, 15–16, 31, 108).

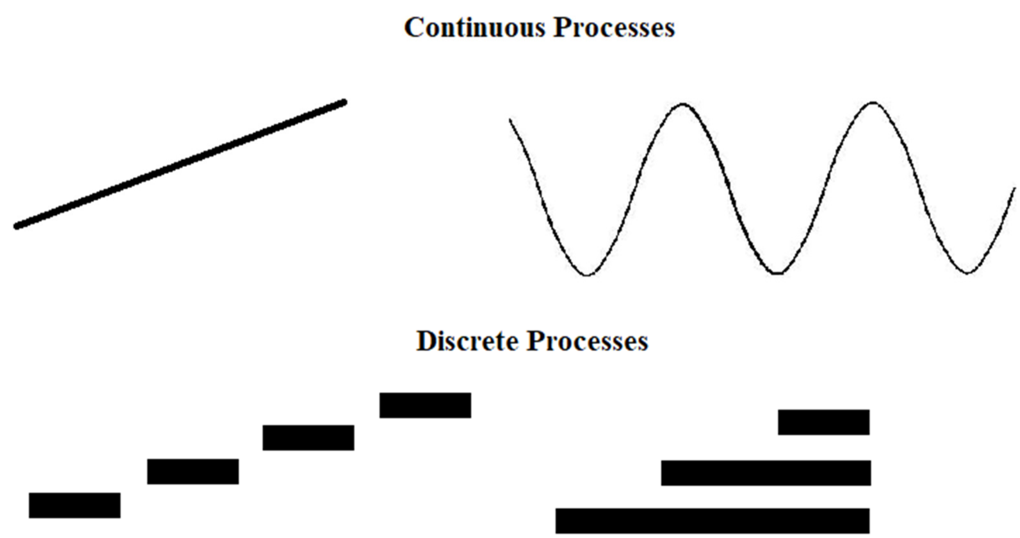

Figure 1-1. Visual Representations of Continuous and Discrete Processes.

Using the terms continuous and discrete to describe musical processes raises important questions. It is useful to uphold this binary opposition, but the opposition can also be problematized. How does one decide whether a musical process is continuous or discrete, how long a single process is, which sound it pertains to, and which aspects of that sound are changing? Most of the music I am analyzing was produced digitally, and therefore computers understand it discretely. Processes like glissandos, however, are perceived by human listeners as continuous.[12] This is because of the principles of Gestalt psychology. Specifically, the principles of proximity and similarity allow us to perceive continuous changes as part of a whole musical object that exhibits good continuation.[13] In general when I classify something as a continuous process, it is because I am *perceiving*

[12] Bregman (1990, 133–136).
[13] Ibid. (196–203).

it changing continuously, with no breaks or gaps. There are some processes that do not clearly or consistently fit into either the discrete or the continuous category. For example, the rate of change for a continuous gesture could be so fast that it is almost (but not totally) perceived as happening instantaneously. Cases like these, and adjustments to the rate of change to make processes sound more discrete or more continuous, will be discussed at the end of chapter 3.

For the purposes of this dissertation, I will say that one continuous process pertains to what is perceived as one parameter being changed in one sound layer. EDM is constructed of many sound layers, including fundamental rhythmic layers such as the kick drum, snare drum, and hi-hat, melodic layers such as bass lines and "leads," and harmonic layers such as synth "pads." In professionally-produced tracks (pieces), each of these layers often comprises multiple sounds with slightly different characteristics,[14] but I will consider each sound layer as a single entity that could have continuous processes such as a pitch slides, crescendos, accelerations, or filter sweeps applied to it. The distinctions between different sound layers are based on auditory scene analysis using the Gestalt principles of similarity, proximity, closure, and good continuation.[15] In EDM, these distinctions are made especially with respect to different timbres and rhythms. Sometimes it is difficult to discuss continuous processes as happening to a specific sound layer though, because sound layers can gradually merge together or separate perceptually.

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[14] For example, in lesson 11 of Deadmau5's video masterclass on masterclass.com, he creates a unified kick-drum sound out of three duplicated kick-drum sounds, each of which is slightly modified to have different frequency content, and different ADSR envelopes. "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 11).
[15] Bregman (1990); Meyer (1956); Tan, Pfordresher, and Harré (2018, chap. 5).

Often, multiple musical parameters are adjusted in one sound layer at the same time. Usually I will consider the alteration of each individual parameter as a separate continuous process. For example, if a sound layer undergoes a crescendo, a pitch slide, and a filter sweep, these will be discussed as three separate continuous processes applied to one sound. However, sometimes it is difficult to hear the different effects of these processes individually, and the actual parameters changed lead to perceptual changes in different parameters. This will be discussed further in the next chapter. If multiple sound layers with clearly distinct timbres undergo the same type of continuous process (for example, if a crescendo is applied to many layers in the mix) then I may group these continuous processes together in my discussion, even though I am aiming, for consistency, to treat the crescendo in each layer as a separate continuous process.

The starting point and ending point of a continuous process can also be difficult to determine. In general I will say that one continuous process lasts until the continuous change is no longer clearly audible, or until the next clear marking point (determined by meter and phrase structure) occurs in the music, which may encourage a reading of a single continuous gesture as being split into multiple parts. For example, an ascending and descending pitch "wave" may be understood as a single process if both parts take place within a single phrase, measure, or beat, but it will be more easily understood as two separate processes if the ascent takes place over eight measures and the descent takes place over the next eight measures, in a different phrase or formal section of the track.

A group of continuous processes may also be part of a longer process that is not entirely continuous, for example if a long pitch slide is broken up into clearly separated segments (by a plateau in the shape of the slide, whether it is sounding or silent) that all help build towards a climax point. There is no perfect way of discussing continuous processes that will always be consistent, since analysis of these sound phenomena is subjective. As I will discuss more in chapter 4, everything in the universe could be thought of as entirely discrete or entirely continuous,[16] and it is sometimes difficult to apply these labels to musical processes.

In studio-produced EDM, every aspect of the music is precisely programmed, so continuous processes always have clear starting and ending points, and in the studio it is easy to identify which sounds and which parameters are being changed continuously. However, I do not have access to files of the pieces in production software, so I will discuss these pieces based on my own perception and, in some cases, the descriptions of others' perceptions in personal discussions or published materials.[17]

Context: Literature Review

In this dissertation I use electronic dance music (EDM) as an umbrella term for a style of popular music that uses electronically-produced sounds, clearly-articulated beats, and repetitive loops to establish groove. I use the term EDM in this way, as is standard in scholarship, despite the acronym being used more specifically in recent years by the North-American music industry, which generally uses it to refer to more mainstream, "radio-friendly" dance music based on the genres of trance and progressive house.[18]

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[16] Grant (2013, 70–71); Heller-Roazen (2011, 131–140); Petkov (2007); Wishart (1996, 54).
[17] For example, I have asked local electronic musicians, producers, and audio engineers for their opinion on specific techniques used in many of the pieces I discuss. I also utilize resources such as EDM magazines, news websites, and discussion boards. One particularly valuable resource has been Deadmau5's masterclass on masterclass.com.
[18] Wright (2017, 25–26).

Musical groove encourages body movement, and therefore EDM is usually accompanied by physical movements such as dancing, running, or walking.[19] For this reason, EDM can be linked with dance music throughout history, and it has stylistic similarities with other forms of dance music such as the gigue, ballet, tango, samba, and others from many different time periods and places around the world. EDM adds contemporary electronic sounds such as those produced by synthesizers to this dance-music tradition.

The term EDM, however, encompasses a wide variety of music that is heard in many different contexts, some of which involve little to no dancing. Much of the literature on EDM has focused on underground club and rave culture, since these contexts are where the music originated and are still an important part of EDM as a whole today.[20] In recent years however, EDM has branched out and become associated not only with clubs and raves, but also with mainstream commercial music, as evidenced by superstar artists such as Deadmau5 (pronounced "dead mouse"), The Chainsmokers, and Calvin Harris, who routinely perform for sellout audiences at individual concerts or EDM festivals, and who have each had albums sell hundreds of thousands of copies. The availability of music through digital libraries and streaming services has made EDM easily available not only for dancing at clubs, parties, or weddings, but also for working out at a gym, walking around a city, or listening intently at home, without dancing. Sometimes different contexts for listening are linked with different genres of EDM.

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[19] For discussions on groove in popular music generally, see Butterfield (2006); Danielsen (2006); Fink (2011); Madison (2006). For discussions on how groove encourages body movement in dance music, see Butler (2006); Danielsen (2010); Wiltsher (2016b); Zeiner-Henriksen (2010b).

[20] Farrugia (2012); Garcia (2011); Malbon (1999); Reynolds (1998); Reynolds (2012); Thornton (1996).

There are many different genres under the EDM umbrella.[21] Although EDM is known for having an absurdly high number of genres and subgenres that "mutate" and evolve (with new labels being created regularly),[22] using genre distinctions, especially the more general ones, is still useful in providing context for the music analyzed in this dissertation, since genre labels have a basis in not only musical structure but also social and economic structures.[23] Some genres of music push the boundaries of the EDM umbrella. For example, IDM (intelligent dance music) is seen as more artistic than most EDM genres. It "evokes dancing without encouraging it," and is therefore often listened to but not danced to.[24] Conversely, much of today's "top 40" pop music could be classified as a type of EDM (often just called the "dance" genre), and it is heard by millions of listeners in cars and shopping malls, as well as through phones, smartwatches, and digital personal assistants. The boundaries between EDM and "top 40" pop music have also become blurred, since many musical characteristics of EDM, including some of the most salient continuous processes occurring in "buildup" sections, have been adopted in mainstream pop music.[25] One example of a specific genre that is linked with its most common listening context is "big room," which has developed in the 2010s for large EDM festivals, concerts, or clubs.[26]

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[21] For an in-depth description of many EDM genres see Snoman (2009, chaps. 11–18).
[22] A good summary of scholarship on genres in EDM is provided by Wiltsher (2016a, 416–419).
[23] For more discussion of genre in popular music, see Drott (2013); Frith (1996); Johnson (2018); Negus (1999).
[24] Wiltsher (2016a, 416).
[25] Peres (2016).
[26] For more information on EDM festival culture see Redfield and Thouin-Savard (2017, 54); Ruane (2015); Schmidt (2015); St John (2017).

The examples in this dissertation are from tracks covering a wide part of the EDM spectrum. Most are from the large category of genres and subgenres of house and trance (including electro, progressive, big room, acid house, deep house, and future house), but some are from other genres like techno, drum and bass, IDM, or pop. House and trance are known for their "four-on-the-floor" drum pattern (with a kick drum sounding on every beat) and a tempo of roughly 120–130 bpm (beats per minute). Trance and progressive house in particular are the EDM genres most closely linked with mainstream commercial music, large festival performances, and the more specific usage of the acronym EDM in the North-American music industry.[27] I have chosen to focus on these genres in order to highlight the importance of EDM in mainstream culture today, to make the dissertation more unified, and because of my familiarity with them. However, continuous processes are important techniques that are used in all parts of the EDM umbrella.

Another distinctive aspect of EDM is the ontological fluidity of musical pieces or "works." Théberge notes how the "infinite malleability" afforded by sequencing and arranging tools challenged the concept of a single authoritative version of a song.[28] Producers create original versions of tracks, but it is understood that they will often be remixed in other studios or improvised with and combined with other records by DJs in live performance.[29] Remixes, covers, and mashups are increasingly common in popular

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[27] Wright (2017, 25–26).
[28] Théberge (1997, 229–230).
[29] For example, Butler describes the creation of the "third record" when two records are matched successfully in DJ performance. Butler (2014, 40–41).

music today.[30] Deadmau5 describes how he and other popular artists sometimes release the "stems" of a track (files that contain the basic elements of a track such as the drum, bass, harmony, and "lead" melody part), to collaborative websites where fans can study them and use them to create remixes.[31]

Based on his ethnographic work with producers and DJs, Butler has developed a three-pronged approach to labeling EDM in various contexts.[32] First, "works" are "abstract conceptualizations of musical identity."[33] Different versions of the same "piece" are considered variations on the same work. Second, "texts" are "material instantiations of ontic entities."[34] Texts are objects that inscribe fixed musical material such as scores, records, or software files.[35] They can be utilized in various ways, including Butler's third category, "performances." Each performance is unique, and in EDM performances involve the appropriation, alteration, and combination of various texts and works.[36] Texts can be used not only to create different versions of the original work that they are attached to (remixes), but to create new works through the use of sampling, which takes specific parts of a text and places them into new contexts.[37] Ratcliffe has proposed a typology of sampled material in EDM, from short fragments to long sections or entire tracks.[38] In this dissertation I analyze various studio-produced tracks as fixed texts, some

[30] Moorefield (2010).
[31] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 14: Remixes).
[32] Butler (2014, chap. 1).
[33] Ibid. (35).
[34] Ibid.
[35] Ibid. (38–40).
[36] Ibid. (39–56).
[37] For more information on sampling in popular music generally, see Adams (2015); Harkins (2010); McLeod and DiCola (2011).
[38] Ratcliffe (2014, fig. 1).

of which are original mixes and some of which are remixes. Most are part of the mainstream music market and have been released on albums for the general public to listen to.

Compared to the large amount of scholarship on EDM culture, analytic literature on the musical aspects of EDM has been scarce, especially in North-American music theory. However, certain themes have arisen in this small body of literature. One area of focus has been rhythm and meter. This was written about extensively in the early career of music theorist Mark J. Butler, who showed that the interaction of many sound layers in EDM often creates ambiguity of interpretation.[39] Two of his most important contributions to the field in this time were the identifications of "turning the beat around" and "embedded grouping dissonance."[40] The former phenomenon occurs when a new sound such as the kick drum enters the texture and causes a reinterpretation of a previously established metrical groove. The latter is an extension of Krebs' metrical dissonance theory and arises when there is: "(1) the simultaneous presentation of multiple grouping dissonances; (2) the presentation of grouping dissonance at multiple metrical levels; and (3) a causal relationship in which the cyclical non-congruence of the lower-level dissonance generates the larger dissonance."[41] Other scholars have written more explicitly on the connections between the rhythm and meter of EDM and body movement,[42] or on the possibilities afforded by precise quantization in EDM.[43]

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[39] See especially Butler (2006, chap. 3).
[40] Butler (2001); Butler (2005).
[41] Krebs (1999); Butler (2005, 232).
[42] Hawkins (2003, 84–97); Zeiner-Henriksen (2010a).
[43] Brøvig-Hanssen (2010); Brøvig-Hanssen and Danielsen (2016, chap. 5).

Another theme of analytical EDM scholarship has been how formal structures of individual tracks and entire DJ sets create narratives that are crucial to the aesthetic experience of the music. Central aspects of this are tension and release, heightened expectation leading towards climaxes, and a narrative of disorientation followed by clarification.[44] EDM is based on the alternation of dancing sections, which have high levels of energy and groove,[45] with non-dancing sections that either buildup or release tension and often lack consistent beats.[46] I will call the former, dancing sections "cores," and the latter, non-dancing sections intros, outros, buildups, and breakdowns.[47]

During core sections, the music has a thick texture of many sound layers that loop repeatedly and coordinate to create a clear beat and a groove. But grooves cannot last forever; listeners grow weary of pounding beats and incessant melodic "hooks," and dancers run out of stamina. This is why the other sections are needed. Intros and buildups are goal-oriented and transitional, mounting the tension until it spills over at the beginning of the core. In contrast, breakdowns and outros occur right after core sections, decreasing the energy by taking away sound layers that contributed to the vitality of the core. Buildups usually end with an anacrustic "cue" that lasts for four beats or less. Cues are distinctive and highly salient. Sometimes they are only one sound such as a clap or

[44] Butler (2006); Butler (2014); Eigenfeldt and Pasquier (2013); Hawkins (2003); Redfield and Thouin-Savard (2017); Solberg (2014).
[45] I use the terms "energy" or "energy level" as alternatives to "intensity," since the latter could be confused with tension. By tension I mean the uncomfortable sense felt in listeners during buildup sections and sometimes breakdown sections. The tension created in a buildup section is released at the start of the next core, which is filled with intensity, not tension.
[46] The "non-dancing" sections can still usually be danced to because a clear beat is usually still articulated, but these sections are marked by *not* being cores. They are associated with instability and transition.
[47] The term "core" in this context was coined by Butler (2006, 221–224). The other terms are also used by him, but are common parlance in EDM culture.

snare hit, other times they are short percussive motives. Often they come in the form of vocal speech samples (sometimes using the title of the track) even in an otherwise entirely instrumental piece.

A typical instrumental EDM track will have two or three core sections, so a prototypical example of the form would be: intro, buildup 1, core 1, breakdown, buildup 2, core 2, outro. The final core is often more energetic, with a thicker texture, and it is usually preceded by the most intense buildup. This is seen in Butler's diagram of a prototypical EDM track (Figure 1-2) and the producer Snoman's "typical song map" (Figure 1-3).

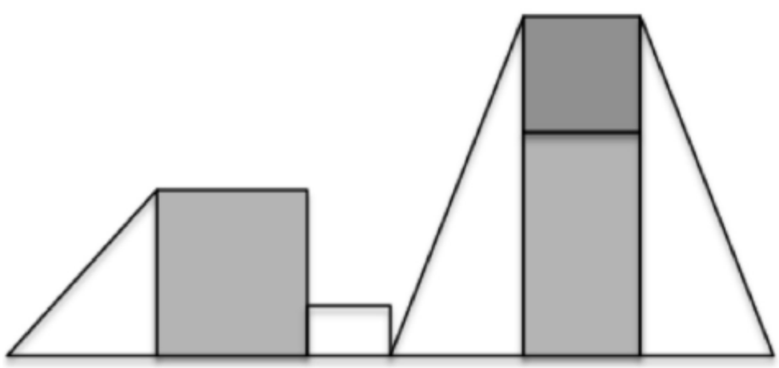

Figure 1-2: Butler's formal prototype of an EDM Track.[48]

[48] Ibid. (222).

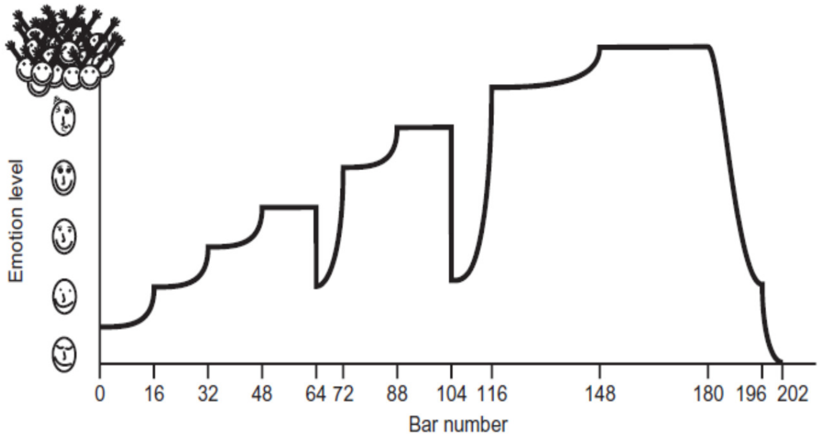

FIGURE 10.5
Example of a song map

Figure 1-3: Snoman's typical "song map."[49]

Related to this is the important notion of the climactic "drop" that usually occurs at the beginning of each core. This term is sometimes used as a noun, as in "the drop," "the beat drop," or "the bass drop," and sometimes used as a verb, as in "drop the beat" or "dropping the beat." Scholars, musicians, and fans alike have used these expressions to refer to the instantaneous climactic moment when the "beat" (specifically the kick drum/bass drum and sometimes also the melodic bass line) is (re-)introduced into the texture after a prolonged absence.[50] Solberg notes how the drop generates intense physical and psychological responses from listeners.[51] The variety of approaches to dropping the beat is one of the key delineating features of various EDM genres,[52] but in all cases it involves a discrete process, since the (re-)addition of some sound layers occurs at a sudden point in time.

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[49] Snoman (2009, 225).
[50] Butler (2006, 246–47); Garcia (2011, chap. 4); Peres (2016, 19–20); Sayre (n.d.).
[51] Solberg (2014); Solberg and Jensenius (2016).
[52] For example, trance and dubstep have more climactic builds and drops, and more of them, compared with genres like techno that keep the beat more consistently. Holmberg (2017).

The description of formal sections based on the presence or absence and instantaneous addition or subtraction of sounds is part of a trend in existing scholarship of portraying EDM as a construction of individual building blocks, with musical structure being generated by immediate changes at strategic times. It has been acknowledged that these individual building blocks may come in different shapes and sizes, but it has generally been assumed that the blocks have a *fixed* size and shape. For example, Snoman says that in all EDM "collecting and introducing sounds every 4, 8, 16, or 32 bars" is "a natural progression that we have all come to expect from music."[53] Garcia also discusses EDM this way, as an example of what Spicer terms "(ac)cumulative form."[54] Butler describes EDM as heterogeneous and stratified, featuring the gradual construction of meter through the sudden addition of sound layers.[55] He also describes the "rate of change" in terms of time spans between new sounds being introduced: for example, every two measures.[56] The instantaneous entrances or exits of new sounds every two measures are discrete processes, not continuous ones. A continuous version of these processes would have new sound layers fade in to the texture gradually. Both discrete and continuous processes are highly important in EDM.

Butler's view of EDM as heterogeneous and stratified is especially evident in his method of analysis with a "sound palette," showing each sound layer in staff notation as a fixed and repeatable thing.[57] In these representations he groups together different

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[53] Snoman (2009, 269).
[54] Garcia (2005, sec. 4). Spicer and Attas both describe the addition of new instruments one by one as a common technique for introductory sections in pop and rock music. Spicer (2004); Attas (2015).
[55] Butler (2006, 93, 182, 224).
[56] Ibid. (213).
[57] Butler (2006) describes this in chapter 5. A good example of it is in the appendix on pp. 280-81.

rhythmic patterns with the same or similar timbres under headings of 1a, 1b, etc., and separates ones that have different timbres, implying that the two never merge together or are perceived as a whole even if they have the same rhythm. In Butler's analyses, the "sound palette" is then used to create a "textural graph" that shows when each layer is present in a track and when it is absent. These graphs are discrete, showing only sudden entrances and exits of sounds.

Since Butler is primarily thinking of EDM as a stratified texture comprising many building blocks, instead of focusing on continuous changes to the sounds themselves he focuses on changing *perceptions* of fixed, repeatable loops. One of his central points in the seminal book *Unlocking the Groove* is that the grooves established in the core sections of EDM tracks are open to flexible and changing interpretations. The stacking of many repetitive loops creates music that can be focused on in different ways upon each listening. "I am…seeking to highlight a characteristic that is central to the aesthetics of electronic dance music – namely, its structural and interpretive openness."[58]

Butler, Garcia, and Fink also discuss the importance of repetition and flow in EDM.[59] Each separate sound layer can be looped, and many repeated loops that each have their own teleology can have discrete or continuous processes applied to them to build towards climaxes in what Fink calls "recombinant teleology" and Butler describes as a kind of spiral teleology.[60] Garcia describes this as a combination of looping and

[58] Butler (2006, 127).
[59] Butler (2014, chap. 4); Fink (2005, chap. 1); Garcia (2005).
[60] Fink (2005, 43–47); Butler (2014, 205–06).

accumulative form that creates a pleasurable process.[61] Repetitive loops can also be used for transitioning between tracks in live performance, so that there is no break in the sound. This is one of seven musical "technologies" described by Butler that can be accomplished with loops: repeating, cycling, going, grooving, riding, transitioning, and flowing.[62] In a live DJ set, keeping the flow going throughout a night is important for keeping the audience engaged.[63]

The repetitiveness and flow of EDM is a kind of continuity that is highly valued by EDM fans and creators. However, this is *not* the kind of continuity I am referring to when I describe continuous processes in this dissertation. What I am referring to are the continuous changes of musical parameters, rather than incessant repetitions of loops with no breaks.[64] What I emphasize in my analyses is how the building blocks of sound layers can evolve over time by growing or decaying, morphing to emphasize different aspects of their sound quality, or merging with other layers. The utilization of continuous processes in these ways is an essential part of the compositional process for EDM that has so far not been thoroughly explored in scholarship.

Certain types of continuous processes (such as crescendos in buildup sections) have been studied more than others, but in general they have been dismissed under umbrella terms such as "effects," "tweaking," or "processing." For example, Hawkins refers to "effects processing," "phasing effects," "studio effects (filtering)," "heavy echo

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61 Garcia (2005, secs. 5–6).
62 Butler (2014, chap. 4).
63 Butler (2006, 242).
64 Thank you to Edward Spencer for helping me clarify this point by asking a question about it during my presentation at the 2018 annual meeting of the Society for Music Theory. Smith (2018).

effects," and "special effects" in his analysis of "French Kiss" by Lil' Louis.[65] He also describes "gradual manipulation of tempo" and a gradual "working up of the textures" without discussing these in detail.[66] The term "effects processing" references a device called an "effects processor" that accomplishes "processing" (the modification and manipulation of sounds): one of the four functions of electronic music-making machines (along with synthesis, sampling, and sequencing).[67] Effects processors and mixing boards contain knobs and sliders that allow for continuous changes to musical parameters (continuous processes) to occur. Butler calls these knobs and sliders "continuous controllers."[68] They can change parameters through technologies such as filters, LFOs, and ADSR envelopes, with physical interfaces or digital ones,[69] and they can be utilized in live performance (as Butler describes) or in studio production (as Wright describes).[70]

Digital interfaces occur in DAWs (digital audio workstations). These are software programs that are immensely important to the production of EDM. They are increasingly becoming the primary tools for popular-music creators (not just in EDM) to organize and improvise their music.[71] In DAWs, sound clips are represented as building blocks of music that can be changed, but are almost always quantized to the tempo and the key of the music. Discrete melodies are usually created with the "piano roll," a vertical

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[65] Hawkins (2003, 90, 91, 95, 96, 98).
[66] Ibid. (94).
[67] Butler (2006, 56–57, 60).
[68] Butler (2014, 71).
[69] LFOs (low frequency oscillators) are often used to create continuous alterations of pitch (vibrato) or amplitude/volume (the tremolo effect). This will be discussed further in chapter 3. The manipulation of ADSR envelopes (discussed in a previous footnote) is most commonly used to adjust amplitude or filter resonance.
[70] Butler (2014, 70–87); Wright (2017, chap. 5).
[71] Wright (2017, 202–06).

representation of the black and white piano keys. Continuous processes can not only be created through "in-time" movement of virtual knobs and sliders, but they can also be programmed into preset sounds that are stored in sound banks (such as when a particular bass sound has vibrato programmed into it), or created through *automation curves*.

In music production, automation refers to changing musical parameters "automatically" rather than manually. When automation occurs, it is the technology that is controlling the changes itself, rather than human agency.[72] This can help reduce the workload for DJs both in live performance and in the studio.[73] In DAWs, automation is produced with "automation curves" that represent continuous changes to musical parameters. They can be altered by clicking and dragging them into different shapes. Figure 1-4 shows a screenshot of the DAW file for "Beneath with me" by Deadmau5 & Kaskade f. Skylar Grey (2016). The discrete building blocks of sound clips can clearly be seen, as can the piano roll in the bottom left, but continuous processes are also represented, since the orange lines in the middle of the picture are automation curves.

Wright discusses how automation curves in DAWs are a vital means of expression for house and techno music specifically. "While other forms of popular music use automation, it is not as directly responsible for such drastic transformations of musical material, transformations that are so significant to the construction and consumption of house and techno tracks." In the minds of the producers he interviews, automation: 1) is linked with creativity and experimentalism, 2) is a means of creating

[72] Butler (2014, 223).
[73] Snoman (2009, 74–76); Wright (2017, 297).

momentum, and 3) allows “the desired balance between repetition and constant change.”[74]

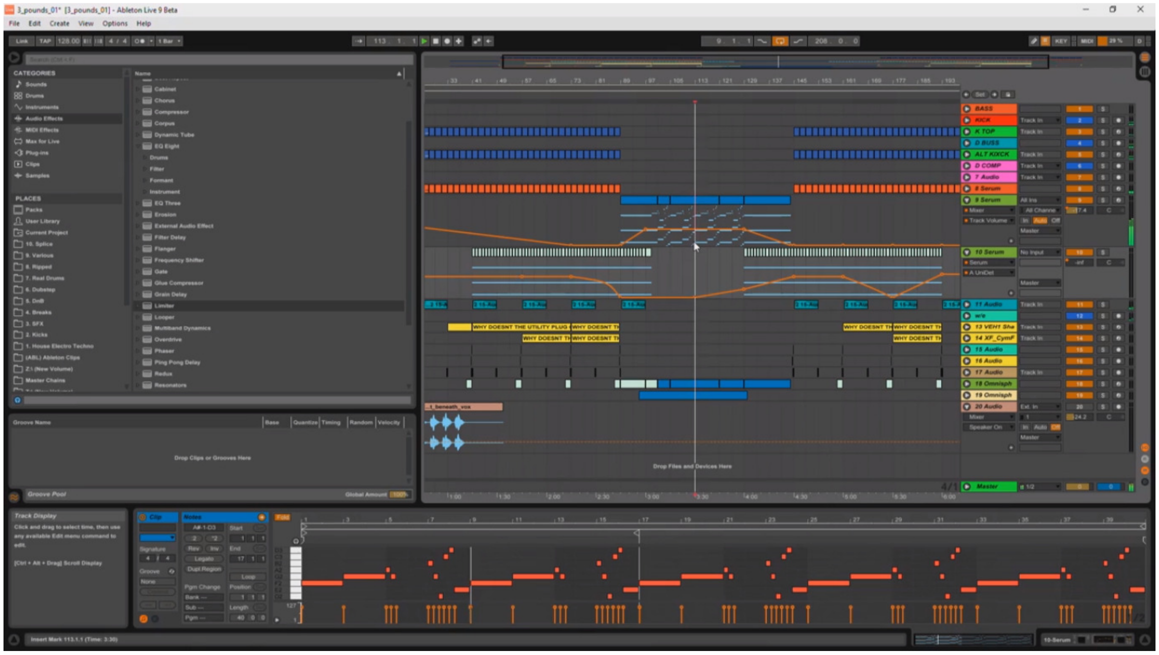

Figure 1-4: Screenshot of the DAW file for “Beneath with me” by Deadmau5 & Kaskade f. Skylar Grey (2016).[75]

It is true that continuous processes are often improvised during live performance or added to EDM tracks through automation after the main melodies, harmonies, rhythms, and form have been decided, and that many continuous processes (especially the shorter ones) can be described as “effects.” However, this does not diminish their importance. Many “effects” such as vibrato, siren sounds, the tremolo effect, and increasing delay or reverb, are highly salient and influence the “feel” of the music. Furthermore, in most of today’s popular EDM tracks, long crescendos and pitch slides

[74] Wright (2017, 300).
[75] “MasterClass | Deadmau5 Teaches Electronic Music Production” (2016).

are highly important continuous processes that are central to the form and aesthetics. These have been discussed by Peres and Solberg as "risers" and "uplifters."

These terms do not have universally-accepted meanings. In general both "risers" and "uplifters" refer to ascending pitch slides (glissandos), but they can also have more specific meanings. Peres describes risers in EDM and contemporary pop music as sections of pieces "which build up a heightened sense of anticipation in the listener, whose attention is directed toward the rising frequencies until it is time for the *drop*."[76] In the way Peres uses the term, "riser" is interchangeable with "buildup" and it can not only utilize pitch slides but also filter sweeps and crescendos. While I will not use the terms riser and buildup interchangeably, I will use riser as an umbrella term for a group of continuous processes that increase tension leading towards a musical climax. However, there can be other discrete processes in buildup sections that are not risers, such as the rhythmic diminution of the "drum roll effect" (the snare roll or fill discussed above).[77]

The general meaning of "uplifters" refers to any kind of ascending frequencies,[78] but some use the term specifically to refer to what Solberg calls "the typical white noise uplifter."[79] When this specific technique of a filter sweep being applied to "noise" happens in the music I discuss, I will refer to it as a "noise sweep" as Peres does,[80] to differentiate it from pitch slides that continuously change more definite pitches, even

[76] Peres (2016, 19).
[77] Solberg (2014, 70).
[78] Ibid.; Solberg and Jensenius (2016, 308).
[79] Solberg (2014, 70). In this sentence, Solberg separates the "uplifter" from "several long synth sounds being pitched upwards," suggesting that uplifters are different from regular pitch slides. Another example of "uplifters" being referred to as "white noise being opened up by a filter" is in an article by Zen World (2017).
[80] Peres (2016, 44).

though there is a continuum between clearly-defined pitches and noise, and the distinction between the two is not always easy to identify.[81] I will use the term uplifters as an umbrella term to describe ascending frequencies, regardless of their pitch definitiveness.

Risers and uplifters have been discussed as important parts of buildup sections in EDM. However, pitch slides and noise sweeps are used not only over multiple measures in large-scale anacruses to beginnings of sections, but also as short anacrustic features that help lead to and highlight different levels of hypermeter such as four-measure and eight-measure subsections. Peres notes that "noise sweeps" are often used this way in contemporary pop music as well.[82] Pitch slides and noise sweeps are also commonly used not as ascending gestures but descending ones, such as at the start of a new track or a new section of the track. These are sometimes referred to by the oxymoronic term "downlifters."[83]

Existing scholarship on EDM and pop music analysis has focused on only certain types of continuous processes such as short effects or long risers, and not discussed them systematically.[84] In this dissertation, I build on previous scholarship by highlighting many different types of continuous processes of different lengths, which affect many different parameters, and have a variety of functions in contemporary EDM that are influenced by their salience and shapes. To do this, I also draw on a body of literature

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[81] Smalley (1997, 120).
[82] Peres (2016, 79–82).
[83] Zen World (2017).
[84] Latour (2018); Peres (2016); Solberg (2014).

that *has* addressed continuous musical changes systematically, and that is analytical and compositional theories of electroacoustic music.

Smalley has developed a theory of "spectromorphology" based on concepts from Pierre Schaeffer's writings.[85] His system describes various types of "motion and growth processes," as shown in Figure 1-5. He also distinguishes between "continuous motion" and "discontinuous motion," saying that "The continuity–discontinuity continuum runs from sustained motion at one extreme to iterative motion on the other."[86] Although it is useful to make a distinction between continuous processes and discrete processes in EDM, I also discuss borderline cases in chapter 3. Blackburn has taken Smalley's system of spectromorphology and added many visual representations to it.[87]

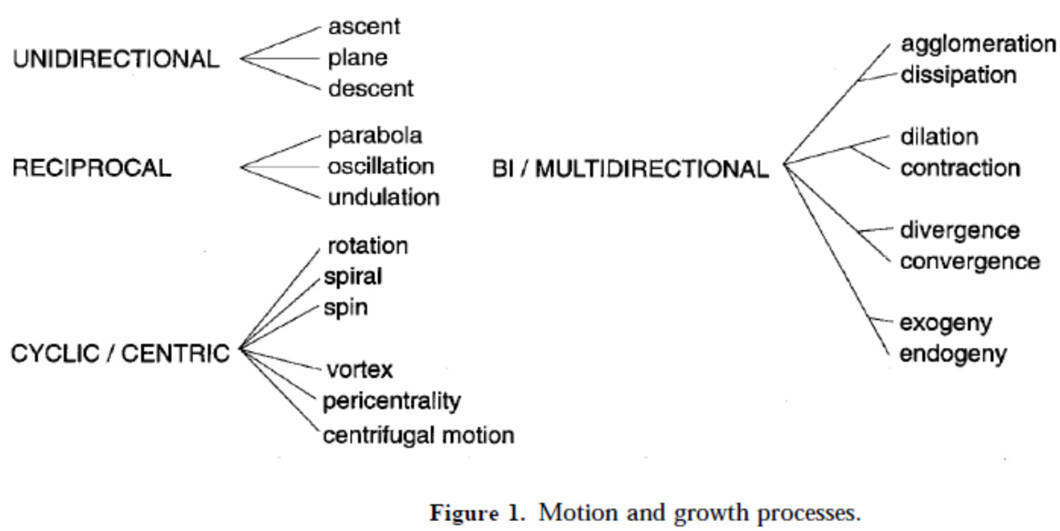

Figure 1-5: Motion and growth processes as outlined by Smalley.[88]

[85] Smalley (1997).
[86] Ibid. (117).
[87] Blackburn (2011).
[88] Smalley (1997, 116).

Wishart describes continuous processes in a similar way, as gestures exhibiting "dynamic morphology."[89] He notes that what Robert Erickson called "spectral glide" and Pierre Schaeffer called "allure" are examples of dynamic morphology, demonstrating how long composers have been thinking about continuous processes in electronic music.[90] Wishart also develops a system for classifying what I call continuous processes according to 1) magnitude or range (for example the depth of a pitch bend), 2) morphology/shapes (for example stable, increasing, decreasing, increasing-decreasing, stable-becoming-unstable), and 3) second-order morphology (the rate of change or acceleration).[91] He also discusses methods for comparing continuous processes according to how similar (homogenous) or different (heterogeneous) they are, and "whether the gestures appear to interact with one another or appear to behave independently of one another."[92] I will draw on these methods when discussing different degrees of salience for continuous processes in EDM, and different shapes of them.

Outline of the dissertation

Chapters 2 and 3 investigate categorical questions regarding continuous processes and begin exploring guidelines for comparing their salience. What are continuous processes and what are they not? How do we (as EDM fans, creators, and analysts) categorize them? How do we compare them? As Smalley notes in the quotation above, there is a continuum between continuous and discrete motion in music. Some processes are perceived as continuous much more easily than others. The majority of the examples

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[89] Wishart (1996, 93).
[90] Ibid. (94).
[91] Ibid. (119–20).
[92] Ibid. (121–22).

in chapters 2 and 3 (which are small excerpts of entire tracks) showcase musical changes that are easily perceived as continuous and not discrete. The end of chapter 3, however, investigates borderline cases, when changes to sound parameters are difficult to assign as clearly continuous or discrete. I draw on Danielsen's conception of "microrhythm" to discuss these processes,[93] which have discrete components so close together that they could be perceived as either quick discrete processes or continuous ones. EDM creators sometimes exploit the continuum between clearly discrete and clearly continuous processes to gradually change the rhythmic clarity of a sound layer and create or dissipate tension.

For processes that can easily be perceived as continuous, I make a distinction between "long" and "short" varieties, which are the subjects of chapters two and three respectively. Long continuous processes are more than two measures long and short ones are two measures long or less. This is a somewhat arbitrary distinction, but there is a significant difference between the aesthetic effects of long and short continuous processes in EDM. In general, long ones are used as more structural aspects of the music such as risers (which are groups of continuous processes that usually include ascending pitch slides, filter sweeps, and crescendos as discussed above), and short ones are more ornamental. Given that most producers talk about adding continuous processes to the music after creating the melodies, harmonies, and rhythms as a base, all continuous processes could be thought of as effects in some way. However, some continuous processes such as the multiple ones contained in risers are like expanded effects that have

[93] Danielsen (2010).

become highly significant structurally, especially in more mainstream genres like progressive house and trance. They are often the main contributors to the tense aesthetic of buildup sections, and provide listeners with a signal that a climactic core is about to start. In both chapters two and three I include discussions of how fans and producers think about long and short continuous processes.

Within the categories of long and short continuous processes, I divide further according to the primary parameter being altered, including: volume, tempo (usually just of one sound layer), pitch, and timbre. I also include a separate category for filter sweeps, which change pitch, volume, and timbre simultaneously. As mentioned above, often multiple continuous processes are applied to one sound layer at the same time, such as a crescendo and a pitch slide. In these chapters I establish these as separate kinds of continuous processes because they can each have different shapes, rates of change, and functions, even though they are often perceptually grouped together.

Sometimes there is a difference between the parameter actually altered and the perceived effect. For example, in chapter 2 I discuss the "illusion of acceleration." An example of this scenario is eighth notes seeming to continuously speed up to become sixteenth notes, accomplished through the gradual fading in of sixteenth notes. Similarly, in chapter 3 I show examples of the "tremolo effect," in which rhythmic pulsations are created by repeated volume swells. Changing the steepness of the volume curve in this situation can create perceived continuous changes in rhythm or articulation style.

In chapter 3 I also introduce another parameter that could change continuously, that of space. When multiple speakers are utilized, producers can continuously change the volume of sound coming out of each speaker, so that the music continuously changes its location and direction in space. This is called panning, and it is more often employed as a short continuous process rather than a long one, which is why I discuss it in chapter 3.

Chapters 2 and 3 also explain the first five in a set of nine analytical guidelines for comparing continuous processes in terms of their salience, which will be completed in chapters 5 and 6. The meaning of "salience" in these guidelines is broad and multi-faceted. It encompasses prominence and noticeability on the musical surface, memorability in mental processing or reflection, and structural significance or importance. I am thinking about how well these continuous processes stand out to listeners, both when hearing them for the first time and when thinking back on them, and also about how significant they are to the formal structure or semiotic meaning of an EDM piece. There is no definitive way of measuring this for any aspect of music but my guidelines are starting points for comparing the salience of continuous processes in EDM. This is useful for analysis since the guidelines make explicit the kinds of foreground-background parsing involved in listening and point towards how continuous processes saturate EDM with multiple levels of prominence.[94]

The first two guidelines say that a continuous process is more salient than others if it has relatively loud volume or is applied to a sound layer that is distinctive in some way, such as having a timbre or a rhythmic pattern that stands out. Guidelines 3 and 4 say that groups of continuous processes that occur at the same time (for example, one sound

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[94] Bregman (1990, 490–502); Meyer (1956, 87, 122, 136–138).

layer undergoing continuous changes in many parameters at once, or one parameter changing in many sound layers at once), are more salient than individual ones. If a crescendo occurs in many sound layers simultaneously, the salience of each crescendo is magnified by the others. The fifth guideline, which is introduced in chapter 3, says that a continuous process is more salient if it is heard many times because it is frequently and consistently repeated in a track. A short pitch bend, for example, becomes more salient if it is repeated throughout a track rather than just occurring once as an anacrusis to a new section.

After chapters 2 and 3 explore the categories of long and short continuous processes and begin the discussion of their salience, chapter 4 is a kind of "interlude" before the discussion on salience, shapes, and functions continues. Chapter 4 shows that music theory has long had a discrete bias by outlining the history of discrete and continuous thinking about music from ancient Greece to the present. This incorporates mathematical and philosophical perspectives on music. In contemporary times, there has been much research on continuous processes in music, however most of it has come from scholarship that is generally outside music theory or marginalized in the formal discipline of music theory, at least in North America. Instead, much of music theory's recently developed systems rely on discrete geometry that focuses on the nodes of discrete shapes or, in transformational theory, abstract (non-sounding) connections between them.[95] Wishart points out the discrete bias in musical analysis by calling this "lattice sonics," as evidenced by the separate lines and spaces and distinct rhythmic values on a staff, and the

[95] Cohn (1996); Lewin (1987); Tymoczko (2011).

separate staves on a score.[96] Dolan also points toward the discrete bias in Western musical thinking in general due to "keyboardification."[97] Even though the distinction between discrete and continuous processes is not always a clear binary and there is a continuum between the two as already discussed, there is still use in separating the two concepts and in trying to remedy the discrete bias by accounting for the importance of continuous gestures in all kinds of music, not just EDM.

Chapter 5 focuses on various kinds of shapes for continuous processes and how this affects their salience. After an overview of how music theorists have used shapes to describe music, including a review of Wishart's archetypes of first and second order morphologies as described above, I argue that the perception of each continuous process in EDM is best modeled with one of four types of mathematical functions: linear, exponential, sinusoidal, or sigmoidal. The basic versions of these functions and their reflections about the x- and/or y-axes are different shapes that have different effects on listeners.

When the x-axis represents time and the y-axis represents the value of the musical parameter being continuously altered, linear functions can only be increasing or decreasing the parameter, but exponential curves can be increasing or decreasing and accelerating or decelerating. Each of the four types of exponential curves is commonly used for specific kinds of continuous processes. For example, increasing-accelerating (exponential growth) curves are commonly used for tempo accelerations, and decreasing-

[96] Wishart (1996, 8).
[97] Dolan (2012).

decelerating (exponential decay) curves are used for tempo decelerations. With volume changes, fade-ins are best modeled perceptually as increasing-decelerating exponential curves, whereas fade-outs are best modeled as decreasing-accelerating exponential curves. Sinusoidal functions are good models for some continuous pitch slides or volume changes, particularly the tremolo effect. Finally, sigmoid functions (which are sometimes called S-curves) are best for modeling other continuous processes because they have plateaus at the starts and ends of their shapes.

This chapter also introduces three more guidelines for comparing the salience of continuous processes based on their shape model. Guidelines 6 and 7 say that a continuous process is more salient if it has more *length* (lasts longer in time) than others or has more *depth* (a greater range on the y-axis for the parameter being altered) than others. Guideline 8 says that a continuous process is more salient if it has a higher overall *rate of change* than others. The rate of change may itself change over time (as in any function that is not linear), but here I am referring to something broader, the combination of length and depth. If two processes have the same length (of time) but one has more depth, then that one has a higher rate of change and is more salient. If two processes have the same depth, but one has less length (is shorter), then the shorter process will have a higher rate of change and thus more salience according to guideline 8. This contradicts guideline 5, but each guideline can be used individually, and in general guideline 5 on length is a better tool for describing long continuous processes whereas guideline 8 is a better tool for describing short continuous processes.

Listening to a riser gradually slow its rate of change approaching a peak point in the music is one of the most fundamental experiences of contemporary EDM. Deadmau5 describes it like a roller coaster.[98] This leads to chapter 6, on the functions of continuous processes in EDM tracks. In this chapter I draw on scholarship of musical form, tension, and energetics to show that continuous processes play important roles in orienting listeners to the form and meter of tracks, and are crucial contributors to the aesthetics of tension in buildup sections and disorientation in breakdown sections. Continuous processes are often used most frequently and saliently in these parts of tracks.

Breakdown sections come immediately after cores, and they allow dancers a chance to rest. They are marked by an aesthetic of disorientation, often due to some or all of the drum parts that articulate the beat being absent. In these sections, continuous processes contribute to the sense of instability because of their constant change. Short continuous processes that embellish melodies and rhythms are often more noticeable in these sections than in cores because the drums are absent. Longer continuous processes that make the rhythm and meter less clear are also used, such as adding significant delay, echo, or distortion. Butler notes how common this is in breakdown sections, calling it "tweaking."[99]

Buildups come after breakdown sections and they lead toward cores and beat drops. The buildups and drops in EDM have been described by Snoman as "emotional

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[98] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 13, 11:02–12:00).
[99] Butler (2006, 92, 222–24).

waves,"[100] in a manner reminiscent of Ernst Kurth's "force waves."[101] Buildup sections are transitional, in between moments of rest (breakdowns) and moments of the highest energy in a track (cores). Therefore, they exhibit tendencies similar to passages of *Steigerung* (intensification) as outlined by Werbeck to explain transitional passages in the tone poems of Richard Strauss, and to *Gang* passages of intense motion as described by Riepel (1754) and A.B. Marx (1841). It is during these sections of EDM tracks that risers are used, incorporating many continuous processes of intensification. Risers in buildup sections also function as sonic signs for dancers, telling them that a climactic drop is coming soon, when they will dance with full energy again after resting in the preceding breakdown.

The anacrustic function of risers is one way in which continuous processes generally function to orient listeners to important points that reinforce the duple hypermeter of EDM at various levels. For example, soft noise sweeps often precede and follow the midway points of cores. This is the basis of the final analytical guideline for comparing the salience of continuous processes in EDM tracks. Guideline 9 says that a continuous process is more salient if it is used to highlight a more important marking point or hypermetric beat than others. For example, a riser that leads to a climactic drop at the downbeat of measure 32 in a track is more salient than an ascending noise sweep that leads to the start of a new phrase in measure 24. Even a descending noise sweep at

[100] Snoman (2009, 269).
[101] Rothfarb (2002, 943).

the start of a main section of the piece is more salient than a continuous process leading to or from a midway point of a section.

Having outlined the categories of long and short continuous processes, nine guidelines for discussing their salience, a methodology for describing their shapes, and their functions in EDM tracks, the final chapter of the dissertation puts all these methods and concepts together to form detailed hermeneutic analyses of two tracks by Deadmau5 and The Chemical Brothers. Both tracks use continuous processes to represent paranormal or science-fictional phenomena.

The first track discussed is “Phantoms Can’t Hang” by Deadmau5 (2014). Deadmau5 is a Canadian producer who became an EDM superstar in the 2010s. His work, especially early on, is mostly in the progressive house genre, but recently he has explored many musical styles that are more experimental and ambient. In “Phantoms Can’t Hang,” continuous processes are very important in the breakdown and buildup sections. The two buildups contain huge risers with sigmoidal shapes that seem to plateau near the end, leading to climactic drops. In the breakdown a ghostly melody is featured that has no articulation and is sung continuously for many measures at a time. The breakdown also uses continuous processes to change white noise into clear chords, and create the “illusion of acceleration” with a continuously growing echo in the bass. The ghostly melody fades out of the texture in the second buildup, as if it “can’t hang,” but then it returns for the second half of the final core, adding not only melodic counterpoint but also a continuous contrast to the choppy, discrete “hook” that is persistent throughout most of the track.[102] "Phantoms Can't Hang" also provides a good example of how continuous processes such as noise sweeps and "backwards reverb" are very often used in EDM tracks to highlight sectional boundary points and hypermetric downbeats at multiple levels.

The second track analyzed in detail is "Electronic Battle Weapon 4 (Freak of the Week)" (1998) by the English duo The Chemical Brothers. This track is part of the "Electronic Battle Weapon" (abbreviated EBW) series by them that are extended or altered versions (a.k.a. "club" versions) of shorter album tracks that have regular names. In EBW 4, many short and long continuous processes are used as musical signs for a dystopia, such as high pitch slides that invoke warning sirens. The second core of the track is particularly unusual in that it contains a group of long continuous processes that are highly salient and sound like a UFO coming down to earth for an abduction. These continuous processes seem to take over the track and try to interrupt the dancing at this point, which is unusual in core sections of EDM tracks. However, the use of continuous processes as signs for scary, unusual, unstable, or unexplainable phenomena fits with the psychedelic style that The Chemical Brothers are known for, and the use of continuous processes as signs for instability and fear more generally.[103]

Methodology

In order to explain the salience, shapes, and functions of continuous processes in EDM, I use many different methods and techniques in my analyses. Most of my

[102] For literature on "hooks" in popular music see Burns (1987); Kronengold (2005); Traut (2005).
[103] This is especially true in soundtracks for films and video games. For example, Brownrigg discusses the use of continuous processes before scary surprises in horror movies. Brownrigg (2003, 118–21).

descriptions are based on human *perceptions* of EDM tracks when listened to in real time, rather than visualizations or descriptions generated by humans or computers involved in the creation process. In other words, I am focusing on the esthesic level of reception rather than the poietic level of intention by musical creators.[104] Specifically, I am focusing on my own perceptions as a music theorist trained in the Western classical tradition and an EDM fan. To help guide my perspective, I also rely on the descriptions of the music by other fans and electronic music producers (found through digital publications, online discussions, and in-person conversations), as well as my advisors and colleagues.

As mentioned in the introduction to this chapter, in studio-produced EDM, every aspect of the music is precisely controlled and quantized to a metrical grid. This means that from the creator's perspective in the studio, the aspect of the music that is being altered and to what degree it is being changed is clear for every continuous process. It is also interesting to consider how DAWs on computers represent these musical processes in multiple ways. Continuous processes can be represented as a discrete series of numbers or as continuous lines and curves, and this makes the continuum between discrete and continuous clear and the distinction between them seem arbitrary. The way in which creators program continuous processes (through typing in numbers, turning knobs or sliders, or programming automation curves and dragging their shapes) therefore influences their perception of them as discrete or continuous, and to what level they are

[104] Atkinson (2007, 115).

quantized.[105] The poietic perspective of the creator and the digital perspective of the computer are important to keep in mind, and I do bring it in to my discussions as I am able to, however I do not have access to DAW files of the tracks I am analyzing and in most cases do not have descriptions by producers about the specific tracks they made that I am discussing.

For each analysis, I start with complete audio files of the track under consideration. These audio files have been uploaded as supplementary files for this dissertation. I have worked with these audio files in two software programs: Audacity and Transcribe! Audacity allowed me to view amplitude graphs and spectrograms for the audio files, which I use routinely to show continuous processes related to volume and frequency filtering respectively. The computer-generated visual representations help inform my aural perceptions. Figure 1-6 shows a sample amplitude graph, also known as a waveform, which represents amplitude levels vertically on the y-axis, over time in seconds on the x-axis. The amplitude is measured linearly on a scale from -1.0 to 1.0 developed by Audacity. Even though our ears hear logarithmically, which can be represented better with the decibels (dB) scale, linear scaling shows the precise changes in amplitude in a way that is visually intuitive and easier to see.

[105] In this scenario, both the human and the computer are "actors" that participate in the construction of knowledge, according to Actor-Network Theory (ANT), as developed by Latour and Law. Latour (1987); Law (1987).

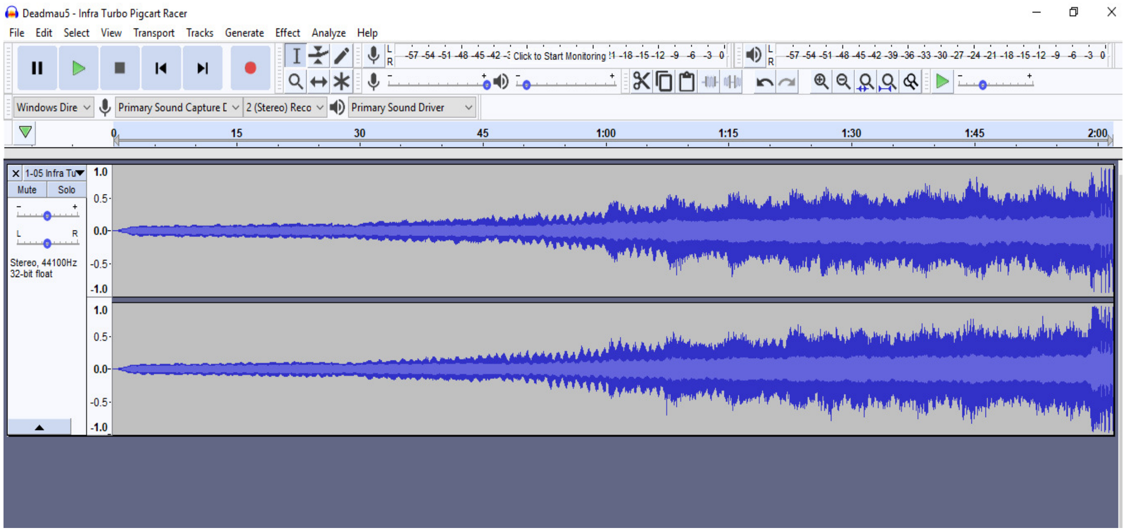

Figure 1-6: Amplitude graph for the Intro (0:00–2:00) in "Infra Turbo Pigcart Racer" by Deadmau5 (2014).

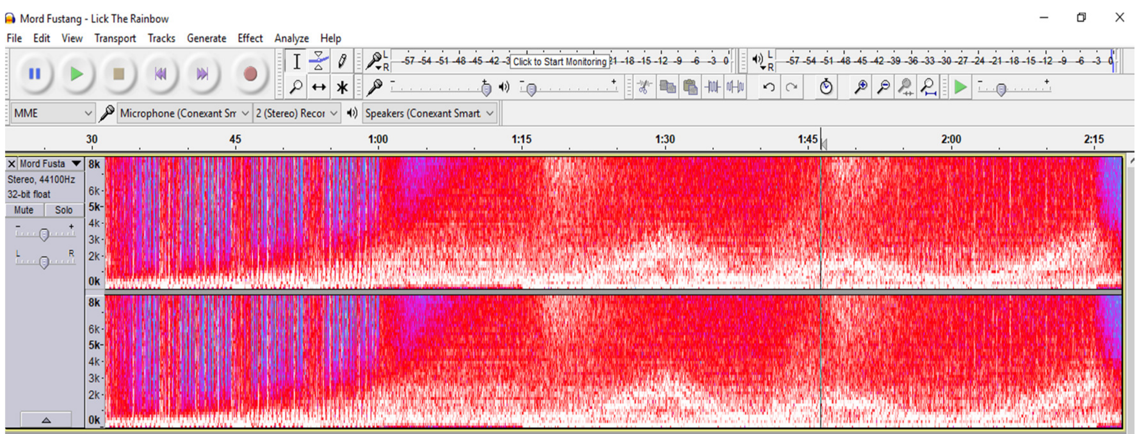

Figure 1-7: Spectrogram for a Buildup section (0:30-2:20) in "Lick the Rainbow" by Mord Fustang (2011).

Figure 1-7 shows a sample spectrogram, also known as a sonograph, which represents the spectrum of frequencies present in a sound and their intensities. The frequencies are on the y-axis on a linear scale, time is on the x-axis in seconds, and the intensity of the frequencies is represented by color ranging from white to gray, with light colors/shades representing more intense frequencies and darker colors/shades representing less intense ones.[106] Spectrograms are very useful for showing filter sweeps and timbre changes in EDM.

I used Transcribe! to slow down audio files and use EQ (an equalizer, which controls the amplitude of specific frequency bands) in order to hear the pitch and speed of continuous processes more precisely. This helped me create detailed graphs of continuous processes using Microsoft Excel. A sample graph created in this way is shown in Figure 1-8. Graphs like this show the shapes of continuous processes according to my perception, and they will be relied on especially in chapter 5, which discusses the aesthetic effects of different shapes. To compare these graphs with mathematically-perfect models of linear, exponential, sinusoidal, and sigmoidal curves, I show representations of those shapes created with the graphing software Graphmatica. Some of my examples overlay graphs from Graphmatica onto my self-created graphs or onto spectrograms for direct comparison. Other times spectrograms or amplitude graphs are annotated and overlaid with lines and curves from Microsoft Paint 3D to highlight their different shapes. This is another reason why I use linear scaling for amplitude graphs and spectrograms, so that the shapes they show look more like prototypical graphs as they are usually represented in linear coordinates.

Occasionally, visual examples are shown from the DAW program Ableton Live, such as the video demonstration I created of automation curves and the immense possibilities they afford for continuous processes. I also reference and show screenshots

[106] A full explanation of the color scaling is in the section "What the Colors Mean" of "Spectrogram View - Audacity Manual" (n.d.). https://manual.audacityteam.org/man/spectrogram_view.html.

from videos on YouTube and from Deadmau5's masterclass on Masterclass.com that demonstrate how continuous processes are created and discussed.

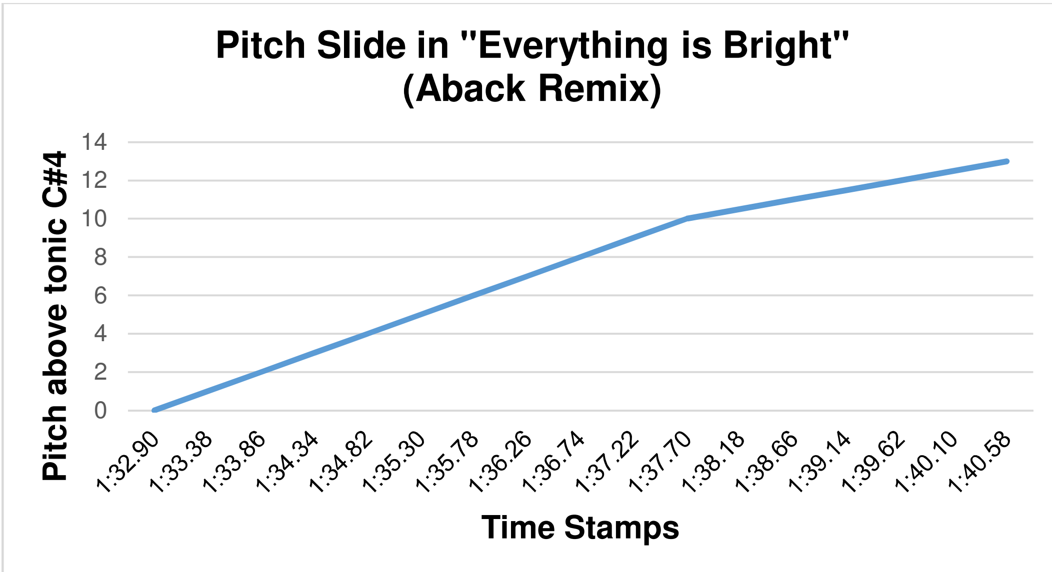

Figure 1-8: Pitch slide acting as an increasing-decelerating exponential curve in "Everything is Bright" (Aback Remix) by Stoned Butterflies (2012).

Finally, I also generate transcriptions of many excerpts from the tracks I discuss into musical staff notation. Sometimes these entail transcriptions of entire sections, and other times they show one- or two-measures that are looped in a single sound layer, in a manner reminiscent of Butler's "sound palette" analysis.[107] Even though staff notation cannot show all the detail in this music, and especially all the aspects of continuous change, it is still a useful tool for showing aspects of the music that are highly important to EDM fans and creators such as traditional and discrete melodies, harmonies, and rhythms.[108] The transcriptions can be used in combination with the other visual tools

[107] Butler (2006, 280–81).
[108] Butler writes with good detail on the difficulties of transcribing EDM. Ibid. (261).

described above to provide useful visual representations of both discrete and continuous processes that are fundamental to the music being analyzed.

Chapter 2 – The Categories and Salience of Long Continuous Processes

What makes a musical process continuous? Once we decide whether a musical phenomenon is continuous or not, how can we further categorize processes so that we can understand how different ones are used for different effects? How do we compare the effectiveness and significance of different musical processes in terms of being perceptually foregrounded, memorable, and "groovy," or introducing tension so that more energetic and pleasurable music for dancing can come later? These epistemological questions are the central focus of this chapter and the next, which divide continuous processes into categories based on their length (long continuous processes in chapter 2 and short ones in chapter 3) and their parameter altered or perceived to be altered (sections within each chapter).

The distinctions between different parameters being continuously changed are made naturally, because our ears make these distinctions when listening, and EDM creators also separate continuous processes this way by programming automation curves in DAWs for individual parameter changes (as described in the previous chapter). In other words, the categorization of continuous processes by parameter altered is valuable from both esthesic (perceptual) and poietic (creative) perspectives. Some of the processes and the parameters they alter (such as delay/echo and reverb) are harder to hear than others without formal training in digital production techniques, but they are still worth categorizing because even though my dissertation is primarily based on the perceptual perspective of listening to details on the musical surface, I am also trying to develop a listening practice that is aware of the creator's perspective.

The distinction between long and short continuous processes is more arbitrary. However, long continuous processes (which I define as being more than two measures long in EDM's standard 4/4 meter) generally have different aesthetic purposes, functions, and salience than short ones (which I define as being two measures long or less). Long continuous processes are usually more salient and significant to the formal structure of tracks, whereas short ones are more ornamental. Put another way, long continuous processes often participate in discursive repetition whereas short continuous processes often participate in musematic repetition.[1] This will also be discussed further in chapter 6.

Most of the musical examples in this chapter and the next are from small sections of complete tracks, so that the reader can become familiar with many different types of continuous processes. Several of the tracks that these excerpts come from will be revisited in following chapters throughout the dissertation, so that a more complete picture and deeper analysis of the work can result. These two chapters also introduce the first five in a set of nine analytical guidelines for comparing the salience of various continuous processes.

The current chapter is divided into sections based on the changing parameter for long continuous processes: volume, speed/tempo, pitch, filter cutoff, timbre, reverb, and delay/echo. Volume changes include crescendos and diminuendos, as well as fade-ins and fade-outs. This is the most common type of long continuous process applied in contemporary popular music.[2] As the examples I discuss demonstrate, perceived volume

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[1] Middleton (1990, 269).
[2] Miller (2018a).

increases can be caused not only by amplitude changes but also changes to the filter resonance, which can boost amplitude levels in the frequency range close to the cutoff for the filter so that the timbre of the sound becomes more resonant.[3] Sometimes continuous volume changes can create the "illusion of acceleration," as I show in one example, when one rhythmic layer fades in to gradually fill more metric positions within the measure.

Continuous changes to the "speed" of music can be applied to individual sound layers, in which case the *rhythm* is altered, or to the entire texture, in which case the *tempo* of the track is altered. If the tempo of the track changes, this makes it difficult to dance to, and therefore significant tempo changes (which are uncommon in EDM overall) usually occur in intro sections of tracks or moments of a DJ set when dancers could use a period of rest. It is much more common to have individual layers accelerate or decelerate. Following the spectral composer Gérard Grisey, I define *continuous* acceleration or deceleration as any situation in which the length between sounds gets shorter or longer with *each* consecutive note.[4] This is technically discrete since the changes are happening "step by step," but I make the distinction between this kind of process and situations in which there are multiple consecutive notes that have the same length between them before the length between notes gets shorter or longer, which I call discrete acceleration or deceleration.[5] Most of the examples I show in this section can be easily perceived as

[3] Snoman (2009, 19).
[4] Grisey (1987, 247–253).
[5] What I call "discrete acceleration" is an example of what Grisey calls "statistical" acceleration, which is a subset of "discontinuous" acceleration. Ibid. (253).

continuous rhythm or tempo changes, but some of them highlight the difficulty of interpreting specific accelerations or decelerations as discrete or continuous.

Continuous changes to pitch can be called many names such as glissandos, portamento, pitch bends, or pitch slides. I will use pitch slides as the general term for this kind of continuous process in this dissertation. Long pitch slides are often used as a part of *risers*, which are combinations of crescendos, ascending pitch slides, and usually filter sweeps that occur often in buildup sections. Sometimes however, long pitch slides are used in many sections throughout entire tracks, as in one of the tracks I discuss by Judah.

The next section shows examples of filter sweeps, which continuously adjust the filter cutoff for frequencies that are to be muted or not included in sounds. They can be applied to only one sound layer or many, and they control pitch, volume, and timbre simultaneously, since frequency content is one of the contributors to a sounds' tone quality. According to my classification system outlined in the previous chapter, I say that a filter sweep applied to many different sound layers is actually many different continuous processes going on at the same time. I also view the filter sweep applied to each sound as only one continuous process, changing the parameter of filter cutoff, even though it alters pitch, volume, and timbre all at once. I have chosen to write an entire section on filter sweeps because they are so important in contemporary popular music and especially EDM.

Following this, I show examples of continuous processes that only change timbre, by adjusting the ADSR characteristics of the sound envelope and/or the frequency content of the sound.[6] One of the most important ways this is done is through compressors. When a sound becomes "over-compressed," it creates distortion and gives "bite" or "crunch" to the sound.[7] Another way that timbre can be changed is through speeding up or slowing down the periodic sound signals so that their frequencies become higher or lower, without changing the rhythm or tempo. Long continuous timbre changes can also be simulated through volume changes in an "illusion of timbre change," similar to the "illusion of acceleration" discussed earlier. In "Turning Point" by Deadmau5, I show how the bass line seems to change timbre over multiple measures but it actually results from a second copy of the pitches and rhythms fading in with a different timbre. Finally, I discuss the use of long continuous changes to echo/delay and reverb. These techniques are similar but also distinct, and they are usually increased continuously in breakdown or buildup sections to make rhythms less clear and create disorientation or tension.

The separation of continuous processes by parameter is not meant to downplay the ways in which they interact and sometimes coalesce as they unfold in musical time. Each continuous and discrete aspect of the music is important to the overall listening experience. Even though EDM has an aesthetic of stratification due to the use of many sound layers at once, and dancers often pay attention to only one or two at a time, the gestalt of the whole texture and the whole piece is also an important part of the

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[6] As mentioned in chapter 1, changing the ADSR (attack, decay, sustain, release) for amplitude is the most common method of altering timbre through the adjustment of a sound envelope.
[7] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 16: Mastering).

experience because it creates a unified groove.[8] We can pay attention to only one line in a piece, but also perceive the texture as a unified whole.[9] The categories I am using in this chapter are a "way in" to discussing and illuminating the importance of these continuous processes for EDM aesthetics in general.

The final section of the chapter outlines the first four analytical guidelines for comparing the salience of different continuous processes. The first two guidelines state that continuous processes are more salient if they stand out as being relatively loud or distinctive in some other way such as having a unique rhythm or sound quality. Guidelines 3 and 4 state that groups of continuous processes, which alter multiple parameters or multiple sound layers at the same time, are more salient than individual ones. I conclude the chapter by discussing the benefits as well as the challenges of applying these guidelines in analysis, and using them to compare the salience of continuous processes previously discussed in the chapter.

Volume

One of the simplest yet most effective and common types of continuous processes is continuous modification of volume. Generally this involves changing amplitude levels, but it could also be accomplished by changing filter *resonance*, as discussed above. Often continuous volume changes are used to fade in or fade out a sound and its characteristic pattern. Butler notes that this technique can provide contrast with the more common

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[8] Butler notes the importance of stratification and heterogeneous texture in EDM, but also uses the phrase "unlocking the groove" to refer to the reality that groove "promotes multiple interpretations and flexible interactions, an *unlocking* of temporal experience into many possible directions." Butler (2006, 93–94, 6).
[9] Meyer (1956, 126).

abrupt addition and subtraction of layers.[10] The volume can be changed for the entire mix (all sound layers), just one, or anywhere in between. One of the "secrets" to the complexity of EDM and popular music in general is that producers use many different sounds for what is perceived as only one sound layer. For example, what is heard as one kick drum (sometimes called a bass drum) is usually composed of several separate kick-drum sounds layered on top of each other and slightly modified.[11] Since there are a multitude of layers looping, there are a multitude of ways to gradually alter sounds by adjusting their volume. It is also possible to fade in one layer while fading out another layer with a technique called cross-fading.[12]

The track "Read only memory" (2011) by Assyrian musician Aril Brikha is very repetitive, but one of the ways that the track generates interest is by incorporating the customary kick-drum sound very gradually into the mix, starting at around 2:15 in the track timing. This piece is not delineated into clear formal sections such as cores, breakdowns, or buildups, but rather it contains one repetitive, groovy loop (transcribed in Figure 2-1) that slowly grows and gradually changes its emphases, much like a minimalist piece by Philip Glass or Steve Reich. Up until this point (2:15), the groove has been created with only melodic instruments, and no drums, but when the kick drum fades in, it adds articulation points to the beats that up until now have only been felt as "virtual reference structures."[13] The fading in of the kick drum makes the meter clearer, encourages more body movement, and contributes to the continual building of energy in

[10] Butler (2006, 216).
[11] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 3: Beats Part 1).
[12] Snoman (2009, 137).
[13] Danielsen (2010, 4).

the piece. Throughout the rest of the track, the overall volume slowly becomes louder, so that the piece as a whole gains energy before finally fading out near the end. Butler calls this a "gradual transformation" in his analysis of the piece,[14] but it could also be said that the fade-in of the kick drum and the overall volume changes are examples of long continuous processes.

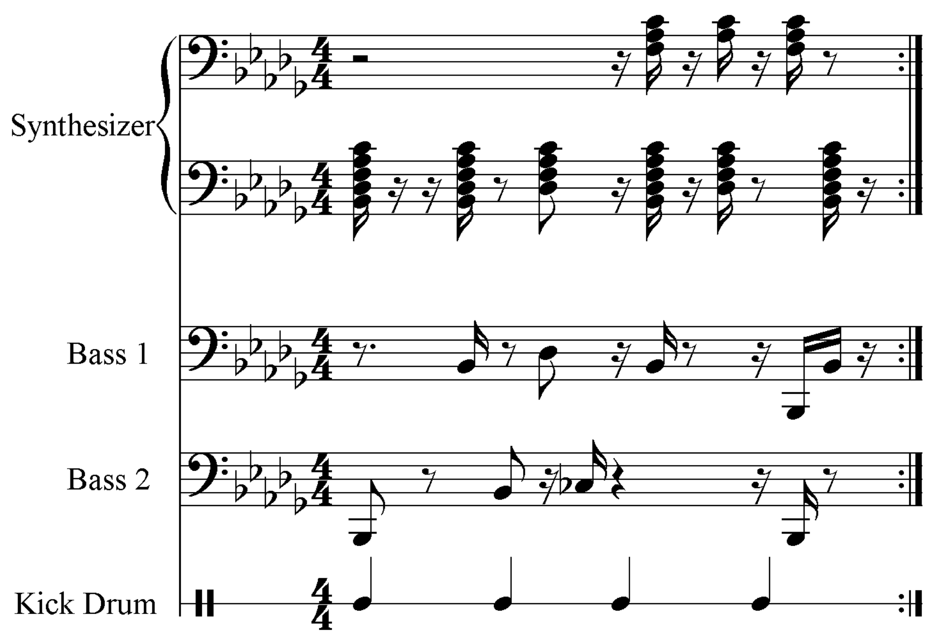

Figure 2-1: Transcription of the main groove in "Read Only Memory" by Aril Brikha (2011).

Another track that uses long continuous crescendos to increase the energy in the track is "Infra Turbo Pigcart Racer" (2014) by Deadmau5. This can be seen in the amplitude graph shown in Figure 2-2. The first two minutes of the track feature a slow and steady growth in volume, starting with very soft opening measures. In the first minute of the track, the chords and the rhythmic breathing gradually become louder, and

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[14] Butler (2006, 144).

then at 1:00 a new melodic line suddenly enters. During the next minute, the crescendos continue in the chords and rhythmic breathing, and near the end of this long intro section the first sample of Deadmau5's car is heard.[15] The long continuous volume changes in the intro allow the main groove of the track to be set up in a more interesting way than just repetitive looping with no changes. The next formal section of the track is the buildup, which actually starts by getting softer so that another crescendo can happen before the first core.

Different kinds of continuous volume changes are emphasized in "Lick the Rainbow" by Estonian artist Mord Fustang. In this track, perceived volume changes accomplished through adjustments in filter resonance are particularly important in the buildup section, which is divided into three parts as shown in Figure 2-3a. During the intro and the entire buildup section there are three main sound layers taking place, which I call synth 1, synth 2, and the chords. A transcription of the two melodic lines is shown in Figure 2-3b. The "chords" layer is probably split into (at least) two separate layers in the production software, with one holding long notes and the other articulating the rhythm of synth 1, but still on the same notes.

[15] The sample of the car sounds is from Deadmau5's own Ferrari driving in Toronto. Lindquist (2014).

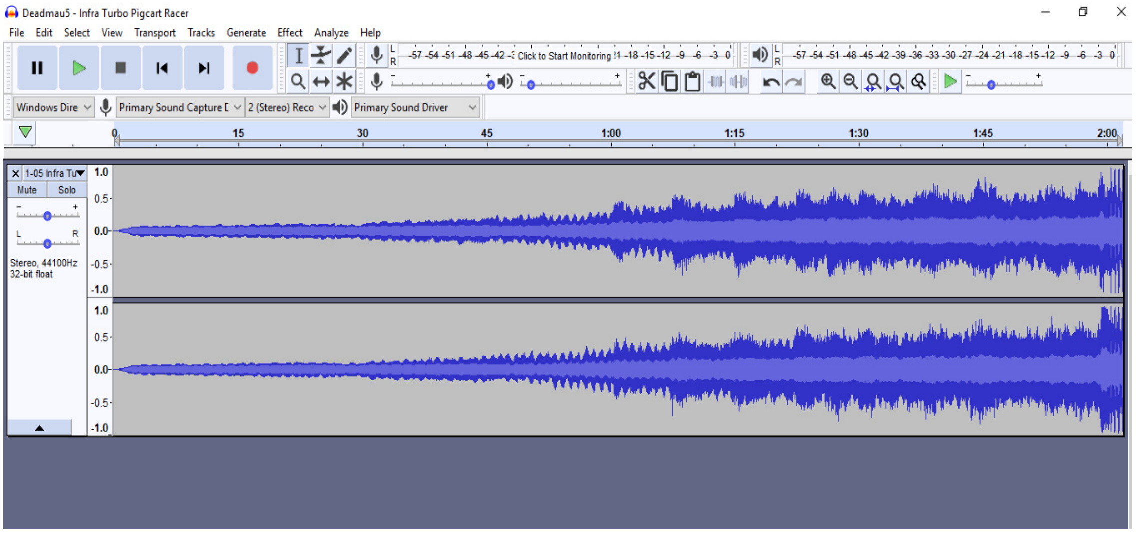

Figure 2-2: Amplitude graph for the Intro (0:00–2:00) in "Infra Turbo Pigcart Racer" by Deadmau5 (2014).

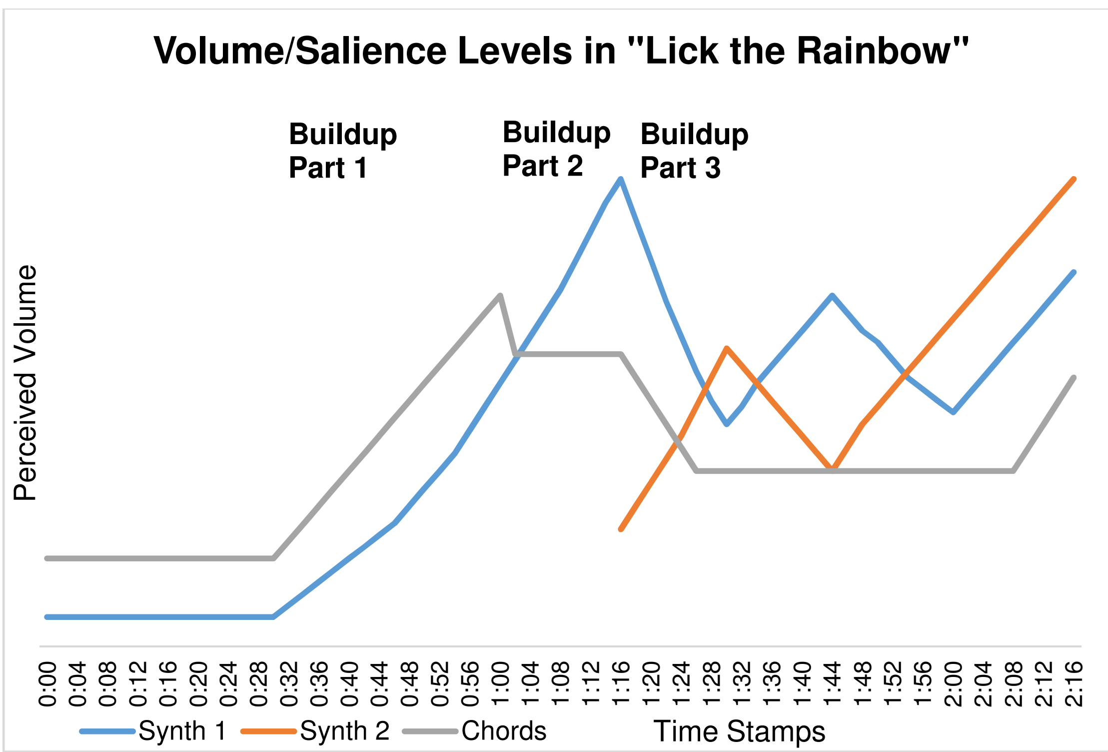

Figure 2-3a: Perceived volume changes in the intro and first buildup of "Lick the Rainbow" by Mord Fustang (2011).

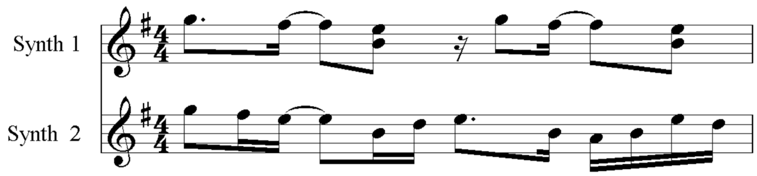

Figure 2-3b: The two main melodic lines in the first buildup section in "Lick the Rainbow" by Mord Fustang (2011).

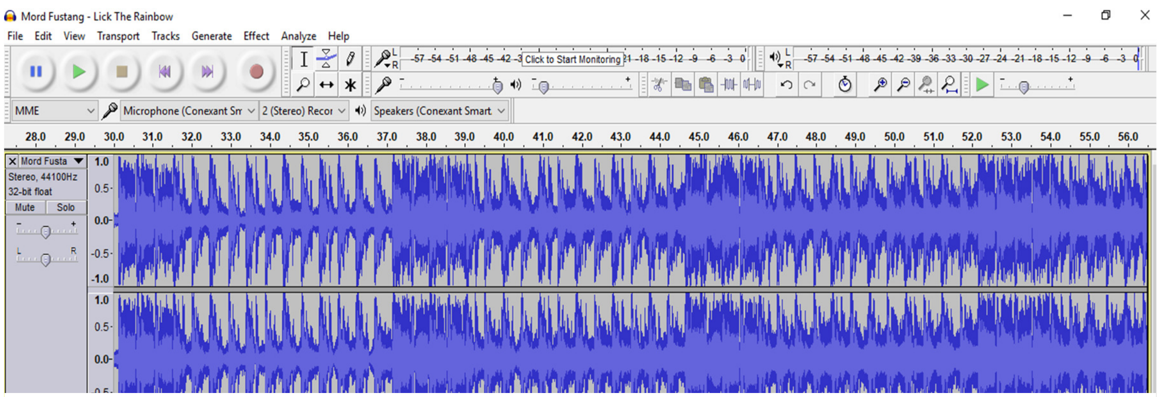

Figure 2-3c: Amplitude graph of the first buildup section (part 1) in "Lick the Rainbow" by Mord Fustang (2011).

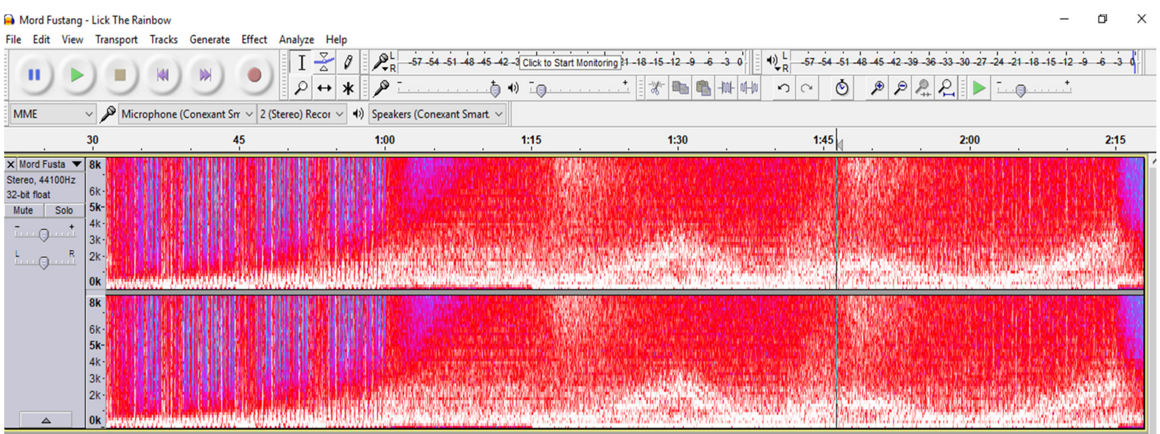

Figure 2-3d: Spectrogram of the first buildup section in "Lick the Rainbow" by Mord Fustang (2011).

At the beginning of the track, synth 1 is very faint and in the background, while the static E minor chords are holding and are a little louder. In the first part of the buildup, both steadily increase in volume, and this can be seen in the amplitude graph, Figure 2-3c. This amplitude graph also shows the discrete entrances and exits of the loud bass part, in contrast with the continuously crescendoing synth 1 and chords that can be seen in the graph when the bass is not present. The increases in volume are also aided by filtering, since higher frequencies are continuously being added to the sounds, as seen in the spectrogram (Figure 2-3d). There is also continuously increasing filter resonance, making the higher frequencies in the sound (specifically, the frequencies around where the cutoff point for the filtering is) more resonant so that the timbre becomes "brighter" and seemingly closer to us.

In the second part of the buildup (which is the shortest of the three, lasting only eight measures) the synth 1 line continues to grow in volume and in salience for the mix, while the chords (or at least the non-rhythmic part of the chords) get softer and settle into an accompaniment role. There is an aspect of merging between the synth 1 line and the rhythmic part of the chords here in a way that was not the case in the first part of the buildup, because there the timbre of the rhythmic articulation in the chords was not as clear as the timbre of synth 1. In the second part of the buildup the timbres are more matched together and therefore they can be perceived as one unit.

The third part of the buildup is the longest and most interesting in terms of volume transformations (accomplished with filtering), as can be seen in the line graph and also the spectrogram (Figure 2-3a and Figure 2-3d). Now the synth 2 gets suddenly introduced into the texture, and it is soft, in great contrast with the synth 1 line that has been building in importance by becoming brighter for the last 45 seconds. Over the course of the next minute however, the two lines will go back and forth in perceived volume and salience, shown by the crisscrossing in the line graph. They are alternating taking up the highest spaces in the frequency band. During this time the chords are still stable in their accompaniment role, but at the end all of the elements seem to get louder as the filter opens up to allow all the frequencies to be used. This is a typical technique for the end of a buildup section.

The very end of the buildup contains four measures from 2:15 to 2:22 in which the sounds decrescendo and seem to naturally decay. After this the loud core enters as somewhat of a shock. In the buildup section Mord Fustang utilizes volume and filter-resonance changes as a means of creating interesting continuous processes beyond the usual crescendo, and this allows him to write an extended buildup section of 60 measures (almost two minutes long), as opposed to the usual eight- or sixteen-measure section.

Sometimes continuous volume changes can be used to create the "illusion of acceleration." More and more notes can be gradually added through fade-ins and crescendos to a repeating, isochronous (evenly spaced) rhythm within the length of its own bounds. This length of time is not necessarily a duple value like one beat or a half beat, as is the case in "Lack of a Better Name" by Deadamu5 (2009), when in the buildup section a metrically dissonant layer gradually gains more notes. As seen in Figure 2-4, the pitch F in "synth 1" at first has the rhythm of a dotted eighth-note (three sixteenth notes in length). This length will continue and act is its "bounds" but as the loop gets louder and the timbre gets harsher, more articulation points are added within those bounds.

First, the loop itself softly enters and continuously crescendos, then Deadmau5 fades in a copy of the sound but displaced by half of the original rhythmic value. Therefore halfway through the buildup the rhythm sounds like repeated dotted sixteenth notes rather than dotted eighth notes, but the first of the two is always more accented. The delayed version also comes only from the right channel in stereo space and the initial sound comes from both the right and left channels. Eventually more echo is gradually added so that it sounds like the rhythm continuously morphs into regular sixteenth notes. Now the rhythm sounds three times as fast as the original dotted eighth note instead of two times as fast, but the transition between these stages sounds continuous and is accomplished more quickly than the transition between the first two stages. It sounds continuous because of continuously more volume and echoes being added. In addition to the "illusion of acceleration" effect shown in Figure 2-4, there are two other pitched sound layers in the texture. A long continuous process also takes place in the bass line, which changes its timbre to make the pitch clearer. The other pitched layer is the melodic hook, which loops repetitively without changing and acts as an anchor. The "illusion of acceleration" effect is reminiscent of phasing techniques in the minimalist works of Steve Reich, who called it "the process of rhythmic construction" and "the process of substituting beats for rests."[16] Richard Cohn also referred to it in Reich's music as "transpositional combination of beat-class sets."[17]

[16] Reich quoted in Fink (2005, 107, 109).
[17] Cohn (1992).

Figure 2-4: The illusion of acceleration in the buildup section (1:33–2:03) of "Lack of a Better Name" by Deadmau5 (2009).

Rhythm and Tempo

The "illusion of acceleration" effect gradually increases the number of articulations within a specific rhythmic value, but the continuous processes involved actually relate to volume. There are however other continuous processes that result from changes in speed, making the rhythm or tempo continuously faster or slower.[18] When the "speed" of music is continuously altered in just one sound layer, it is only a change in *rhythm*, whereas if the speed is continuously altered for the entire texture, it is a change in *tempo* for the track. Significant tempo changes are uncommon in EDM, because they make the music difficult to dance to, but when they do occur it is usually in intro sections

[18] Technically, in electronic music, tempo is different than speed because changing the "speed" of a sound means also changing its pitch. Pitch is nothing more than very fast rhythm with a very high "frequency" of oscillations. Changing rhythm or tempo, then, refers to changing the length of time between beats but not the pitch of the sounds.

of tracks or parts of a DJ set when dancers could use a rest period, for example after a particularly intense track.

Accelerations and decelerations can be difficult to unambiguously discern as continuous or discrete. As mentioned in the introduction to this chapter, I follow Grisey in defining continuous acceleration or deceleration as any situation in which the length between sounds gets shorter or longer with each consecutive note.[19] This is opposed to discrete acceleration or deceleration, in which multiple consecutive notes have the same length before the length between notes gets shorter or longer in a general trend of speeding up or slowing down. For example, a continuous acceleration could have consecutive note lengths of 4, 2, 1, ½ beats, whereas a discrete acceleration could have consecutive notes of 4, 4, 2, 2, 1, 1 beats, so that the acceleration is happening *step-by-step*. Both continuous and discrete accelerations and decelerations are important in EDM, and sometimes it is difficult to tell the difference between the two when listening, since a passage that accelerates overall may have both continuous parts and discrete parts to it. In these cases, I may refer to the whole passage as a continuous acceleration, because the overall increase in speed *sounds* continuous.

One very important example of clear discrete acceleration occurs in snare-drum "rolls" or "fills," which are characteristic markers of buildup sections, especially in the genre of trance.[20] Snare fills occur when the snare drum undergoes rhythmic diminution, first repeating longer values like quarter notes, then repeating shorter and shorter values

[19] Grisey (1987, 247–252).
[20] "MasterClass | Armin van Buuren Teaches Dance Music" (2018); Snoman (2009, 252, 266–268); Solberg (2014, 70).

such as eighth notes, sixteenth notes, or thirty-second notes.[21] Typically each stage of diminution does not last as long as the previous one, so that there is acceleration not only in the rhythmic values which are getting shorter, but the time taken to repeat each rhythmic value, which is also getting shorter. This is reminiscent of the fragmentation and acceleration of harmonic rhythm moving towards a cadence in a Schoenbergian sentence. A prototypical example of a snare fill is shown in Figure 2-5, from the track “Pulsar” by Armin van Buuren, who is a superstar artist in the trance genre.

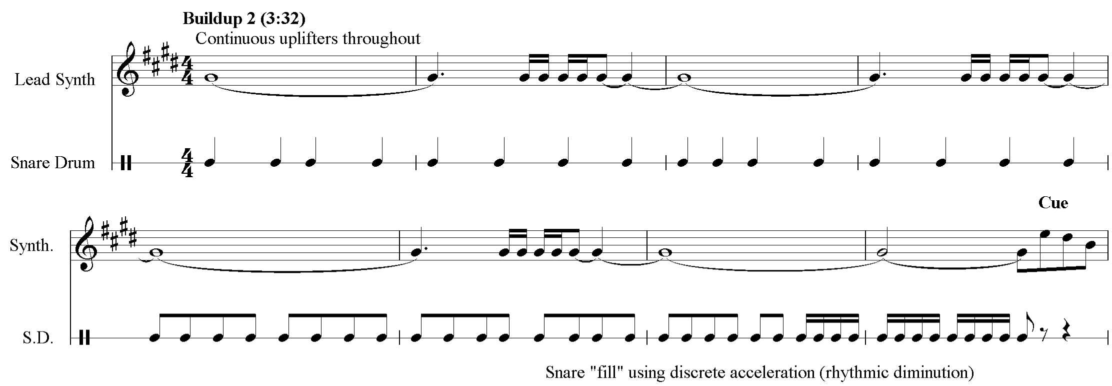

Figure 2-5: Snare fill using discrete acceleration at 3:32 in "Pulsar" by Armin van Buuren (2013).

In a typical EDM track the tempo is constant and clear. The fixed tempo of EDM tracks is typically anywhere between 110 and 160 beats per minute (bpm). However, as mentioned above, there are cases when the tempo of a track significantly changes and does so continuously, usually in intros of tracks, and often in tracks that are designed more for “headphone listening” than club dancing. One example of this is the track “Thousand” by Moby. This is a gimmicky track from the early part of Moby’s career.

[21] For a theory of rhythmic augmentation and diminution in general, see Messiaen (1956, 18–19).

The track's title refers to a tempo of one thousand beats per minute, which is a ridiculous notion to anyone who understands that beats are a psychological phenomenon and not just strikes of a drum (whether acoustic or digital).[22] Nevertheless, the tempo does change significantly, both increasing and decreasing, with only a few points of stability.

Apart from its tempo changes, the track is remarkably simple, with a thin texture and hardly any pitch movement. There are four main layers of sound: a drone bass E, another pitched layer that enters discretely on G, the drums, and the vocal sample from the soul song "Let No Man Put Asunder (A Shep Pettibone Mix)" by the female trio First Choice.[23] The former three layers are manipulated together as one group with regards to tempo, but the vocal sample is treated slightly differently.

If we assume that four drum hits constitutes one measure of 4/4 time, as is the standard in almost all EDM and contemporary popular music in general, then the length of each loop for the drums, pitch-E, and pitch-G layers combined is four measures. The acceleration and rate of change for the tempo can be calculated based on the length of each four-measure loop starting at 0:42.5, with the results shown in Figure 2-6a and Figure 2-6b. Note that once the track starts speeding up, it does so quite quickly, but then as each loop gets faster and faster, once the "momentum" has been established, the rate of change generally slows down, tending towards zero. However, these graphs only show the changes at four-measure intervals, which do not investigate whether the changes are discrete or continuous at a more precise level. To my ear, sometimes the changes in

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[22] Epstein (1979, 56–59).

[23] The pitches employed here actually contain many harmonics that produce several sounding pitches, but I describe the ones that are the most audible.

tempo are quite abrupt, with isochronous drum hits followed by adjacent drum hits of different lengths. Other times the changes in tempo really are continuous, so that each drum hit is non-isochronous with the next, and they are not evenly spaced. In any case, the general trend is one of acceleration and the inconsistencies could be described as what Grisey calls “statistical meanderings” in statistical acceleration.[24]

Another interesting aspect of “Thousand” is that the vocal sample does not always coordinate with the other three sound layers. It usually lasts for eight “measures” (where four drum hits equals one measure), but sometimes it lasts for four, sometimes twelve, and sometimes six plus a short fadeout, as shown in Figure 2-6c. The disjunction between the length of the vocal sample and the other loop is highlighted in the first part of the second half of the track (1:56–2:10, not shown in the graphs and table), but then in the last part of the track as the tempo accelerates to its highest rate yet, the vocals seem to coordinate more closely with the other parts, being reduced to what sounds like just one beat and one note.

[24] Grisey (1987, 253).

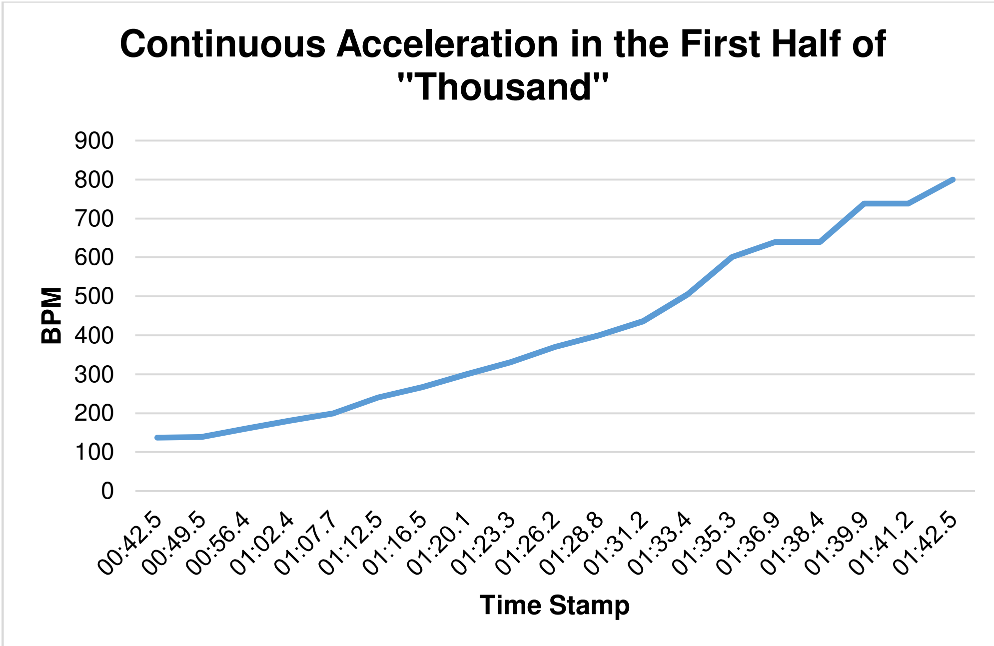

Figure 2-6a: Continuous Acceleration in the First Half of "Thousand" by Moby (1993).

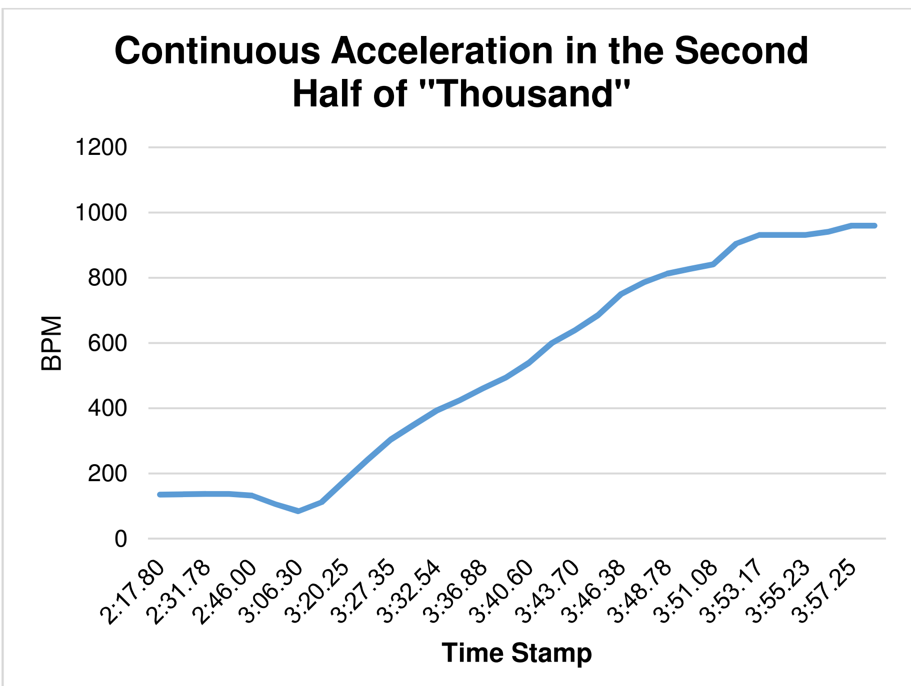

Figure 2-6b: Continuous Acceleration in the Second Half of "Thousand" by Moby (1993).

Time stamp (start of vocal sample)	Length of vocal sample in “measures”
0:21	4
0:42	6 + quick fadeout
0:56, 1:07, 1:16	8
1:23	12
1:31, 1:35,	8
1:38.4, 1:39.9, 1:41.2, 1:42.5, 1:43.7, 1:44.9, 1:46.1, 1:47.3, 1:48.5, 1:49.7, 1:50.9, 1:52.1,	4
1:52.1	6 + fadeout

Figure 2-6c: Length of the vocal sample in the first half of "Thousand" by Moby (1993).

A different track with varying tempo is “Fn Pig” by Deadmau5 (2012). Unlike “Thousand,” the tempo only varies in “Fn Pig” during the extended intro, before the track adopts the standard conventions of EDM and serves as a functional piece of music for the dancefloor. In the intro, there is an interesting relationship between tempo and rhythm that highlights a typical perceptual shift pointed out by cognitive scholars.[25] From the beginning of the track until 2:02, the tempo is slowly and continuously increasing.

At the start, all we hear is a simple, ethereal texture with some drone synthesizer notes creating perfect fifths, a soft, mellow kick drum sound, and some very soft, faster notes that sound like echoes of the drum. Naturally, we take the length between each drum hit to be one beat, but notice that these beats are getting shorter and shorter. Since the tempo continuously gets faster and faster (as shown in Figure 2-7a), somewhere between about 0:40 and 1:20 a cognitive shift takes place that changes the interpretation of what was at first heard as individual beats into now half-beats (eighth notes). This is aided by the synth sounds changing pitch at 0:47 and becoming a homophonic chorale,

[25] London (2012, 30–46).

which at first might be interpreted as hypermetrical but eventually it becomes metrical. During this same passage the kick drum is undergoing a continual transition that began around 0:30. It turns into a pitched sound rather than a non-pitched (perceptually) percussive one, has its timbre change to a harsher sound, and lengthens its attack.[26] As the pitches of this sound layer become clearer around 0:57, it generates a contrapuntal line to the melody in the mellower synths, and rhythmically becomes a repetitive eighth-note layer.

During the next minute of the track, both the synth melody and eighth-note layers become more elaborate and louder, while the tempo continues to increase. Figure 2-7a shows that even though at a precise level there are some points when the acceleration jumps from step to step, it is mostly continuous, and therefore it sounds continuous to the listener. This is also demonstrated by the rate of change remaining quite steady and almost constant. The acceleration in the long intro can also be seen in the waveform shown in Figure 2-7b, since the start of each beat is significantly louder than other parts of the track so the distance between beats is equal to the distance between peaks in the amplitude graph. After 2:02, the tempo rapidly decelerates (the beat lengths increase), and the pitches merely hold a chord from 2:16 to 2:52. This means that the tempo seems to be equal to zero here.[27] Following this long static drone, the main part of the track begins at 2:52, with a steady tempo articulated with discrete, repetitive pulses.

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[26] It is difficult to tell if Deadmau5 actually faded in another layer of pitched sounds and faded out the kick drum, using continuous processes of volume, but to my ear it sounds like one sound layer that is continuously changing.

[27] Starting around 2:30 the timbre also seems to disintegrate a bit, causing fast "crackling notes" to sound softly.

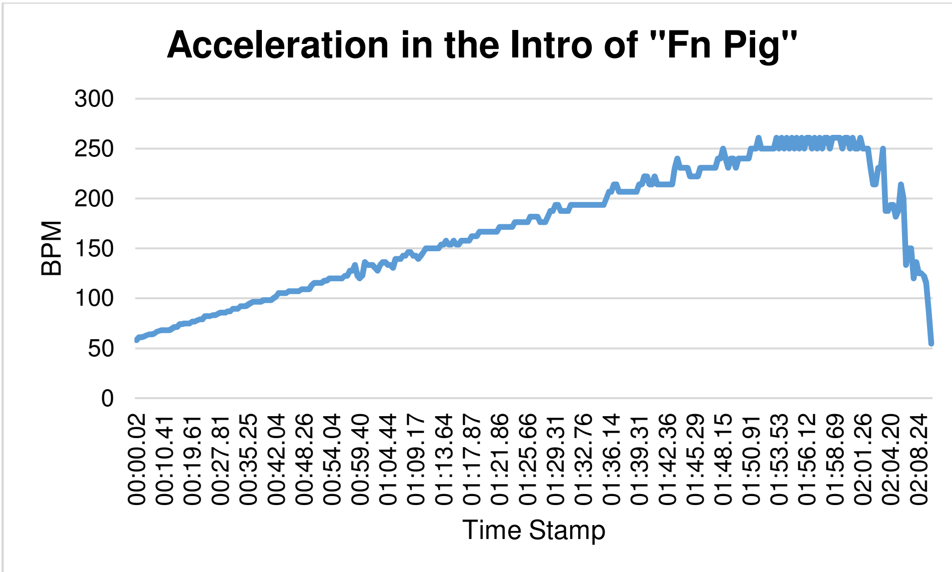

Figure 2-7a: Continuous acceleration in the intro of "Fn Pig" by Deadmau5 (2012).

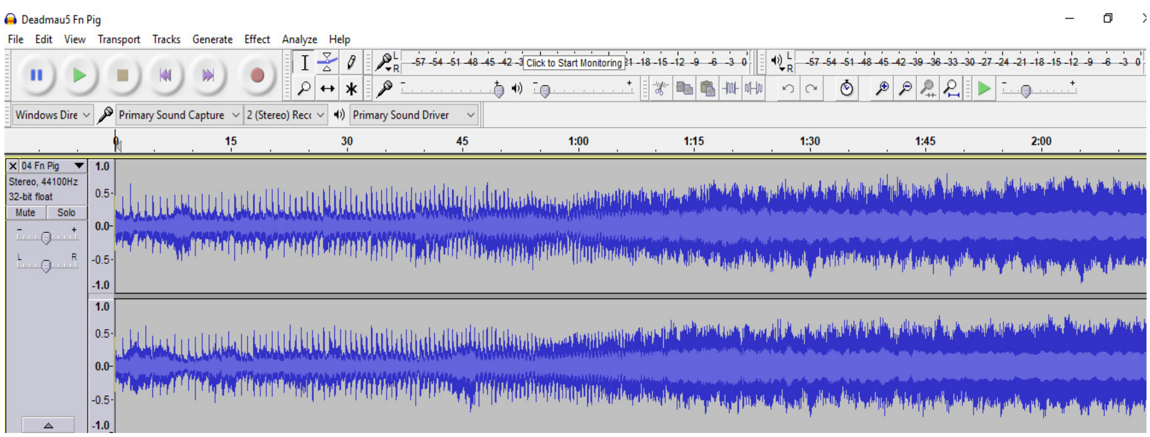

Figure 2-7b: Acceleration shown in the waveform in the intro of "Fn Pig" by Deadmau5 (2012).

The previously discussed two tracks – “Thousand” and “Fn Pig” – continuously increase or decrease the tempo of a track. In other words, they are continuously making the beats faster. The next examples show instances where the tempo of a track stays the same, but the speed of one or more rhythms continuously increases or decreases. A good example of rhythm *decelerating* occurs in “Interferance” (2017) by South-African artist

Chunda Munki.[28] The title refers to cell-phone interference, which is an important aspect of the song's musical structure and story. At 1:03 (the first breakdown section) the harsh sound of cell-phone interference is introduced and immediately begins slowing down its rhythm by having the notes farther and farther apart. It is as if the sound is "breaking up." This process continues for eight measures before the sound re-establishes itself at 1:18 with what will become its repetitive, characteristic rhythmic pattern.

During the deceleration process the melodic hook of the track and two other pitched layers continue in addition to this new sound. This allows for the tempo to remain the same (albeit less obvious) while one layer is slowing down and sounding like it is disintegrating. The transcription of this section with the slowing rhythm is shown in Figure 2-8a, but the slowing process can also be seen in the increasing distance between peaks of the waveform, as shown in Figure 2-8b.

Although this process is only used once during the whole track, it fits well with the narrative presented by the lyrics. During most of the track the only words are "just something I got" (heard from 0:15 to 1:02 and 2:21 to 2:48), but in the *second* breakdown section (3:56–4:27, the beginning of which is transcribed in Figure 2-8c) we get a fuller explanation of the story from the perspective of the protagonist. The one-sided speech presented is presumably from a phone call where they "break up" with their previous romantic partner. The rhythm of the previous vocal sample is now embedded within a

[28] Interestingly, the title of the song is "Interferance" (spelled with a), but the title of the album is *Interference* (spelled with e).

sentence and a larger musical phrase, providing context and meaning for the previous iterations.

There are both musical and narrative associations between the first breakdown and the second breakdown. Musically, in both sections, the foregrounded sound layer is accompanied by the melodic hook and a high pedal point (drone) on the tonic pitch, in what I call synth 1 and synth 2 in my transcriptions (compare Figure 2-8a Figure 2-8c). Narratively, the sound effect itself breaks up in the first breakdown, and the relationship breaks up in the second breakdown. The fact that the interference sound effect is used for the repetitive rhythm throughout most of the rest of the track could also be interpreted as cell-phone interference being constant throughout most of the couple's communications. This would allow the partner who is being broken up with to remain in denial, and it would mean that the deceleration of the interference sound in the first breakdown signals clearer phone reception and almost a situation of forced confrontation with the troubles of the relationship, which will be made fully clear in the second breakdown section when there is no interference sound. There is no cell-phone interference during the second breakdown section, meaning that both partners can communicate clearly and the anonymous receiver heard the message loud and clear. In this track, the use of deceleration in one sound layer has a profound impact on the emotional meaning of the song. The unique timbre of the sound is an icon for cell-phone interference but it also symbolizes social interference and "breaking up" at a metaphorical level.

Now looking at Figure 2-8a and Figure 2-8b more closely, it becomes evident that the deceleration process I have been discussing is actually not continuous, but discrete.

The space in between notes can be calculated in positive integers of sixteenth notes, with no non-whole numbers, and more importantly, there are at least two iterations of almost every distance between notes. Yet because of the lack of clear beats provided by the other sound layers and the increasing amounts of silence between each note, the deceleration process is easily *perceived* as continuous. The other, pitched synth layers provide enough familiarity to maintain the tempo of the track, but not enough to highlight the discrete nature of the slowing process. If the typical drum parts that metrically frame EDM were present and articulating quarter-note beats along with eighth-note and sixteenth-note subdivisions, then the deceleration could easily be perceived as discrete. However, with the drum parts absent, even if listeners use "virtual reference structures" to maintain a sense of the beat in this relatively static section,[29] it is hard to keep track of the rhythm in the interference sound because of the increasing space between notes. Through these compositional processes, Chunda Munki maintains the *effect* of a continuous process and of being non-grounded in musical space.

[29] Danielsen (2010, 4).

Figure 2-8a: Deceleration in the first breakdown (1:03–1:18) of "Interferance" by Chunda Munki (2017).

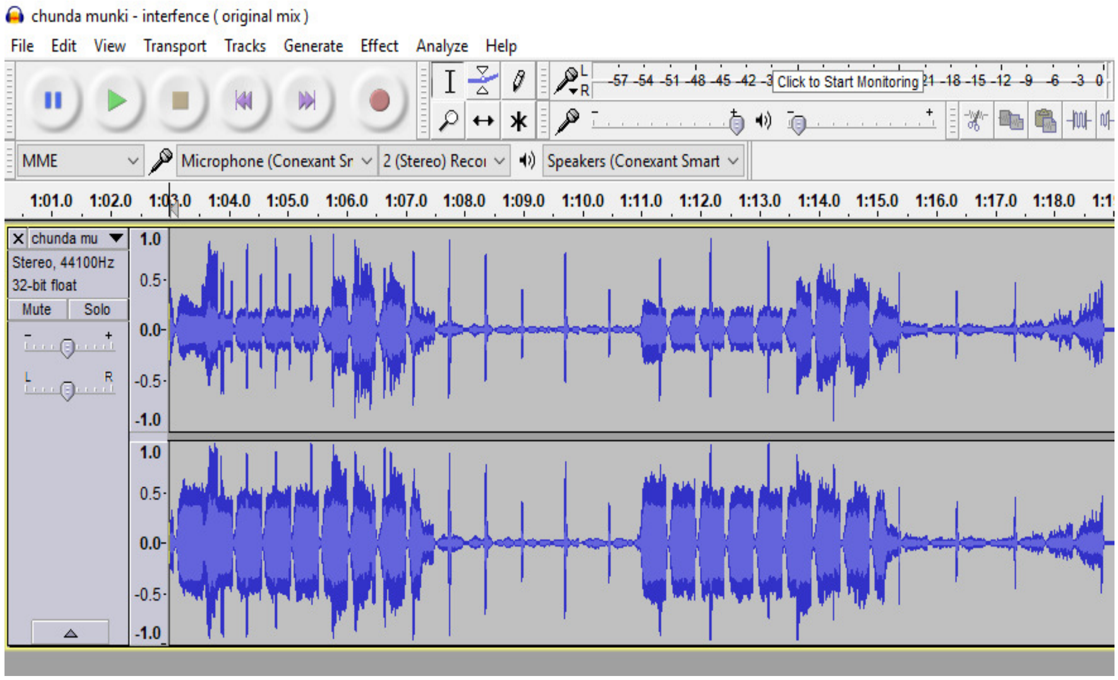

Figure 2-8b: Waveform for the deceleration in the first breakdown (1:03–1:18) of "Interferance" by Chunda Munki (2017).

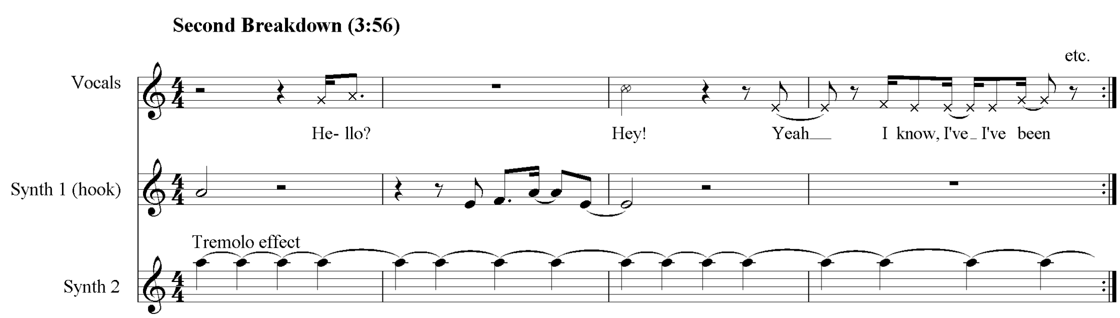

Figure 2-8c: Transcription of the beginning of the second breakdown (3:56–4:27) in "Interferance" by Chunda Munki (2017).

Another track that uses similar processes is "Cthulhu Sleeps" by Deadmau5 (2010). This track has a very long intro that can be broken up into three parts. It is the second of these parts (from 2:00 to 3:00), that utilizes extensive continuous processes related to rhythm. In this section there are three rhythmic layers. All three were introduced in the previous section, and all were initially repeated at constant (isochronous) intervals. Figure 2-9 shows the speed of each of the three layers, in attacks per measure, for the thirty-two measure section that features continuous acceleration and deceleration (2:00–3:00).[30] This is an imperfect method of measuring it, and that is reflected in the graph that looks jagged and not perfectly continuous, especially in the pitched synth. However, this was the most practical method for my purposes. Only Deadmau5 knows how he created these accelerating effects, whether it was through turning real or virtual knobs or entering values in a precise table in a software program. But to the listeners the actual acceleration and deceleration occurs at a precise enough level that it sounds smooth and continuous.

Two of the three rhythmic layers begin the section by accelerating. The other rhythmic layer maintains isochronous beats, so as with "Interferance," the tempo remains static, linking this section to the surrounding ones that are much more stable rhythmically. Of the two layers that accelerate, one does so much more rapidly, to the point that it almost merges into one continuous sound with no perceptible subdivisions. This sound layer is the most salient and recognizable feature of the track as a whole, and it can be thought of as representing the mythical Cthulhu monster.[31] I will call it the "rhythmic synth" for lack of a better term, because unlike the other two layers it does not have an easily-identifiable pitch.

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[30] I chose to do this per beat rather than per second because the beat is persistently articulated in this section and thus provides an easier reference point than the arbitrary marker of time outside music that is "seconds." It is best to keep it inside "musical time" rather than "ordinary time" Kramer (1988, 17). However, given that two levels of acceleration are going on, it can also be disorienting and hard to perceptually maintain the tempo.

[31] The Cthulhu monster originated in H.P. Lovecraft's short story *The Call of Cthulhu* (1928).

The behavior of the “rhythmic synth” in this section can roughly be mapped into three phases.[32] First is the acceleration phase that takes place in measures 1–13 of this 32-measure section. During this section it can be imagined that the Cthulhu is waking up. Notice how the rate of change is fairly constant but towards the end it accelerates quite quickly. The second phase is when the rhythmic synth reaches its peak speed in mm. 14–17. This is when it almost blurs into one continuous sound and therefore it is particularly easy to perceive the acceleration as being continuous and not discrete. The third phase is the deceleration phase in mm. 18–32, when it slows down to much slower than it was before, even in the first part of the track before the changes started. At this point the Cthulhu can be imagined to be going back to sleep here, and settling into a calmer state.

The second layer has an obvious element of pitch to it so I will name it the “pitched synth.” This sound was introduced in the previous section of the piece, fading in around 1:45 and having a steady rhythm, albeit a metrically dissonant one with the beat.[33] The pitched synth accelerates like the rhythmic synth, but it does so at a much slower rate, and also continuously heightens its pitch at the same time from about F4 to D5.[34] Unlike the rhythmic synth, the pitched synth only accelerates until it fades out around 2:47; it never decelerates. The use of only acceleration, but at a slow rate, marks this layer as different from the other two in the texture. The third sound layer, the “pulsing

[32] Even though the perceived effect of the changes to the “rhythmic synth” is one of acceleration and deceleration, the speed changes were probably accomplished with the continuous turning of an LFO knob clockwise and counter-clockwise to alter the rate of waves being produced.
[33] The repeated rhythmic value here is roughly equivalent to a double-dotted eighth note, a.k.a. seven thirty-second notes or 7/8 of one beat.
[34] At a more precise level, it sounds like there are multiple layers to what I call the “pitched synth,” only one of which is pitched and the other one is rhythmic, but I group them together because they are easily perceived as one unit.

drone," sounds like an alarm clock repeatedly going off. It maintains the tempo of the track while the pitched synth and rhythmic synth accelerate and/or decelerate at significantly different rates. All three of these layers put together creates a tense and highly disorienting effect.

It is also interesting to track the volume and perceived salience of each of the three layers in this section, and this is represented by the thickness of the lines in Figure 2-9. The rhythmic synth (which could represent the Cthulhu) stays strong throughout, but at times one or both of the other layers seem to be competing with it for preeminence. The pulsing drone starts the section with a strong, harsh sound and accentuated overtones, but then it becomes mellower and continuously changes its timbre as it fades to the background while the two accelerating layers are reaching their peak speeds.[35] Then as the pitched synth fades out, the pulsing drone is getting louder, highlighting the absurd slowness of the rhythmic synth by this point, and preparing the listener for the upcoming section when the pulsing drone will take over and repetitive discrete elements will be much more salient. So overall the section starts and ends with *both* discrete and continuous processes being highly salient, but in the middle the continuous processes are the most salient, and are brought to the foreground.[36]

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[35] Specifically, by measures 7–8 of the section the low frequencies are emphasized much more than at the beginning.

[36] For most of the rest of the piece, the "rhythmic synth" is just heard on the off beats as one of many sound layers in the cores, and the "pitched synth" is heard accelerating again at the start of the second core (which is unusual).

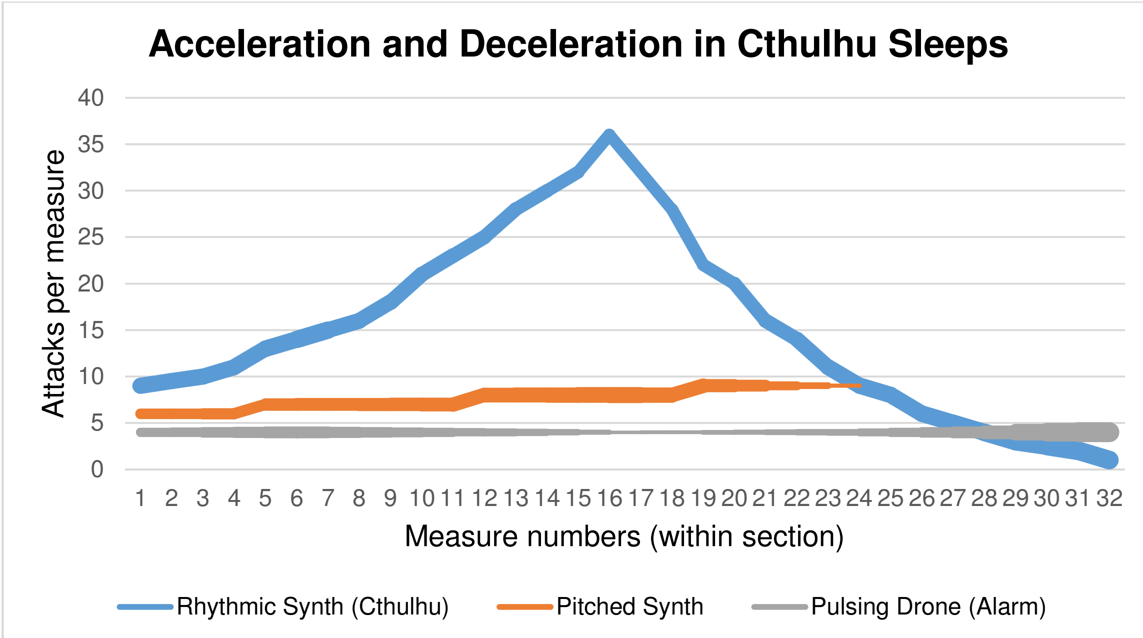

Figure 2-9: Continuous acceleration and deceleration in the second part of the intro (2:00–3:00) in "Cthulhu Sleeps" by Deadmau5 (2010). The thickness of the lines represents perceived volume and salience.

Pitch Slides

Continuous changes to pitch have many names, such as portamento, a glissando, a pitch slide, or a pitch bend. In general I will use the term pitch slides. In music production, ascending pitch slides are often referred to as uplifters and descending pitch slides are referred to as downlifters.[37] As with other continuous processes, these changes can be accomplished through many means, including automation curves, knobs and sliders, or the pitch wheel on a synthesizer. Many pitch slides are quite short, lasting less than one measure or one beat, and these are generally used as quick "effects," which will be discussed in the next chapter. Since this chapter focuses on longer, multi-measure continuous processes, the next several examples show how gradually and continuously

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[37] Solberg (2014, 70); Solberg and Jensenius (2016, 308); Zen World (2017).

raising or lowering pitch affects the tension levels and the aesthetic impact of an EDM track.

Let us first return to “Cthulhu Sleeps,” and the second section of the intro (2:00–3:00) that was discussed previously in the section on rhythm and tempo. Note that the “pitched synth” gradually raises its pitch level while also accelerating its rhythm. Both of these continuous processes take place slowly, so that the differences in speed and pitch between the starting point and the ending point are not extreme. In terms of pitch, the rate of change is high enough that a pitch slide is easily recognized, but it is also recognized as an extremely slow one. This creates an almost agonizing effect that creates high tension during this portion of the track, before the main part for dancing starts. As already discussed, the slow acceleration of the pitched synth provides contrast with the fast acceleration of the rhythmic synth, but the use of continuous speeding up in both layers allows them to be grouped together perceptually; with regard to rhythm, in this section there are two continuous layers and one discrete layer. With regard to pitch, however, there are two discrete layers and only one continuous layer, so the pitched synth stands out as the only one with a pitch slide.

Finally, it is interesting to track the role of the pitched synth throughout the whole track as compared with the large-scale structure. It appears three times, each time starting with a steady isochronous rhythm and a consistent pitch for several measures (1:38–2:00, 3:37–4:30, and 6:33–6:59). Then it begins to slowly accelerate, rise in pitch, and fade out. Interestingly, the second of the three iterations of the pitched synth is employed differently than the other two. Firstly, it is the only time that the sound abruptly enters rather than fading in, and it has a longer time span before its continuous processes start. Even more significantly, the continuous processes of both the first and third iterations coincide with buildup sections (2:00 and 6:59), when the entire texture is in a state of tension and uncertainty, but the continuous processes of the second iteration occur during the first main *core* section of the track (at 4:30). This is an uncommon instance of an extensive continuous process being used during (and even at the *start* of) a core, when the drums, bass line, and rhythmic synth are all loud and repetitive, creating a great groove for dancing. In this context the continuous processes of the pitched synth stand out, but not enough to disrupt the hardcore pounding of the beat in the other layers.

A more persistent and obvious use of extended continuous pitch slides occurs in "Tissot" by the young Russian producer Bolivaro. Even though the track is less than five minutes long and contains only two cores (with a heavily pulsating bass and a catchy melodic hook), there are *twelve* instances of continuously rising pitch over extended periods of time. These are split into two types that each occur *six* times, as shown in Figure 2-10.

Time Stamp	**Section**	**Continuous Pitch Slide Type**
0:00–0:30	Intro	
0:30–0:45	Buildup 1	A (rhythmic), with tonic chord
0:45–1:18	Breakdown 1	
1:19–1:33	Buildup 2	A (rhythmic), with chord progression
1:34–1:48	Pre-Core 1	
1:49–2:03	Buildup 3	A, with tonic chord
2:04–2:05	"Cue" space	
2:06–2:38	Core 1	B 2:14–2:21 and 2:30–2:35
2:38–2:56	Breakdown 2	B 2:49–2:56, sharp timbre and attack
2:56–3:11	Buildup 4	A, with chord progression
3:11–3:26	Pre-Core 2	B 3:20–3:26
3:26–3:41	Buildup 5	A, with tonic chord

3:41–3:43	“Cue” space	
3:43–4:15	Core 2	B 3:52–3:58 and 4:07–4:13
4:15–4:51	Outro	A 4:30–4:45 with no chords

Figure 2-10: Form chart of "Tissot" by Bolivaro (2013).

The first type of pitch slide (Type A in Figure 2-10) ascends approximately from F4 to F5. The ascent is broken up by various attack points and cutaways to a lower register (which is also slowly rising but has less definite pitch because it contains numerous short pitch scoops), but the linear automation curve is still continuously rising, with no breaks in terms of pitch. Interestingly, the total number of attack points for both the upper and lower lines create a rhythm that is a textbook example of discrete acceleration, halving the number of attack points in a unit from eight (one lower plus seven higher) to four (one lower plus three higher) to two (one lower plus one higher) to one (one lower). However, this example is slightly unusual in that each group begins on either beat four or beat two, rather than the customary beats one and three of a 4/4 measure.

Aside from the obvious timbre difference, the second type of continuous pitch ascent (Type B in Figure 2-10) differs from the first (Type A) in numerous ways. Firstly, Type B is half as long as Type A, occurring over roughly four measures rather than eight. Its ascent is also larger, moving approximately from C4 to C6, almost two octaves, and double the span of Type A. Another difference is that Type B usually has somewhat unclear attack points, suggesting a rhythm of repeated eighth notes but not articulating them very clearly. This means that the ascent could easily be perceived in a casual hearing as a continuous line with no breaks or points on the line. Even if the attacks are articulated more clearly, as in the occurrence during the second breakdown section (2:49–

2:56), the continuous rise in pitch is easier to hear because unlike Type A, Type B does not cut away to another, lower rhythmic idea. An additional notable difference between Type A and Type B is that the latter crescendos then diminuendos, whereas Type A only crescendos, so its continuous changes of volume are more complex. However, both lines begin by fading in from apparent nothingness which is why their time stamps vary according to how quickly they become apparent to my ears.

The aforementioned differences between the two types may allude to why they were used at different times in “Tissot” by Bolivaro. They never occur at the same time, competing with each other, but each has their specific purpose. Type A is used as part of a formulaic riser, to build up the energy of the track in all five buildup sections, because the pitch slide is accompanied by crescendos and discrete acceleration each time. Contrastingly, Type B functions more as an “effect” and usually occurs during sections where the track is more stable, including both cores and once during what I have called a “pre-core” that provides an intermediate level of stability in between two buildup sections. It is probably used this way because even though the pitch is continuously ascending (a technique that is associated with instability), the rhythm (when it is clear) is steady and the volume crescendos and then diminuendos. So in general Type A ascents are used during transitory sections and Type B ascents are used during stable sections, but both are used once in places that contradict those expectations. Type A occurs for the final time in the outro, when it is presented for the first time with no harmonies to anchor it to the home key of F minor, and in a context that normally decreases the energy of a track rather than increases it. Type B also occurs once during the sectional type associated with the least stability in EDM, the breakdown. It is noteworthy that this occurrence in breakdown 2 is the one with sharpest timbre and clearest attack points, setting it apart in another way from its other manifestations. Overall, in this track continuous processes are used to create a constant feeling of energy and movement towards a goal, even during sections that are otherwise stable.

A more recent track that utilizes both long continuous ascents and descents is "Zero-day" by the American duo Judah.[38] In fact, continuous pitch slides are used almost throughout the entire track. Generally they are quite drawn out, with sixteen measures of ascent and sixteen measures of descent. This length contributes to their high salience in the track. Their span is also wide, approximately two octaves between D4 and D6 on scale-degree 5 in G minor, with the highest note sometimes being undershot or overshot. The pitch slides also have a fairly steady rate of change, but they slow down towards the top and the bottom of the arc, usually reaching a plateau at the top for a few seconds. The volume of the sound with the pitch arc also continuously adjusts its volume, generally so that the highest and lowest points are softer than the rest. See Figure 2-11 for an overview of how the pitch slides intersect with the form of the piece. The use of long pitch slides throughout contributes to the overall "smooth" feeling of the track, with no obvious or jagged breaks between sections.

Time Stamp	**Section**	**Continuous Pitch Slide**
0:00–30	Intro part 1	None
0:30–1:00	Intro part 2	Ascent
1:00–1:30	Intro part 3	Descent

[38] I am using the extended mix here because the original mix is unusually short and does not use continuous processes as much as the extended mix.

1:30–2:00	Buildup 1	Ascent
2:01–2:31	Core 1	Descent
2:31–3:01	Buildup 2	Ascent
3:01–3:31	Core 2	Quick Descent (first half) then Quick Ascent (second half)
3:31–4:01	Breakdown	Descent
4:01–4:32	Buildup 3	Ascent
4:32–5:32	Core 3	None in first half, ascent in second half
5:32–6:48	Outro	None in first half, ascent in second half

Figure 2-11: Form chart for "Zero-day" by Judah (2017).

Over the course of the first minute, the vocal part, which contains a scoop every four beats into a held-note G, fades in from nothing and crescendos, before it decrescendos from 1:00 to 1:30. This correlates with the first continuous pitch ascent that takes place from 0:33 to 0:59, and the following continuous descent from 1:04 to 1:30. As stated previously the long arc created moves between D4 and D6, a wide span of two octaves. Rhythmically, the arc has repeated attacks that are one beat long in this section, but articulated slightly after the "real" beat articulated by the kick drum. Even though the rhythm is clearly discrete, this does not nullify the continuous nature of the pitch alteration. The long pitch arc and the crescendo/decrescendo in the vocal part, as well as the removal of the kick drum at 1:00, all suggest an up-and-down change in intensity for the intro section (0:00–1:30) as a whole. However, this is contradicted by the behavior of the G-D open-fifth dyad, which begins to crescendo starting around 0:20 and continues to do so until 1:30, even adding a melodic part at 1:15. The melody continues in the buildup section, which is an example of the smooth transitions between sections that characterize this track.

After the intro the long pitch arc continues for the next few sections, which all last for sixteen measures, including the first and second buildups and the first core. The second core is also sixteen measures long, but interestingly, the two-octave ascent and descent is accomplished twice as fast here, so that it can all take place within the same section. This also means that the pattern of using descents only at the beginning of cores is now broken, and allows for the descent to be used in a more conventional manner at the start of the breakdown section. The pitch arc returns to its normal length in the breakdown and final buildup sections, so that the descent and ascent both last sixteen measures. The final two sections of the piece last for a minute or longer, and both of them contain only ascents and not descents. This is part of what makes them more energetic than previous sections, in addition to other contrapuntal melodies being added, and it is also what makes the piece very typical of the genre progressive house, in which it is best classified, since progressive house is characterized by its cores getting progressively more intense and energetic. The long pitch slides in this track are generally a salient part of the texture that contribute to the fluctuations in energy and tension, however sometimes they are obscured by other sound layers and they move in and out of the perceptual foreground, partially due to their changing volume levels.

Filter Sweeps

Most of today's electronically-produced music (not just EDM) heavily relies on the use of EQ (equalization) and filtering, which control the amplitude (volume) of specific frequency bands. For example, high, mid, or low frequencies can be emphasized, downplayed, or removed altogether. One very common continuous process is a "filter sweep," which continuously adjusts the cutoff point(s), above or below which, frequencies are allowed to be a part of the sound.[39] The filters used can be high-pass (sometimes called low-cut), low-pass (high-cut), band-pass, or band-reject.[40] In the latter two cases, there are both high and low cutoff points, in between which is a “band” of frequencies that sound (in a band-pass filter) or are silenced (in a band-reject filter). A common type of filter sweep uses a low-pass filter to start by silencing or dampening frequencies above a certain threshold, and then continuously raises the threshold so that higher frequencies are gradually allowed to be a part of the sound and the sound becomes fuller. Another example is a high-pass filter continuously raising its cutoff point so that low frequencies are gradually silenced and the sound becomes “brighter.”

Filter sweeps can be applied to only one, many, or all sound layers in the texture at once. Often in buildup sections a filter sweep is applied to many but not all sounds. For example, a repetitive melodic hook in the mid-frequency range may keep looping as all the other loops fade away because their lower frequencies are being cut off. When filter sweeps are applied to “noise” sounds (with no clearly defined pitch) then they are referred to as “noise sweeps,”[41] which generally create “whoosh” sounds that also function as uplifters or downlifters.[42] I have chosen to include examples of this type of continuous process in a separate category because this technique relates to volume, timbre, and pitch simultaneously, and because filter sweeps are an essential part of contemporary popular music, including EDM.

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[39] Peres writes a good explanation of how filter sweeps work and the role the EQ in general for contemporary pop music. Peres (2016, 17–20).
[40] Holmes (2012, 226–227).
[41] Peres (2016, 44).
[42] Solberg (2014, 70); Zen World (2017).

One track that uses filter sweeps to make the music sound fuller in its buildup sections is “Smash” (2014) by Exodus. The track builds in energy throughout the first two minutes, but from 1:30 to 2:00 the first buildup section increases the tension to a breaking point before the first core. At 1:30 the section starts with downlifters in the form of a descending noise sweep, which can be seen in the spectrogram (Figure 2-12) since lighter colors are gradually taken away for higher frequencies. This dissipates some musical tension before it is increased again through ascending gestures. Another filter sweep applied to many sound layers takes place from 1:30 to about 1:38, with the threshold of a low-pass filter continuously being raised so that higher frequencies can pass through. This can also clearly be seen in the spectrogram (Figure 2-12), since lighter colors are gradually introduced for higher and higher frequencies. The filter sweep creates the effects of a crescendo and a change to a fuller timbre.

At around 1:38 uplifters begin in the form of continuous pitch ascents. The uplifters continue until 1:57, when they suddenly stop two measures before the end of the section. The highest pitch ascent has a very wide span of almost three octaves, and it ends on the leading tone (G-sharp) of the key (A minor), increasing the tension levels even further. An overall crescendo also takes place during this time, even though the bass line and some other melodic lines fade out (but are not filtered out). At 1:58 a very quick descending noise sweep takes place, which sets the stage for the vocal cue just before the core, and the drop at 2:00.[43] The second buildup in the track (3:30–4:00) features a similar set of processes, including the same types of filter sweeps and uplifters.

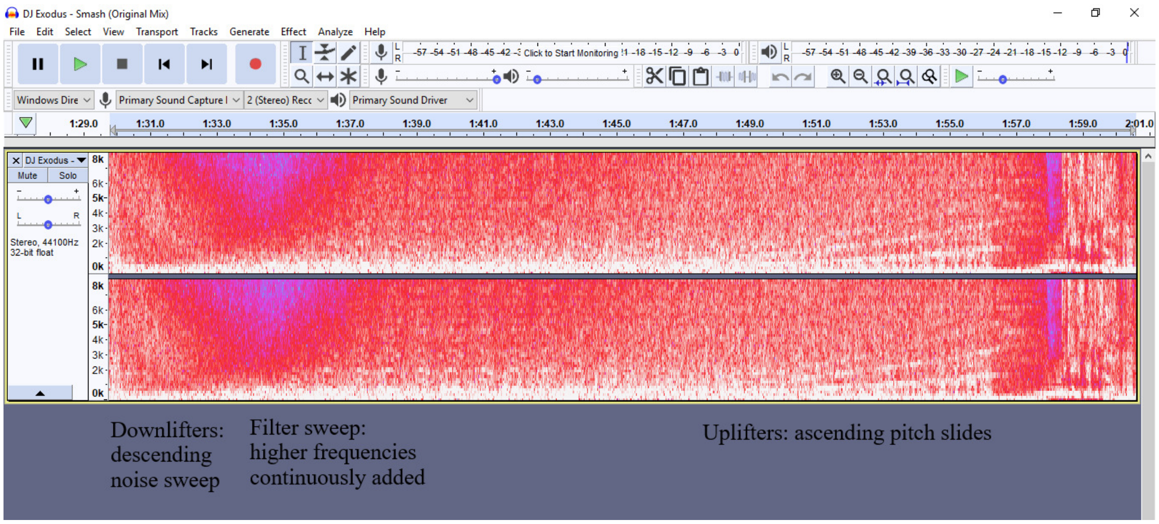

Figure 2-12: Spectrogram for Buildup 1 (1:30–2:00) in "Smash" by Exodus (2014).

Another good example containing filter sweeps occurs in the second buildup of Redub's at 5am remix of "Summer Feeling" (2013) by Nafis. A spectrogram of the section (3:01–3:16) is shown in Figure 2-13. First, a descending noise sweep is used at the start of the section, functioning as downlifters. Then, ascending pitch slides are used as uplifters, similar to the ones used in "Smash." However, at 3:12, two measures before the end of the section and the start of the next core, a different kind of filter sweep takes place, using a high-pass filter that continuously removes low frequencies from the texture. This can be seen in the continuously-increasing darker colors for the lower frequencies of the spectrogram. The filter sweep lasts for seven beats, and then on the last beat of the section, tension is released and the low frequencies are re-introduced, not

[43] Cues as anacrustic features of buildups just before cores were first explained in chapter 1 and will be discussed more in chapter 6.

suddenly, but quickly, acting as an anacrusis to the upcoming drop, when the bass and kick drum sound again. The high-pass filter sweep and uplifters are used in this anacrustic way also in buildup 1 from 0:57 to 1:01, and to highlight the midway points of core 1 and core 2 from 1:57 to 2:01 and 4:12 to 4:16.

The three types of filter sweeps shown in these two tracks (higher frequencies being continuously added, lower frequencies being continuously removed, and noise sweeps) are the most commonly used in EDM and contemporary popular music in general. Filter sweeps are very often used in buildup sections to create intense rushes of energy through changes in timbre, volume, and pitch.

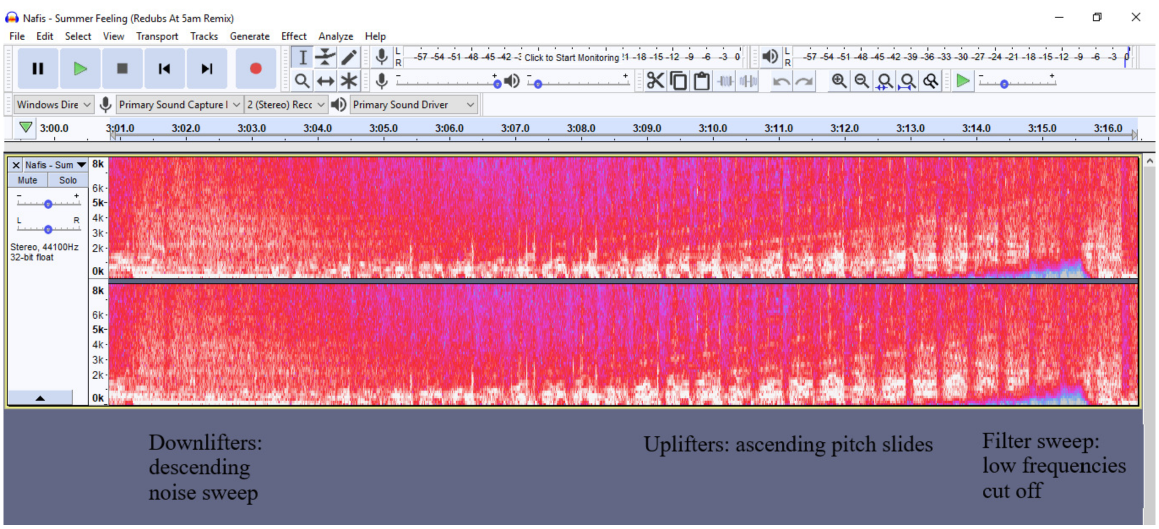

Figure 2-13: Spectrogram of Buildup 2 (3:01–3:16) in "Summer Feeling" (Redub's at 5am remix) by Nafis (2013).

Timbre

Timbre is a complex parameter of music. The word timbre is a simplistic umbrella term that actually refers to many aspects of a sound's composition.[44] With digital

[44] Fink, Latour, and Wallmark (2018, 9); Wishart (1996, 62–70).

technology each of these aspects can be controlled separately and thus the term can be problematic when applied too broadly. However, it is still useful to discuss in musical analysis because it refers to what is unique about a sound's "quality" and how it is perceived at any given time. The most important contributors to the timbre of a given sound are frequency content and ADSR characteristics of the sound envelope.[45] Recently, many scholars have brought to light the aesthetic and artistic importance of timbre in popular music.[46] Timbre is very important in EDM in particular, since club-goers on drugs like ecstasy have heightened sensitivity to it,[47] and since EDM comprises many heterogeneous sound layers primarily distinguished by timbre. However, timbre can also be changed continuously as sound layers gradually evolve. The previous section on filter sweeps discussed one way of changing the frequency content of sounds, but timbre can also be changed through speeding up or slowing down sounds to change their frequency content without changing the rhythm or tempo.

In "Electronic Battle Weapon 10 (Midnight Madness)" by The Chemical Brothers (2008), one part of the melodic line continuously changes its timbre from 4:53 to 5:02 and 5:07 to 5:16. These are the second and fourth iterations of the four-measure loop transcribed in Figure 2-14.[48] In the first and third iterations of the loop, the timbre of synth 3 stays the same, but in the second and fourth iterations, the timbre becomes progressively more distorted because of an oscillator modulating the frequency at

[45] Fink, Latour, and Wallmark (2018, 11).
[46] Fink, Latour, and Wallmark (2018); Heidemann (2016); Osborn (2018); Peres (2016).
[47] Fales (2018, 35).
[48] There are many other sound layers in the music at this time, but I transcribed what I perceived as three layers that are crucial to understanding and hearing the timbre change in synth 3.

extreme speed.[49] This makes the pitches and rhythms less clear, and by the end of the second and fourth iterations of the loop, the layer is almost unrecognizable. The distortion contributes to the overall aesthetic of disorientation found in this breakdown section of the track, which is also achieved through the use of different rhythms in many sound layers that gradually evolve over the course of this extended section.

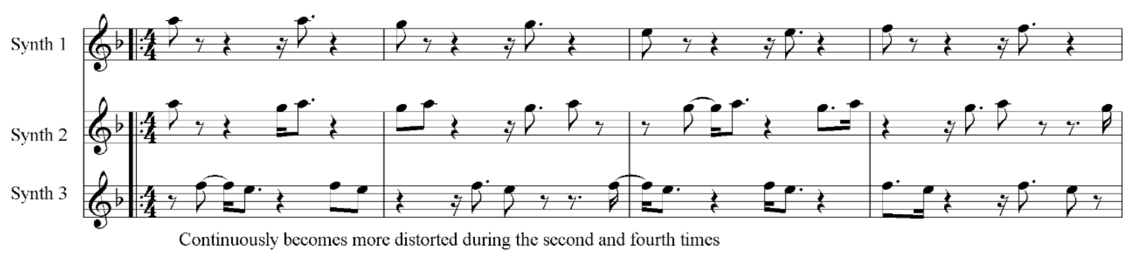

Figure 2-14: Transcription of some melodic lines from 4:47 to 5:16 in "Electronic Battle Weapon 10 (Midnight Madness)" by The Chemical Brothers (2008).

Another track that features long continuous timbre changes is "Find a Way" by the acclaimed American producer Wolfgang Gartner, featuring vocals from the hip-hop artist Snow Tha Product. At 2:15 in the track, the final breakdown section starts. The "breaking down" aspect is less obvious than in many EDM tracks, but it *is* signified here by the snare drum and hi-hat suddenly (that is, discretely) dropping out. This section also contains an extended continuous transformation of the timbre in Snow Tha Product's voice. It seems to become deeper and more conventionally masculine, even though the pitches stay the same. This effect is accomplished through the slowing down of the voice, so that its frequencies become lower, but adjusting the rhythm as it slows down so that it

[49] Essentially, the timbre is changed through very fast, imperceptible vibrato. As Holmes notes about frequency modulation, "when the control voltage is in the audible frequency range, the resultant signal contains sidebands of the carrier wave and the very rapid undulation of pitch is perceived as a change in timbre." Holmes (2012, 230).

stays in tempo with the track. When a sound is literally sped up or slowed down, its frequency content becomes higher or lower and thus the timbre is adjusted.

In breakdown 3, Snow Tha Product's voice slows down and sounds lower, but in buildup 3 (2:30–2:45, transcribed in Figure 2-15), her voice is changed in the other direction, speeding up, so that it becomes higher. Having been fragmented and reduced to only its last word of text, the voice then gradually transforms and seems to become less and less human. At first, the speeding up makes the voice sound whiny and tinny, but then the human element disappears altogether, so that by the end of the section it sounds like any other instrumental loop. The continuous speeding up of the voice is also reflected in the rhythmic changes that are shown in the transcription, with the notes in between the beats gradually disappearing. Notably, the song's lyrics are about "trying to find a way," and "struggling to find the words to say." In breakdown 3 these words are said as the voice continuously transforms its timbre, and then in the buildup the voice is reduced to only one word and blends in with the instrumental track, so the voice is literally struggling to find any words to say.

There are other long continuous processes used in this buildup section as well. The main instrumental line of the piece, just called the "synth" part in my transcription, fades in and becomes stronger, before fading out along with the voice part near the end. There are also multiple layers of uplifters rising in pitch throughout the section, helping achieve the intensification that is characteristic of buildup sections. Discrete processes also play a role in this intensification. At the start of the section the hi-hat returns to the texture but the kick drum drops out, as is very common in buildup sections. The removal of the kick drum, which is a fundamental aspect of contemporary EDM, creates a noticeable feeling of absence that will be remedied with the upcoming beat drop at the climactic start of the final core.[50] The hi-hat also undergoes discrete acceleration, fragmenting itself, even though the articulation of the rhythm also becomes continuously less clear.

[50] Butler (2006, 246–247).

Figure 2-15: Transcription of Buildup 3 (2:30–2:45) in "Find a Way" by Wolfgang Gartner f. Snow Tha Product (2017).

As already discussed, sometimes the parameter that is perceived to be altered in a continuous process is actually not the one being changed. Earlier, I showed how the “illusion of acceleration” can occur when another copy of the same sound fades in to gradually fill in more metric positions within a measure. A similar continuous process using volume can create an “illusion of timbre change.” In “Turning Point” by Deadmau5, the two-measure loop in the bass part (transcribed in Figure 2-16a) is a fundamental feature of the track. For much of the track it is heard as the only pitched layer, and when other pitches join they have the same distinctive rhythm and diminished-triad arpeggiation as the bass.

In the breakdown section (2:30–2:45), the bass is heard alone again, but it now has a different timbre that is less harsh and does not have clear articulation or attack points. From 2:45 to 3:00 (the buildup section), the timbre seems to continuously change and become harsh again, with the change mostly taking place in the first few seconds. However, the continuous process being used here is actually a fade-in and crescendo, of a second bass instrument that has a harsher timbre than the mellower one which sounded by itself from 2:30 to 2:45. The harsher bass also has a staccato articulation style that is different from the unclear articulation of the mellower bass. In retrospect, one can hear that both the mellow and harsh bass sounds have been used throughout the track, and that one of them was just removed for the start of the breakdown section to lessen the energy of the track. Since the two instruments have the same pitches and rhythms, they are easily perceived as one sound layer rather than two, which makes the continuous crescendo of the harsher layer seem like a timbre change to the overall bass line.

The harsher timbre fading in can be seen in the spectrogram shown in, since it contains many more overtones than the mellow bass line. These overtones are represented by lighter colors in the higher frequencies of the spectrogram for the short instances when the harsher bass sounds. As Figure 2-16b shows, these colors grow stronger from 2:45 to 2:48, when the fade-in happens. Continuous timbre changes, whether real or simulated through volume changes, are another important way in which EDM utilizes continuous processes to keep the music moving.

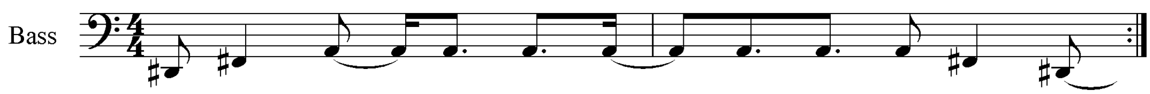

Figure 2-16a: Transcription of the bass line in "Turning Point" by Deadmau5 (2007).

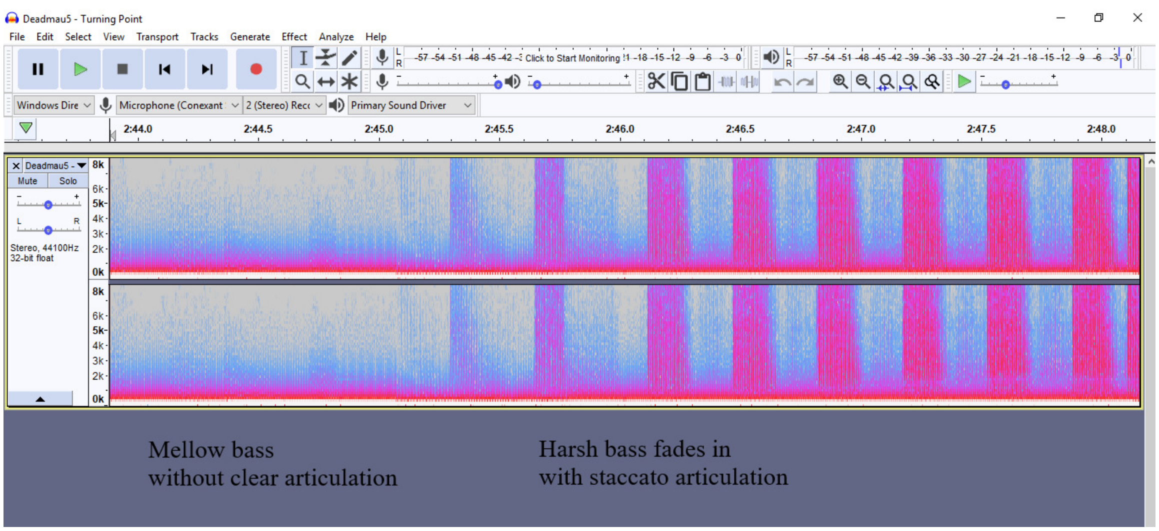

Figure 2-16b: Spectrogram for part of the breakdown and buildup (2:44–2:48) in "Turning Point" by Deadmau5 (2007).

Echo/Delay and Reverb

Echo/delay and reverb are two of the most important effects used in EDM production.[51] Zak lists them as two of the five categories for all sounds on records, along with musical performance, timbre, and texture.[52] In sound recording, the term echo is

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[51] Wright (2017, 292).

[52] Zak also calls reverb "ambience." Zak (2001, 49).

used interchangeably with delay to mean "the presence of one or more slightly delayed repetitions of a discrete source sound."[53] Reverb (short for reverberation) is similar but different. It refers to "a generally reverberant-sounding continuation of the source sound – as though the sound has been recorded in a highly resonant acoustic space."[54] When the echo effect is used, each repetition of the source sound is usually distinct and clearly audible, whereas when reverb is used, there are so many repetitions and reflections that occur within such a short time of one another, that each one cannot be aurally separated.[55] Generally, distinct echoes of a sound gradually decrescendo and become less clear with each repetition.[56] The volume of each echo, though, and the length between each one, can be automated so that they continuously change. Similarly, the "amount" of reverb and how long it lasts can be automated parameters, which influence the timbre and rhythm of sound layers.[57] Reverb can also influence the perceived volume of a sound, since it makes a sound seem farther away.[58]

Continuous volume changes to echoes are used effectively throughout the intro of "Right This Second" by Deadmau5. This track is an uncommon example of an EDM piece in compound rather than simple quadruple meter (in 12/8 rather than 4/4). However, the more than two-minute long introduction is best understood in simple triple meter, or 3/4 time. When the drum beat first comes in at 2:17, the beat is understood to be divided into three parts as in compound meter, but in the intro, based on the melody

[53] Doyle (2004, 32).
[54] Ibid.
[55] Ibid.
[56] Holmes (2012, 162).
[57] Wright (2017, 294).
[58] Doyle (2004, 32).

alone, the beat is understood to be divided into two parts as in simple meter. For most of the track the melody utilizes hemiola, and it combines with the drum beats to create metrical grouping dissonance,[59] but in the intro, there are no drum beats so the meter is easily interpreted in 3.

A transcription of the first measure in the intro is presented in Figure 2-17a. What is called synth 1 in the transcription is the main melody for the track. It is consistently louder than the sixteenth notes heard in synth 2, which are so fast they are difficult to hear without the piece being slowed down. However, when the audio is played slower, it is clear that there are sixteenth notes being articulated in the synth 2 part at the start of the track. The rhythmic patterns in this first measure are looped throughout the intro section, even though the pitches, volume, and timbre change, other layers are added in, and echoes crescendo or decrescendo.

From 0:00 to 0:12, both synth parts crescendo and a static bass note fades in. From 0:12 to 0:24 the synth parts continue to crescendo, and their echoes also become louder, obscuring rhythmic clarity.[60] It seems as if echoes for synth 2 are audible before echoes for synth 1 are. During this same time period, the timbre of the synth parts becomes noticeably more sharp and buzzy, with higher frequencies being continuously added.

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[59] Specifically, a G3/2 (eighth note = 1) grouping dissonance is formed. Krebs (1999, 31).
[60] It is difficult to tell the speed at which the echoes come in, however it could be in a rhythm of thirty-second notes (1/8 of a beat), which is common for Deadmau5. Tallchief (2018, 7:30–7:45).

Over the next minute, the echoes continuously increase and decrease their volume, as shown in Figure 2-17b. The use of the echo/delay effect is most prominent leading up to 1:13, before it dissipates, and other layers start to be added to the texture such as vocal chords. There are also other continuous processes like the fading in of a lower octave of synth 1 at around 0:43, and the gradual "detuning" of the synths.[61] In the long intro of this track, Deadmau5 uses continuous changes to the volume of echoes to make the rhythms of the melody more or less clear, and generate more or less musical tension.

Figure 2-17a: Transcription of the first measure and main loop for the intro (0:00–2:17) of "Right This Second" by Deadmau5 (2010).

Time Stamps	**Synth Parts Echoes Volume**
0:00–0:24	Crescendo
0:24–0:32	Decrescendo
0:32–0:39	Crescendo
0:39–0:54	Decrescendo
0:54–1:13	Large crescendo
1:13–2:17	Fades to the background

Figure 2-17b: Volume of the echoes for synth 2 in the intro (0:00–2:17) of "Right This Second" by Deadmau5 (2010).

One noticeable example of reverb being continuously increased is in the extended mix of "Who's That Chick?" by David Guetta featuring Rihanna. David Guetta is a

[61] This is another technique commonly employed by Deadmau5. Ibid. (7:45–8:17).

French DJ and producer that rose to fame with the release of his fourth studio album *One Love* (2009), on which this track was the second single. His music is noteworthy for fusing the styles of EDM and "top 40" pop music, leading to his fame and success. "Who's that chick?" uses verse-chorus form, which is standard for contemporary pop songs, and after the second chorus there is a bridge section that also functions as a breakdown to temporary relieve the high energy. This section starts at 2:49 in the extended mix and uses only Rihanna's voice, soft synth chords in the background, and a syncopated rhythm in the kick drum that contrasts with the standard "four-on-the-floor" beat heard throughout most of the song.

After the breakdown there is a short four-measure section that functions as a quick buildup section before the final chorus (3:24–3:32). It utilizes repeated F-sharps on a syncopated rhythm and with a harsh, grinding timbre. This pattern has been a hook throughout the song, but in the first three measures of this buildup section the amount of reverb is continuously increased to make the rhythm and the music in general less clear. The increasing reverb also leads to a decrease in perceived volume because of reverb's "distancing effect," as shown in Figure 2-18.[62] After three measures of more and more reverb being added, the fourth measure suddenly reverts back to the "normal" version of the hook with no reverb, which sounds louder and nearer. This functions as the anacrustic cue before the start of the chorus. Without the increased reverb, the fourth measure would

[62] Zak (2001, 147).

not sound different enough to be a successful cue, since cues are distinctive and highly salient.

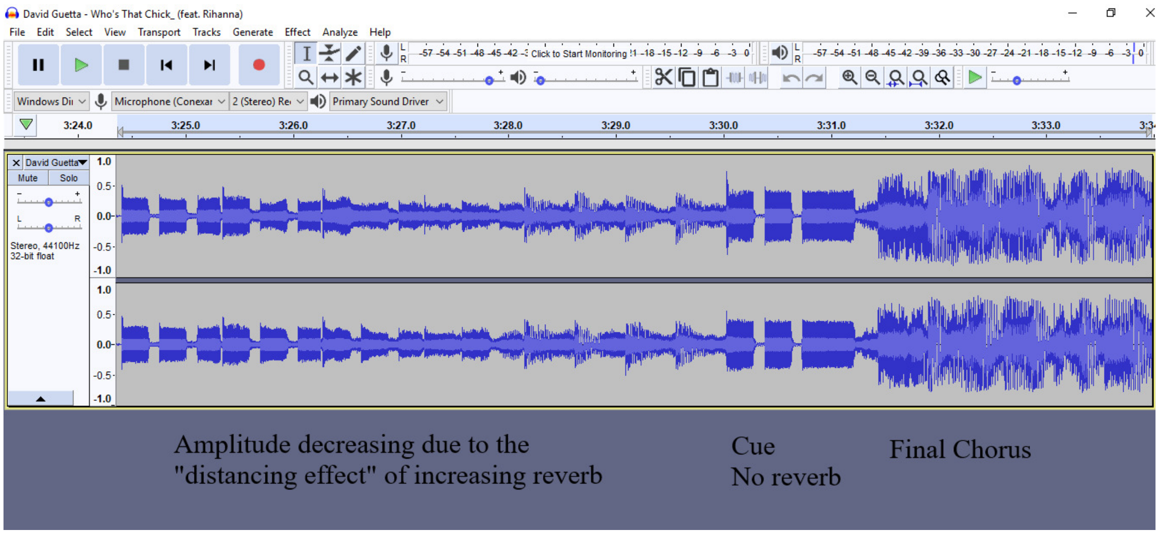

Figure 2-18: Amplitude graph for the final buildup section and start of the final chorus (3:24–3:34) in "Who's that Chick?" (extended mix), by David Guetta f. Rihanna (2011).

Guidelines 1–4 for Comparing the Salience of Continuous Processes

Now that I have shown multiple examples of long continuous processes changing various musical parameters, this final section of the chapter outlines the first four analytical guidelines for comparing the salience of different continuous processes within and across EDM tracks. As mentioned in the previous chapter, what I mean by salience is multifaceted, incorporating prominence, memorability, as well as structural and semiotic significance. If a process is salient it will stand out to listeners, both when hearing the music initially and when thinking about it afterward.[63] Musical salience cannot be measured definitively, but the heuristic guidelines I outline throughout the dissertation

[63] My conception of memorability is based on verbatim memory and recall, exhibited in earworms, for example. Margulis (2014, 81–89).

are based on foreground-background principles of aural perception and they can be useful in analysis for comparing the purposes and effects of different continuous processes in EDM, both within and across tracks.[64] The first four guidelines that are explained here have to do with how a continuous process is contextualized when it takes place, and its place in the foreground or background of the mix.

1) A continuous process that has an overall louder *volume* relative to the rest of the musical texture is more salient than a continuous process that has an overall softer volume relative to the rest of the texture.
2) A continuous process applied to a sound layer that is *distinctive* in some way (such as having a timbre, rhythmic pattern, or melodic motive that stands out in the texture) is more salient than a continuous process applied to a sound layer that is not distinctive in the texture.

These first two guidelines are intuitive and simplistic, but still important. Volume levels, which can be precisely controlled and edited with studio production tools such as amplitude automation and filter resonance, contribute significantly to salience levels of particular sound layers. Producers are very aware of this, and it is an important part of sound mixing and mastering.[65] There is a finite amount of space in the frequency band, and sounds can "compete" for prominence. As we heard in "Lick the Rainbow," two synth parts alternated taking up the highest place in the frequency band. Producers also

[64] For more on foreground-background or "figure-ground" listening see Bregman (1990, 490–502); Meyer (1956, 87, 122, 136–138). An extreme instance of the figure-ground principle is masking, when "one set of frequencies hides another from the ear." Sterne (2012a, 94). A specific application of masking is the perceptual coding of digital audio, which is used in the creation of the mp3 format. Ibid. (96–106).
[65] Marrington (2017, 205).

prize originality, and put great effort into making unique sounds that stand out not only within a track but also within an entire set or festival.[66]

If a continuous process such as a pitch slide or timbre transformation takes place in one of the sound layers that is louder and more in the foreground of the track, the salience of that process will be stronger than if it were soft and in the background. Similarly, if a pitch slide, crescendo, or continuous acceleration takes place in a sound layer that has a distinctive timbre, melody, or rhythmic pattern, it will be more salient than a continuous process taking place in a less distinctive layer. If a sound layer is salient because it is loud and/or distinctive, then changes to that layer will also be salient. Under guideline 2, the deceleration in "Interferance," which occurs in a sound layer with the distinctive timbre of the cell-phone interference sound effect, is more salient than the increasing reverb in "Who's That Chick?," which takes place in a sound layer with a timbre that is less distinctive and has been associated with background harmonies accompanying the melody throughout the track.

According to these guidelines, if a continuous process alters volume, then its salience changes as the volume changes, and if a continuous process alters timbre to make a sound continuously more or less distinctive than other sound layers, then the salience changes as the timbre changes. For example, recall the continuous accelerations and decelerations in the rhythmic synth and pitched synth in "Cthulhu Sleeps." As shown in Figure 2-9 with the thickness of the lines, in mm. 1–16 the acceleration in the rhythmic

[66] In lesson 10 of his masterclass, Deadmau5 highlights the importance of making unique sounds by manipulating them with many different tools. "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 10: Shaping sounds with effects and processing).

synth is becoming less salient because it is changing its volume to be softer, while the acceleration in the pitched synth is becoming louder and more salient. Then, in mm. 19–24 the deceleration in the rhythmic synth is becoming louder and more salient than the acceleration in the pitched synth, which is getting softer and fading out. In a larger-scale view, the whole shape of the acceleration and deceleration of the rhythmic synth in this section of the intro could be heard as more salient than other shapes, but there are changes to the salience of continuous processes within the larger shape.

3) A group of continuous processes that change a higher *number of parameters* in one sound layer at the same time is more salient than a group of continuous processes changing a lower number of parameters in one sound layer at the same time.
4) A group of continuous processes that change the same parameter in the same direction in a higher *number of sound layers* at the same time is more salient than a group of continuous processes changing the same parameter in the same direction in a lower number of sound layers at the same time.

Recall that for the purposes of this dissertation, I am defining a single continuous process as a continuous change to one parameter in one sound layer. Guidelines 3 and 4 say that groups of continuous processes are more salient than individual ones, and that groups with higher cardinalities of parameters or sound layers changed are more salient than groups with lower cardinalities. When many continuous processes take place at the same time, their salience is magnified. For example, if one sound layer simultaneously crescendos, undergoes a pitch slide, and adds more reverb, then guideline 3 says those changes are collectively highly salient and draw attention to that sound more than if only a crescendo took place in that layer. One highly salient group of continuous processes discussed earlier in this chapter is the transformation of the kick drum in “Fn Pig.” As mentioned previously in the section on rhythm and tempo, it accelerates and changes its pitch, timbre, and attack length at the same time.

If a crescendo takes place in many different sound layers at the same time, which can easily be accomplished through automating the “master volume” of a track, guideline 4 says that this overall continuous volume change will be more salient than a crescendo in only one layer such as the bass line. However, if a crescendo takes place in one layer at the same time as a diminuendo in another layer, or one layer has an ascending pitch slide and another has a descending pitch slide, these processes are changing the same parameter at the same time but in different *directions*, which means that guideline 4 does not apply to them, but guideline 1 does. Two tracks discussed earlier in the chapter demonstrate this. In “Lick the Rainbow” Synth 1 crescendos while Synth 2 decrescendos, and in “Cthulhu Sleeps” the rhythmic synth decelerates after accelerating while the pitched synth continues to accelerate and ascend in pitch. Guideline 4 has some precedence in Berry’s theories of how different parameters interact to create musical intensity, which is related to but slightly different from salience.[67]

The principles in guidelines 3 and 4 are true generally, but they cannot always be applied with a rigorous quantitative counting of parameters. Patty emphasizes this in his

[67] Berry (1976, 3–13).

discussion of musical intensity.[68] Sometimes it is difficult to aurally separate sound layers and to decide how many continuous processes are taking place at one time. Furthermore, all parameters are not equal contributors to salience. The combination of volume and pitch changes has a different effect from the combination of volume and reverb changes, for example. It is also important to keep in mind that often many literal sound layers in the production studio contribute to making one perceptual sound layer. Occasionally this is revealed in listening because continuous volume changes can strip away parts of the full version of a drum sound or a melody, or can build various individual layers up into the full version of the perceived sound layer. The complexities of studio production add difficulties to musical analysis, but in this dissertation, I base my analytical decisions on my aural perception rather than visualizations or descriptions generated by humans or computers involved in the creation process. The principles outlined in the guidelines are still valid as heuristics for perceiving continuous processes, and more analyses using them will come in later chapters.

This chapter has shown many examples of long continuous processes (which I define as lasting for more than two measures) in EDM tracks, and categorized them into various types based on the parameters they alter. Discussing these continuous processes in the context of specific sections of music reveals their importance to the structure and aesthetics of EDM, which has not previously been highlighted in scholarship. Each type of continuous process outlined in this chapter is used frequently in this repertoire, and each individual process has the potential to play many different roles based on when it

[68] Patty (2009, 326–330).

occurs in the track and its salience, which can be discussed using the four guidelines in this final section. The next chapter continues to focus on the categories and salience of continuous processes, but of a fundamentally different kind: those that are short, embellishing effects.

Chapter 3 – The Categories and Salience of Short Continuous Processes

The previous chapter explored the categories of long continuous processes and showed how they can have varying levels of salience in contemporary EDM tracks. This chapter focuses on short continuous processes that are more limited both in length and in scope. In other words, because these continuous processes are shorter, they generally feature smaller adjustments to musical parameters. For example, the pitches may only move continuously across the distance of a whole step instead of an octave. Both long and short continuous processes are used frequently in EDM, but with different functions. As will be discussed further in chapter 6, long continuous processes contribute more to the structural forms of EDM tracks, whereas short continuous processes are used more for expressive effects and ornamentation.

However, the dividing line between short and long continuous processes is sometimes fuzzy. Recall that in chapter 1 a continuous process was defined as lasting until its continuous change is no longer clearly audible, or until the next clear musical marking point (determined by meter and phrase structure). Following this, a long continuous processes was defined as lasting more than two measures and a short continuous process was defined as lasting two measures or less. These definitions are based on function, because generally, if a continuous process is two measures or less, it is not part of an extended riser in a buildup section and is not a fundamental part of the structural form of a track. Short continuous processes can be used as effects or ornaments that slightly modify a clear, discrete melody (in a manner similar to Baroque ornamentation as detailed by Neumann),[1] and they can also be used as part of uplifters just before hypermetric downbeats, but they will not typically be used to highlight large sectional boundary points or climaxes by immediately preceding them or following them, as long continuous processes do.

Short continuous processes are often repeated over and over, and included in loops. When this happens, they can be described as continuously-shaped gestures repeated in a discrete fashion. This type of repetition within short phrases or loops can be called "musematic," and Middleton notes how "musematically recursive frameworks" in popular music often utilize short continuous processes.[2] Sometimes short continuous processes generate or are involved in what Butler calls "autoteleology," in which goal-directed musical progressions that occur at a small-scale level repeat many times.[3] A simple example would be a one-measure loop that contains a crescendo. A related process is what Fink calls "recombinant teleology," which can take place on both extremely large and extremely small scales. He says that instances of recombinant teleology "create musical universes in which tension and release are pursued on a scale that far outstrips the ability of the individual human subject to imagine a congruent bodily response,"[4] and "recombinant musical teleology can spread itself so thin, or coalesce so infinitesimally, that listeners simply fail to register it as such – thus leading critics to ascribe the arousal they feel to *jouissance*, to teleology's absence."[5] This helps explain

[1] Neumann (1983).
[2] Middleton (1990, 269).
[3] Butler (2014, 209–211); Fink (2005, 42–47).
[4] Fink (2005, 44).
[5] Ibid. (45).

why short continuous processes are fundamentally different than long ones because they are used as expressive effects rather than structural elements.

It is useful, however, to connect these two kinds of processes together under the label of continuous because they both utilize continuous changes to sound parameters to create musical gestures, and both create varying levels of musical instability. They can also be combined together, as many examples in this chapter will show. In repetitive musical styles like minimalism and EDM, "Often the cycles will pile up into what sound like higher-level goal-directed sequences – the systematic addition and subtraction of beats, a gradual rhythmic phase shift, build-up and breakdown of grooves, even the artificial rise and fall of a sampled loop's pitch through sliding band filters."[6] When each repetitive cycle has its own goal but the larger progression is also moving towards a goal, this is called spiral teleology.[7] This can occur without the use of continuous processes as I define them, but short and long continuous processes can be combined to create spiral teleology. One way this commonly occurs is when a short continuous process itself continuously changes over a longer period of time. For example, a periodically-repeating ascending and descending pitch wave can become deeper with each cycle.

Short continuous processes can be created with automation curves or continuous controllers such as knobs and sliders. One of the most common controllers used to create them is the modulation wheel that appears on most synthesizers. In electronic music, modulation refers to one electronic signal being used to modify a different one.[8] For

[6] Ibid. (46).
[7] Butler (2014, 205–206).
[8] Holmes (2012, 229).

example, the shape of one sound wave can be used to control (and therefore visually represent) the changes to a musical parameter in a different sound wave. Amplitude modulation changes the volume and frequency modulation changes the pitch, but other parameters can be continuously altered through modulation as well.

The most common way of generating short continuous processes is with the use of an LFO (low-frequency oscillator), which uses inaudible frequencies (typically of 20 hertz or less) to modulate parameters in other sounds.[9] The wave shapes of the low-frequency signal create wave shapes in parameters of the modulated sound, such as pitch, amplitude, or filter cutoff.[10] Modulating pitch with an LFO can create vibrato, and modulating amplitude can create rhythmic pulses in a technique called the tremolo effect. Figure 3-1 shows a screenshot of Deadmau5 using an LFO in a DAW to continuously alter the filter cutoff of a sound. In this picture, the shape of the LFO curve (which can be adjusted by dragging the lines around) is shown toward the bottom right, above the piano keyboard, and the shape of the resulting sound as it changes is shown toward the top right, in the box labeled "filter." Notice that underneath the LFO curve, the "bpm" setting is turned on and 1/8 is selected, which means that the rate of the process is set to repeat every eighth note according to the tempo of the track, in a good demonstration of how short continuous processes can be used in discrete ways.

[9] Ibid. (221).
[10] Ibid.

Figure 3-1: Screenshot from Deadmau5's masterclass showing the use of an LFO.[11]

This chapter contains three main sections. The first section shows examples of different types of short continuous processes from many contemporary EDM tracks, in a manner similar to the majority of the previous chapter, but more condensed. Four types will be briefly explored. First, short pitch slides (which are the most common and noticeable type of short continuous process used in EDM), can be categorized into scoops that ascend, falls that descend, and waves that both ascend and descend. They can be used

[11] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 7, 12:16).

to embellish melodies, or as uplifters and downlifters. Second, short volume changes will be discussed. One of the most important techniques using short volume changes is the tremolo effect, in which many short volume changes are strung together on a single note to create rhythmic undulations. Third, panning is another important technique that EDM producers and performers use to create continuous processes, usually short ones. Panning refers to the spatial control of sound, in terms of which speaker(s) it comes from and at what amplitude levels. By continuously changing the volume of the sound in one or more speakers, such as getting softer in the right speaker while getting louder in the left speaker, short continuous processes that involve spatiality can be created and used to great effect on the dancefloor. Finally, timbre changes can also happen in two measures or less, as short continuous processes. Short filter sweeps or changes to the ADSR characteristics of a sound envelope are common, and since they take place so quickly, these techniques create more of a perceived timbre change than a volume or pitch change, unlike the long filter sweeps that were discussed in the previous chapter.

The second section of the chapter addresses questions of salience, applying the four guidelines for comparing the salience of continuous processes to several musical examples, and introducing a fifth guideline that is much more relevant for short continuous processes than long ones. This fifth guideline states that a continuous process is more salient (that is, prominent and memorable) if it is frequently and consistently repeated in a track. Depending on their salience level, short continuous processes can merely make melodies and rhythms more interesting with decorative ornamentation, or can make melodies and rhythms significantly unclear and unstable.

The third section of the chapter examines short continuous processes that happen so quickly that they could be perceived as instantaneous and discrete, or could be perceived as continuous. They occupy the middleground in the continuum between discrete and continuous processes, and fall under the category of microrhythm as defined by Danielsen.[12] Processes in this category take place at the "sub-syntax" level and are used as expressive effects.[13] Interestingly, as the musical examples in this section show, EDM creators often use long continuous processes to travel across the continuum between clearly discrete and clearly continuous short processes. I conclude the chapter and this first major part of the dissertation by discussing the impact that long and short continuous processes have on the ontology of EDM in general, and whether they are fundamental parts of a "work," or are unique to each individual text or performance.[14]

Categories of Short Continuous Processes

Short Pitch Slides: Scoops, Falls, and Waves

The first kinds of short continuous processes that I will show in detail are short glissandos that involve the quick manipulation of pitch. There are three sub-categories of short pitch slides that I call scoops, falls, and waves. The first two of these terms are borrowed from traditional descriptions of jazz techniques used in vocals and "horns" (trumpets, trombones, and saxophones). Usually scoops are defined as ascending pitch slides before reaching a "definite" pitch that is on a metric beat or a secure place within the metric grid. For the purposes of this dissertation I will define a scoop simply as a

[12] Danielsen (2010, 1–16).
[13] Ibid. (9).
[14] I use the terms work, text, and performance to describe EDM in various contexts, as detailed in chapter 1 and based on the discussions in Butler (2014, chap. 1).

short ascending glissando, which can occur either before *or after* a definite pitch, connect two definite pitches, or not be adjacent to any definite pitch at all. Similarly, falls have been traditionally viewed as happening *after* "the note itself" is finished, but I will use the term to describe any short descending pitch slide.

Waves are glissandos that both ascend and descend in quick succession, sometimes repeatedly, but always adjacently with no clear fixed pitch in between ascent and descent. I generally define one wave as one short continuous process, including both the ascending and descending parts. The use of vibrato in traditional musical technique is an example of pitch waves, but what I define as waves could also be much more spread out, such as an ascent for one measure and a descent for another measure. Scoops, falls, and waves are hard to represent in traditional music notation, since their beginning and ending points in pitch space are often unclear and/or inconsistent. Yet if they are clear, it is useful to include the high and low points in transcriptions, and to compare various uses of the technique with others to see which ones modify the pitch more than others. I will explore the shape and rate of change of waves more in chapter 5.

The first track I will examine in this section is "Space Junk" by Wolfgang Gartner. This track is full of short continuous pitch slides, occasionally contrasted by clearly discrete moments. From the very beginning of the track the drums provide a loud and discrete rhythmic reference, but the pitched elements in the high bass register (what will eventually become clear as a tenor line) use many falls. To show the difficulty in notating short pitch slides as discussed in the previous paragraph, I have notated this loop in two different ways. The first method attempts to show somewhat more precisely the effects of the pitch slides, and the second uses the traditional method of notating a fall that is just a descending line. It is also worth noting that falls are only used for three of the five main pitches (this is more easily seen in method 2, shown in Figure 3-2a).[15]

After thirty seconds of this loop being the only important pitched element, a new and much more abrasive pitched line enters the texture abruptly at 0:30.[16] I call this the lead synth in my transcription of the next section (Figure 3-2b). This melodic line is centered on F-sharp, the piece's tonal center, yet with each repetition of the loop, the first F-sharp is approached with a fall and left with a scoop. The second half of the second measure in this four-measure loop is the only part where pitch is treated discretely, and there it is obviously so, with quick triplets that incessantly reinforce the tonic.

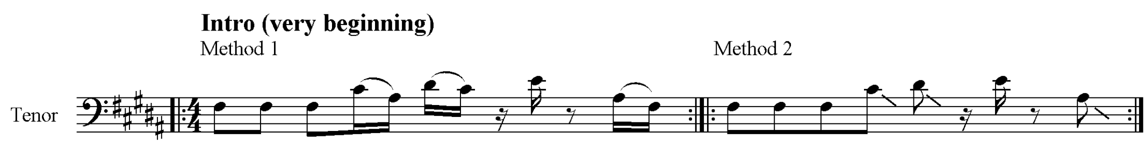

Figure 3-2a: Two methods for the transcription of the opening loop in "Space Junk" by Wolfgang Gartner (2010).

[15] In this tenor line, the pitches I have notated as A-sharp are actually slightly "flat" in tuning. Being "out of tune" and using micro-tonality is another way that composers subvert stability and clarity in EDM.
[16] There is also another layer that started at 0:15, which has short discrete notes (low to high) on the "and of 2" each measure, but I did not include this in my transcription because it is a background element.

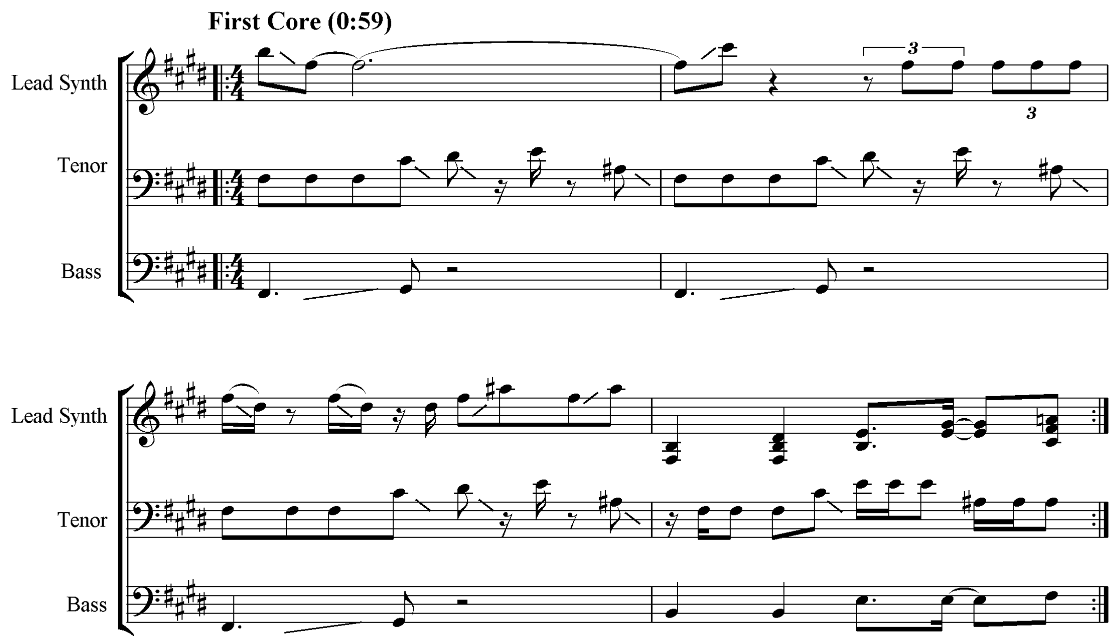

Figure 3-2b: Transcription of the first core (starting at 0:59) in "Space Junk" by Wolfgang Gartner (2010).

Figure 3-2c: Transcription of the breakdown loop (starting at 1:29) in "Space Junk" by Wolfgang Gartner (2010).

So far everything that has occurred fits into the intro section of the track. The first core starts at 0:59, and there is no true buildup section before it.[17] In the last measure of the intro, loud and clearly-punctuated chords are added to function as a cue to the upcoming first core section and clarify the mode of the piece as F-sharp dorian not F-sharp mixolydian, which was used earlier in the tenor line and lead synth. Although the chordal progression begins suddenly on the downbeat, a short continuous crescendo on

[17] It could be argued that the section beginning at 0:30 constitutes a buildup section, which would typically come after the intro. However, this section does not contain any discrete or continuous processes that characterize buildup sections by "building up" the energy and tension leading to the upcoming core.

the note B takes place two beats before this, leading into these chords that are themselves anacrustic.

This chordal progression repeats at the end of every four-measure loop in the core, acting as a recurrent anacrusis to each new loop, as shown in Figure 3-2b. The pitches in the progression are clear and fixed, providing a discreteness that contrasts with the continuousness of pitch in the first three measures of each loop. As shown in the transcription, the lead synth, tenor, and bass lines each use multiple short pitch slides that add a sense of instability to the music. The discrete chordal progression contrasts this because of its fixed pitches, but also because it has multiple notes that move together rhythmically and clearly articulate the first three beats of the measure.

Before leaving this track I would like to highlight one more section that uses continuous pitch slides: the breakdown that immediately follows the first core at 1:29. First, notice that this section is preceded by a two-beat descending pitch slide (a fall over an entire octave) that signifies the upcoming decrease in musical intensity.[18] Then, a single melodic line is heard throughout the breakdown section, over a soft F-sharp pedal in a synth pad. This melodic line is filled with short continuous pitch slides that make it sound slippery and unstable. Figure 3-2c shows a transcription of this line. It is noteworthy that even in this unstable section the last measure is given a clear melodic descent of scale degrees 3-2-1, invoking more of a cadential gesture from traditional tonality than the second-measure "skip" of 3-1. Also, that "skip" down from A to F-sharp

[18] As I will discuss more in chapter 6, descending pitch slides symbolize a decrease in energy and ascending pitch slides symbolize an increase in energy. Huron (2006, 324).

may sound discrete when heard in real time at full speed, but when listening to the track slowed down it is clearly a continuous fall. This is a great example of micro-rhythm, which will be discussed in the last section of this chapter.

Another track, which contains many good examples of short pitch waves, is Aphex Twin's "XMAS_EVET10 [120] [thanaton 3mix]" (hereafter "XMAS_EVE"). Aphex Twin (whose real name is Richard James) is one of the most experimental and innovative electronic-music artists, and he is known for being heavily influential in the development of IDM in the early 1990s.[19] In "XMAS_EVE" there is a section from 4:49 to 5:53 that utilizes repeated pitch waves as part of a four-measure phrase that is transcribed in Figure 3-3. The phrase can be heard at 4:49, 5:05, 5:21, and 5:29, with the last two instances having no intervening material. The pitch waves in this phrase function as embellishments of the melody in synth 2. Since they are so fast, they behave like upper mordents from the Baroque period.[20] However, unlike traditional mordents played on the piano, the movements between the main pitch and its neighbor tone are continuous pitch slides.

In this four-measure phrase, continuous processes combine with discrete ones to create an interesting groove. The accents in each measure of the synth 2 part articulate a *tresillo* rhythm (3+3+2, in this case for eighth notes), which is very common in many forms of popular music.[21] This rhythmic pattern adds syncopation to the music. In each

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[19] As discussed in chapter 1, IDM (intelligent dance music) is seen as more artistic than most EDM genres. It "evokes dancing without encouraging it," and is therefore often listened to but not danced to. Wiltsher (2016a, 416).
[20] For more information on mordents in the Baroque period, see Neumann (1983, 415–464).
[21] Cohn (2016, sec. 4).

measure of this four-measure phrase, pitch waves are used to embellish the longest notes in the first two parts of the *tresillo* pattern, but in the third part of the pattern only clear and discrete pitch movements are used. The pitch waves not only provide an embellishing function to the longest notes in the synth 2 part, but also add a sense of instability, making the pitches less clear than if they were not ornamented with the ascending and descending waves. The intense reverb used in the synth 1 part also adds to the instability of the phrase, since it makes the rhythms in that part unclear.

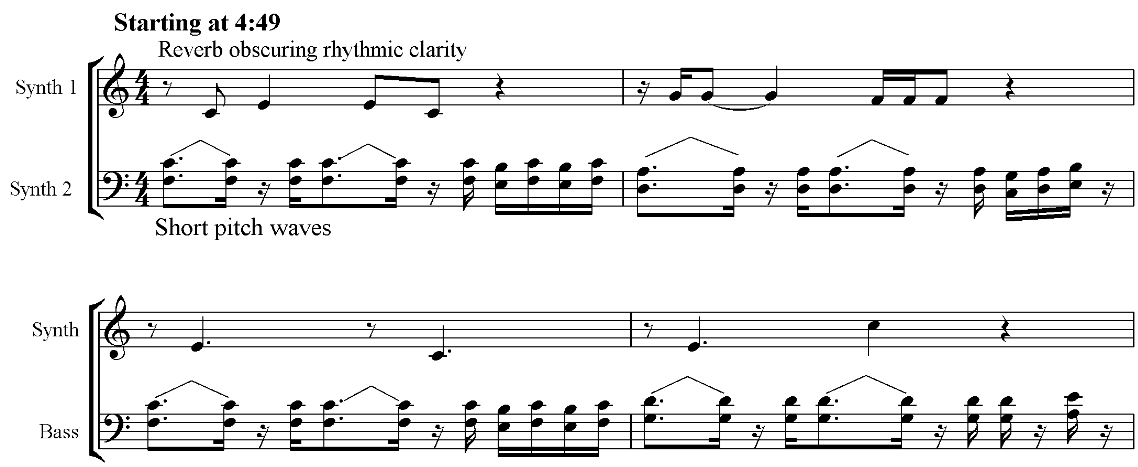

Figure 3-3: Transcription of the section starting at 4:49 in "XMAS_EVET10 [120] [thanaton 3mix]" by Aphex Twin (2014).

Many different short continuous pitch slides also occur in “Diamonds” by the young, up-and-coming producer Popeska. Firstly, there is a recurring two-measure scoop that is very noticeable in the core sections. This will still be classified as a short continuous process rather than a long one, because it is within the two-measure limit that I defined in chapter 1, and because its function is more typical of short continuous processes than long ones. The first core begins at 1:30, and the main melodic motion in the section is provided by this scoop, which only moves slightly less than two semitones up over two measures. Even though the rhythm is punctuated, the pitch is moving continuously upwards.

The first core can actually be separated into four eight-measure (in this case fifteen-second) segments. The continuous pitch slides move at the same rate and in the same way for the first, second, and fourth segments, with the second and fourth parts also adding perfect fifths and octaves above the fundamental frequency. However, in the third part (beginning at 2:00), the pitch ascents only last for one measure each, and the pitches seem to move in a more discrete fashion, with noticeable gaps between the different notes being used. As discussed previously, one way to think about the difference between continuous and discrete processes in mathematical theory is that continuous processes have no gaps or breaks.

The second core (3:00–4:00) starts basically the same way as the first core, but in the third and fourth sections (3:30–4:00) the continuous pitch slides are significantly different. The rhythm is varied, and the second half of each four-measure loop contains an inversional process whereby the original pitch ascent of almost two semitones is now mirrored with a pitch descent of almost two semitones. In the fourth and final section of the second core (starting at 3:45) perfect fifths and octaves are added.

There are also many scoops and falls in the intro section of "Diamonds." They are used to interrupt a much longer group of continuous pitch ascents that last fourteen measures from 0:34 to 1:00. The main teleological aspect of the section that draws listeners in is this group of pitch ascents, but they are interrupted every four or six beats (alternating) with short pitch slides that in total last four or two beats each time. It is difficult to decipher the behavior of the short pitch slides precisely because they are seemingly improvisatory and buried in the mix of the track, but they do include both scoops and falls. The base pitches for these short scoops and falls also rise along with the longer ascents, but the short pitch slides become less prominent in terms of volume with each iteration.

A similar passage occurs in "Tissot" by Bolivaro, which was analyzed in the previous chapter. In that track scoops are used to interrupt the longer pitch ascent that I described as pitch slide Type A in buildup sections (0:30–0:45, 1:19–1:33, and 1:49–2:03). Both of these cases feature long continuous pitch slides being interrupted by smaller ones, breaking up the literal continuousness of the long ascent. However, the long ascents are still perceived as continuous because the time gaps in between parts of them are small enough that they do not let the listener forget what they previously heard. It can easily be imagined that an automation curve controlling the pitch continues to rise even when the pitch in the long ascent is not literally sounding. There is a limit to how long the breaks can be though. If the long ascending line picks back up higher than it would have been if there were no gaps, it may disrupt the perceived continuity of the line because that would break the Gestalt principle of good continuation.[22] As far as I can tell, in the intro of "Diamonds" the long pitch ascent picks up where it left off after the interruptive short processes each time and thus the perception of continuousness is maintained.

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[22] Bregman (1990, 196–203).

It is interesting to think about short continuous processes as “interrupting” something. With long continuous processes, they are usually the main feature of the track in that moment, even if their larger-scale function is to interrupt the core sections of music for dancing. Short continuous processes can be heard as “effects” that only slightly modify the main texture or feel of a track, or as highly destabilizing features of a particular section that interrupt its otherwise secure underlying nature. The utilization and perception of these in different strengths also ties in significantly with genre labels, as I will discuss further in chapter 6. For now it is sufficient to note how in the intro section of “Diamonds” short continuous processes are seen as interruptive, but in the core they are featured and given the spotlight, even if they are inherently destabilizing pitch space.

Before leaving “Diamonds” I will briefly discuss short continuous processes used in the buildup sections (1:00–1:30 and 2:30–3:00). A voice part is added for these sections (although it sounds transparently electronic and computerized), and every second measure it utilizes pitch falls of about a semitone. There is also an interesting effect used in both buildup sections, first heard around 1:04, when the speed of a percussive sound is continuously changed multiple times and the dividing line between rhythm and pitch is crossed.

Short continuous pitch slides can act not only as embellishments for melodies, but also as effects that highlight sectional boundary points by immediately preceding them or following them. Pitch slides that act in this way are described as uplifters of downlifters, which generally precede and follow hypermetric downbeats respectively. In the previous chapter examples of longer uplifters and downlifters were discussed, but these types of pitch slides can also be short, particularly when they are used to highlight midway points of sections or hypermetric downbeats at the four- or eight-measure level, rather than the starting points of large sections or hypermetric downbeats at the sixteen- or thirty-two-measure levels.[23]

This is evidenced in "Find a Way" by Wolfgang Gartner featuring Snow Tha Product. In chapter 2 I discussed the timbre changes to Snow Tha Product's voice in the final breakdown and buildup sections of this song, and I also mentioned the use of long uplifters throughout the final buildup (2:30–2:45). There are also short pitch slides used as uplifters and downlifters to highlight sectional boundaries and hypermetric downbeats in this song. In the fourth and twelfth measures of core 2 (at 1:51 and 2:06) there is a continuous, ascending glissando that softly plays in the background of the track. It leads toward the beginning of the next four-measure hypermeasure, but not in a very salient way. Also, at the beginning of breakdown 3 (2:15) a soft descending pitch slide is used as a downlifter, signaling a decrease in energy.

Noise sweeps (filter sweeps applied to noise rather than clearly defined pitches) are also frequently used for uplifters and downlifters. This can be heard in "Star Guitar" by The Chemical Brothers, when descending noise sweeps are used at the beginning of many sections or subsections, most noticeably at 2:01, 2:46, 4:32, 4:47, 5:33, 5:48, 6:03. It is interesting that in this piece only short downlifters are used and not uplifters, which would typically come right before the sectional boundary points. In fact, multiple times

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[23] Peres shows that this is true in contemporary "top 40" music as well, since he discusses numerous examples of uplifters (including both ascending noise sweeps and pitch slides) occurring just before the midpoint of choruses in popular songs. Peres (2016, 79–82).

there is a prominent three-measure *descending* pitch slide before the beginnings of sections, as can be heard in 1:53–2:01, 3:54–4:02, and 4:39–4:47.

Short continuous pitch slides in the form of scoops, falls, and waves are a very common kind of short continuous process. Depending on their salience and their closeness to clear, discrete pitches that fit in the established tonal area, they can be barely noticeable embellishments of melodies or can be significantly disruptive interruptions. They can be used frequently and repetitively, or used only occasionally, as is the case with short uplifters and downlifters that often precede and follow hypermetric downbeats.

Short Volume Changes: Crescendos, Decrescendos and the Tremolo Effect

"Star Guitar" also contains instances of short volume changes, particularly from 2:46 to 3:02. Figure 3-4 shows the spectrogram for this section, which starts with a downlifter in the form of a descending noise sweep as already discussed. The noise sweep can be clearly seen in the curved white line at the start of the spectrogram. The crescendos and diminuendos can also be seen on the spectrogram, in the increasing white for the frequencies up to about 2000 hz. There are two instances of each crescendo and diminuendo that last two measures each, creating two volume "waves" that each have an ascending and descending part in terms of amplitude. Continuous waves that move up and down in volume are not usually this long, however. It is more common to have shorter crescendos and diminuendos created with an important technique called the tremolo effect.

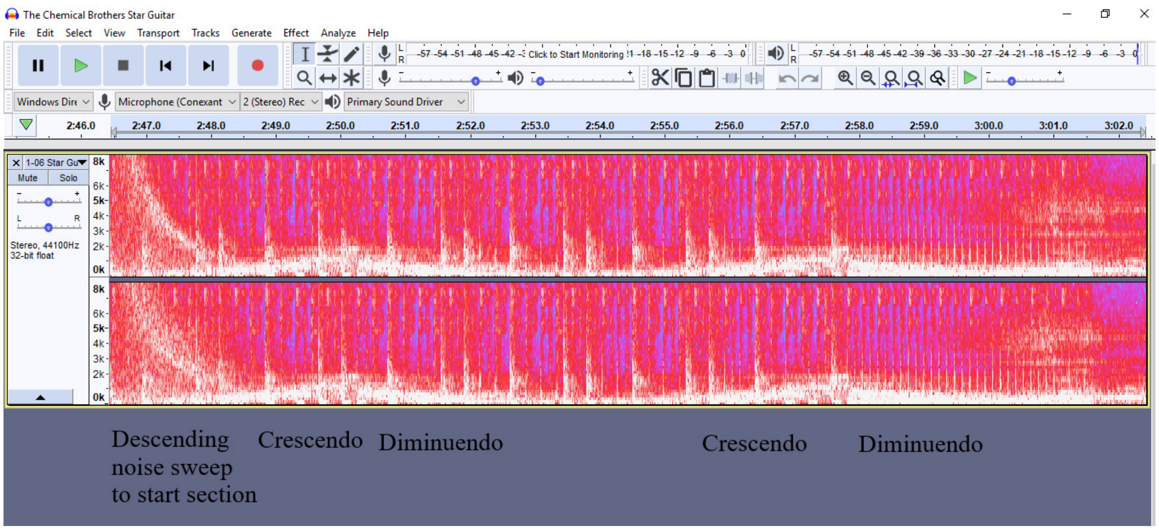

Figure 3-4: Spectrogram of 2:46–3:02 in "Star Guitar" by The Chemical Brothers (2008).

In music production, the tremolo effect refers to repeated continuous volume changes that create pulsating waves of sound. As mentioned in the introduction to this chapter, this is usually created by modulating amplitude with an LFO. A good example of the tremolo effect occurs in “Imaginary Friends” by Deadmau5. It is used throughout most of the introduction, but is especially noticeable from 0:53 to 1:16. Throughout this section, the rhythm is generated by volume swells, with the articulation of the notes seeming to start at the peak points of the waves. The amplitude graph showing these volume waves is shown in Figure 3-5a, and the spectrogram showing them is shown in Figure 3-5b. It is noteworthy that the waves show up clearly on the spectrogram, meaning that short filter sweeps are also being heard since the peak points of the wave have the most harmonics. The repeated changes in perceived volume are due to both the amplitude and the frequency content being altered.

This section also utilizes long continuous processes. Notice how in both the amplitude graph and the spectrogram, the waves gradually become taller and wider. This indicates that the section has an overall increase in volume due to both increasing amplitude, and frequency content that includes increasingly higher frequencies, which create brighter and more resonant sounds. The time it takes to get from the loudest (peak) part of the wave to the softest (valley) also increases, so that the rhythms no longer seem to be articulated almost instantaneously, and the tremolo effect is more noticeable, especially starting at 1:09.

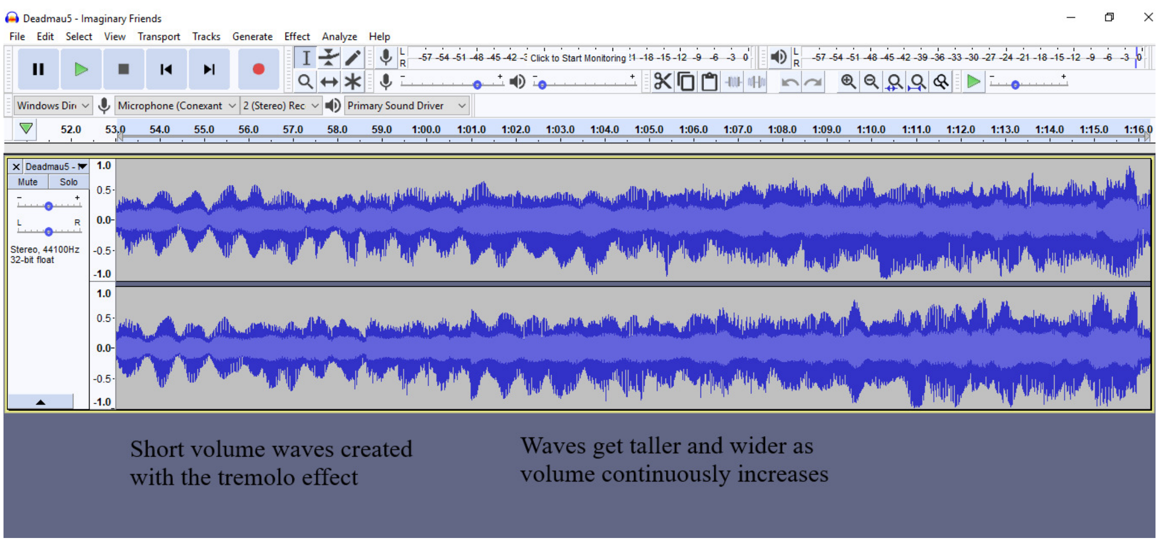

Figure 3-5a: Amplitude graph of 0:53–1:16 in "Imaginary Friends" by Deadmau5 (2016).

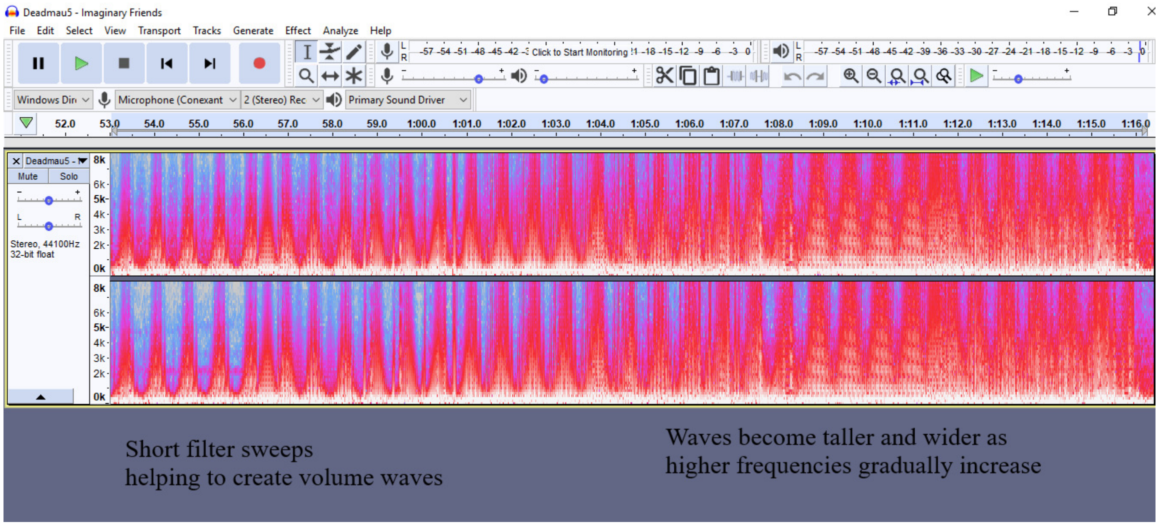

Figure 3-5b: Spectrogram of 0:53–1:16 in "Imaginary Friends" by Deadmau5 (2016).

A more subtle use of the tremolo effect occurs in Aback's remix of "Everything is Bright" by Stoned Butterflies. In the intro to this track, a two-measure motive featuring multiple short volume changes can be heard multiple times, but it is clearest the first time it sounds, from 0:07 to 0:11. As shown in the amplitude graph (Figure 3-6a), both a diminuendo and a crescendo take place from 0:07.8 to 0:08. This is the tremolo effect starting with a decrease in volume followed by an increase.[24] The spectrogram (Figure 3-6b) shows that the crescendo part is aided by a short filter sweep, as was the case in "Imaginary Friends." This short effect is repeated several times over the next few seconds, but it becomes less pronounced and more subtle each time because the overall volume decreases; the pitched layer containing the tremolo effect fades out over approximately six beats. So short continuous volume changes are occurring at multiple

[24] To make sure that both the decrease and increase in volume occur in the pitched layer of sound rather than the percussive hi-hat, I filtered out the hi-hat sound when listening to this clip.

scale levels in this two-measure motive. In addition to the tremolo effect having less depth and occurring more quickly than in “Imaginary Friends,” it is also less noticeable here because there are breaks in the sound of the pitched layer, so that it is not one sustained chord. The rhythm is generated by discrete cuts that are clearly visible in the amplitude graph and the spectrogram, rather than the tremolo effect itself.

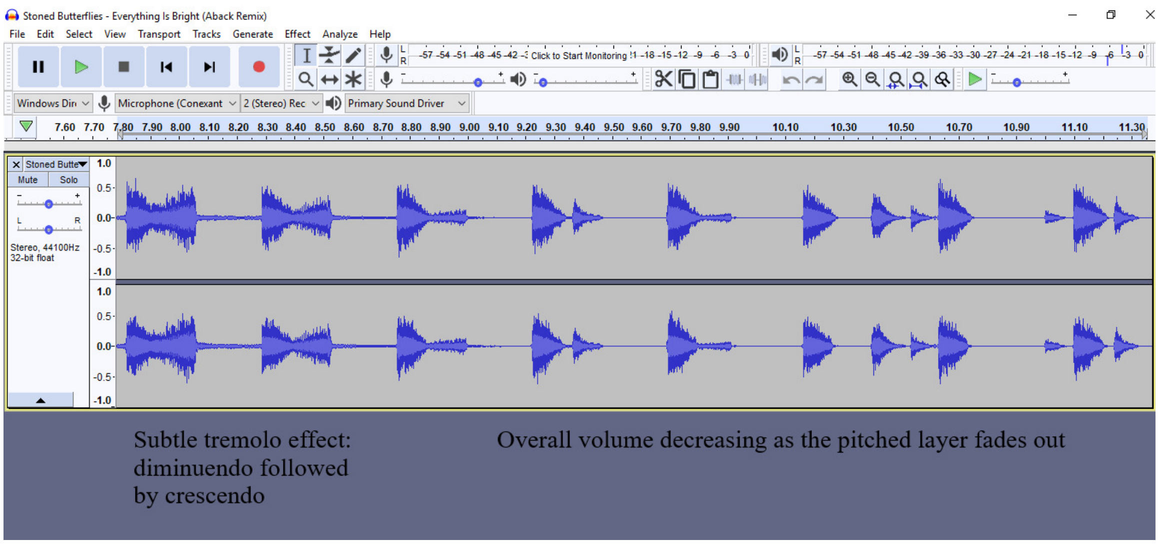

Figure 3-6a: Amplitude graph for 0:07.8–0:11.3 in "Everything is Bright" (Aback Remix) by Stoned Butterflies (2012).

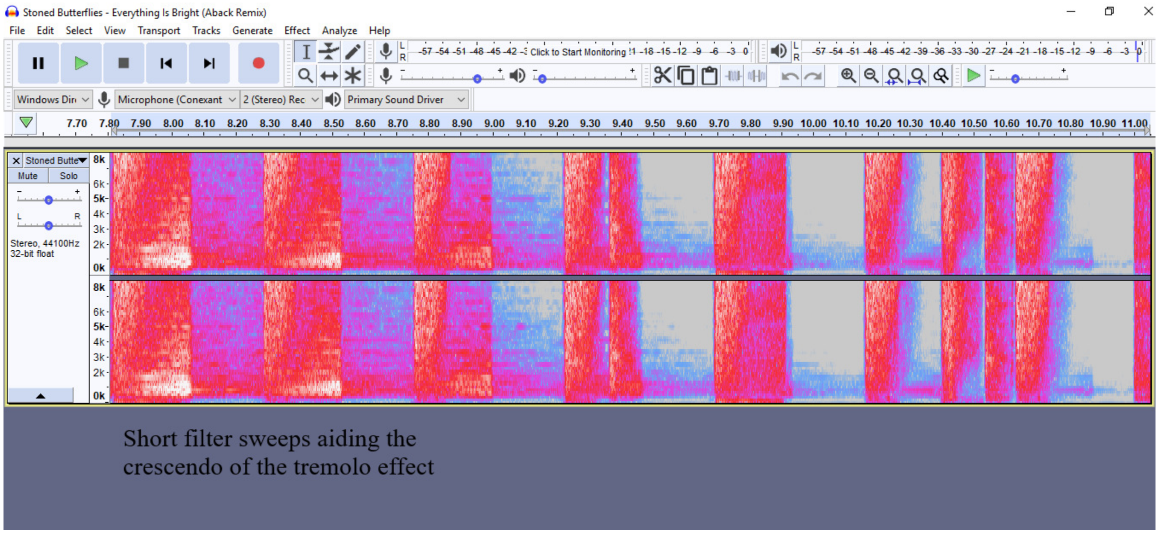

Figure 3-6b: Spectrogram for 0:07.8–0:11.1 in "Everything is Bright" (Aback Remix) by Stoned Butterflies (2012).

Short Spatial Changes: Panning

The control of audio through what is known as "panning" refers to the movement of sound between left and right speakers or headphones in space. With the use of stereo sound equipment, volume can continuously be altered in both the right and left speakers to create a sense of spatiality in the listening experience. The default, normal setting is to have left and right perfectly balanced, contributing equal volume, but audio engineers and mixers also frequently set other arrangements of fixed stereo volume levels to simulate live performances when one instrument would typically be on a different side of the stage than another. Volume levels coming from each side usually remain fixed for a majority of the time in EDM tracks, but panning can also occur in both subtle and obvious ways.

This section will show examples of continuous panning resulting from continuous volume changes in the left and right speakers. Sudden movement between sounds only coming out of the left speaker and sounds only coming out of the right speaker is a different technique that is also sometimes used, as in the megahit "Ping Pong" (2014) by

Armin van Buuren, which represents the epitome of musical discreteness.[25] An abstract example of continuous panning would be starting with equal volume output of the total volume coming from each speaker, then moving one of the volume inputs gradually and continuously higher while the other one is moving gradually and continuously lower. This creates the perceptual effect of sound moving around the listener in a circular fashion, or the listener moving around the sound in space. I have included panning in this chapter as opposed to the previous one because when this effect is highly salient it is usually short and repeating, so that many “circles” around the listener are achieved before the effect stops.

Just like other parameters, panning can be controlled with knobs, sliders, or automation curves in a DAW. It can also arise from LFOs modulating the amplitude of both the right and left speakers, creating the tremolo effect for both the right and left speakers such that they are offset from each other. For example, the highest volume of one speaker could be set to happen at the same time as the lowest volume for the other speaker. In Ableton Live, one of the most popular DAWs, this situation can easily be generated using the “auto pan” tool from the audio effects rack, as shown in Figure 3-7.

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[25] When I attended the VELD festival in Toronto on August 2–3 2014, van Buuren performed this piece and emphasized discreteness in many ways. Musically, the performance started by alternating between two F-sharps, an octave apart from each other, and the rhythm discretely accelerated by cutting in half the length of the notes multiple times. Spatially, the sound alternated between the left and right speakers. Visually, the different sounds and speakers were each associated with a different area of the stage and a different color that lighted up with each note. Finally, van Buuren also led the audience in a physical demonstration of the discreteness by having the audience on the right stand up with each attack on that side and the audience of the left sit down at the same time.

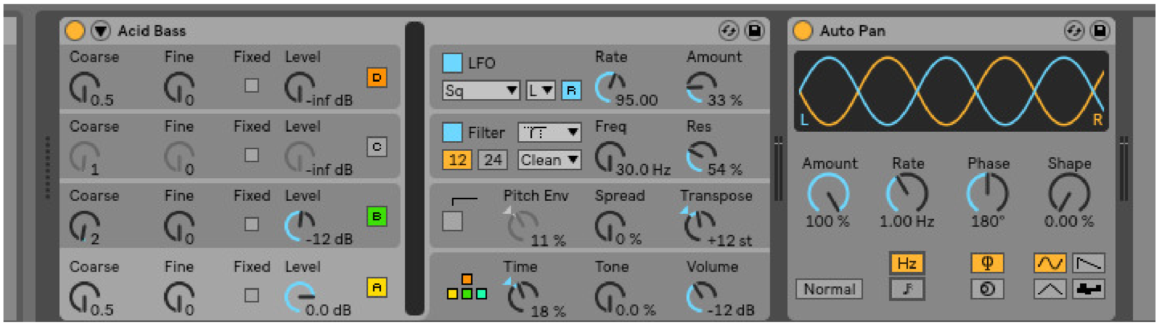

Figure 3-7: Demonstration of the "auto pan" tool in Ableton Live.

Continuous panning is used extensively in “5AM Deep” by Daniel Brooks. This mellow track only utilizes drums, a bass line, and repetitive chords, but there is continuous panning used in the chords layer throughout most of the piece. The panning is very noticeable in the sections before the first core, from 0:31 to 1:32, when the effect created is one of the chords moving in a counter-clockwise circle around the listener. Figure 3-8 shows a graph of my hearing for the continuous panning in this passage. Notice how the crisscrossing looks similar to the visual representation of the “auto pan” feature in Ableton Live.

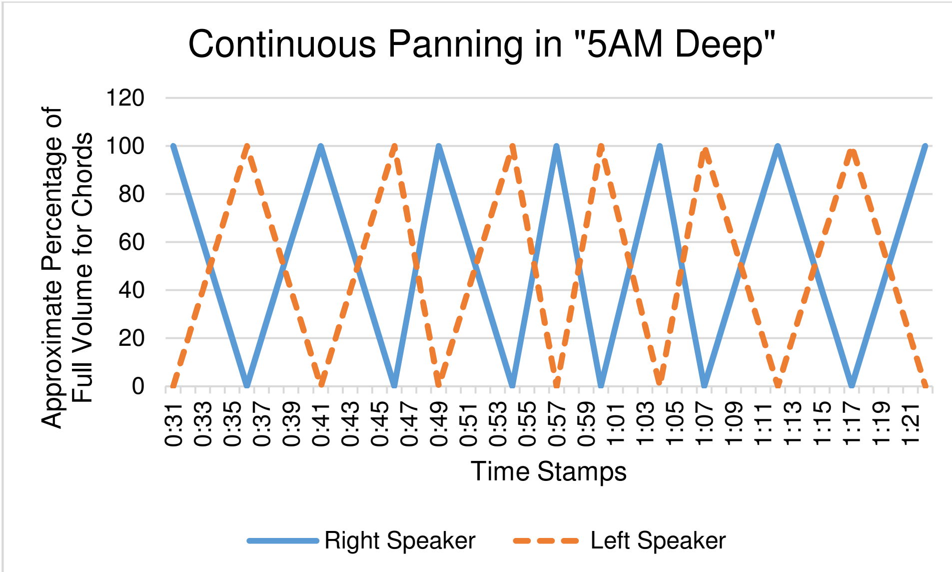

Figure 3-8: Visual Representation of continuous panning for 0:31–1:32 in "5AM Deep" by Daniel Brooks (2016).

Another track that uses continuous panning is Aphex Twin's influential "Come to Daddy (Pappy mix)."[26] Given the title, one would expect that this is a remix by an artist named Pappy, but in fact it is an original composition by Aphex Twin and two other tracks that are also only by him on the same album are "Come to Daddy (Little Lord Faulteroy Mix)" and "Come to Daddy (Mummy Mix)." All three of these are musically quite different.

At the end of "Come to Daddy (Pappy Mix)" panning is used to create the simulation of a car engine circling around the listener. This starts around 4:03 with an emphasis on the left followed by the right and then alternating, continuing until the end of the track. As in "5AM Deep," the motion is counter clockwise. Earlier in the piece

[26] This track is one of Aphex Twin's most famous tracks, and it helped him rise to popularity in the late 1990s, peaking at number 36 on the UK singles charts in 1997. "APHEX TWIN | Full Official Chart History | Official Charts Company" (n.d.).

discrete changes to the speaker inputs were made, with 3:16–3:18 seeming to come mostly from the right and then 3:19 abruptly going back to both sides equally. At the end of the track, however, there is clearly continuous panning going on for the first time.

It is interesting that Aphex Twin decided on saving this technique for this moment in the track, when the main melodic hook and most of the common elements throughout the piece are excluded. For many EDM tracks an introduction of a new technique towards the end indicates that it will be used in the next track as well, so the technique provides a seamless transition on to the next track as part of making a coherent set. Here though, panning is introduced as a kind of conclusive technique, and the track ends as an independent piece before something completely different begins on the album.

Short Timbre Changes: Filter Sweeps and Echo/Delay Effects

As discussed in the previous chapter, the simplistic notion of timbre that was developed for differentiating sound qualities of acoustic instruments is problematic for addressing complex electronic music. Nevertheless, it is a concept that is highly important in EDM. It is what makes the difference between sounds that are bright or dark, and clear or muffled. It can even be the primary determinant of different genres, as is the case with "acid house" being based on the distorted, squelching sound of the Roland 303.[27] The most important contributors to timbre are frequency content and ADSR envelopes, but these can be changed in many ways.[28] As with the other types of short continuous processes discussed in this chapter, quick timbre changes are often the result of an LFO being used to modulate parameters. The most common parameters that

[27] Mcleod (2001, 66).
[28] Fink, Latour, and Wallmark (2018, 11).

are modulated or automated to change timbre are filter cutoff and filter resonance (the strength of frequencies around the cutoff point).

In Daft Punk's "Musique," a one-measure loop is used almost incessantly throughout the track. The buildup sections are the only times when the loop is not fully presented, and there it is fragmented so that only parts of it are used. Even though the pitch content is very repetitive in this track, the timbre of the loop changes many times due to filtering. For example, from 1:14 to 1:19 the filter cutoff for the pitched layers becomes continuously lower, so that only lower and lower frequencies pass through. This timbre change can be seen clearly in the spectrogram (Figure 3-9). Compare the frequency content of 1:12 with the second half of 1:19. At both of these times, the timbre is bright and there is a full range of frequencies present. From 1:14 to 1:19 the spectrogram shows more and more high frequencies getting cutoff in the pitched layer, then suddenly a discrete change brings all of these frequencies back.[29] A shorter example of this same filtering technique being used to make the timbre more muffled occurs from 1:01 to 1:02. Filter sweeps that continuously make the cutoff point lower are used many times in this track to achieve the same kind of timbre change.

[29] Note that the percussion layer is not filtered, so high frequencies still show up when the hi-hat plays, for example.

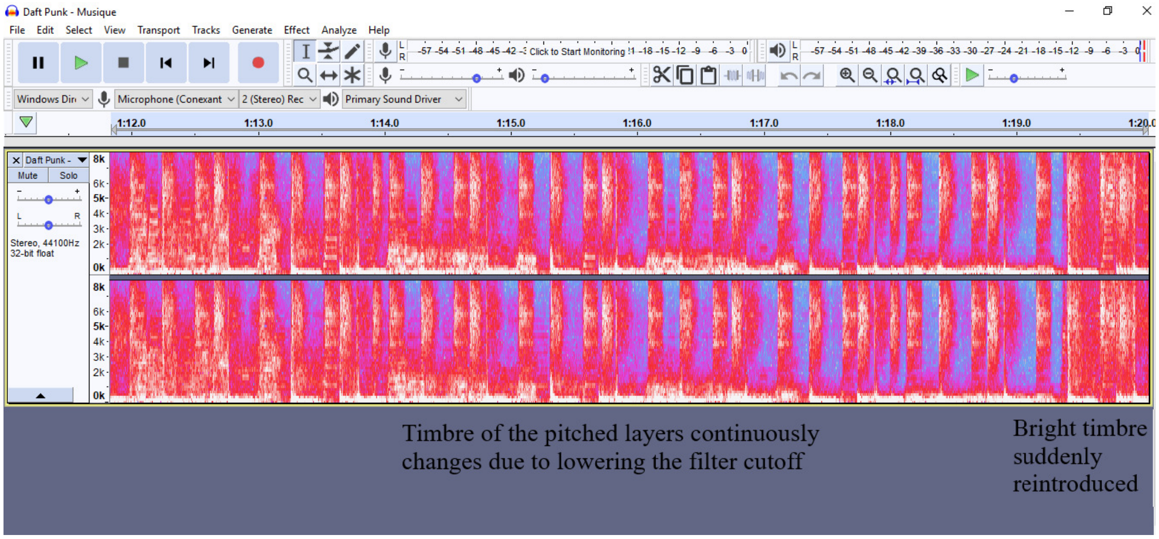

Figure 3-9: Spectrogram for 1:12–1:20 in "Musique" by Daft Punk (1996).

Another track that uses short continuous timbre transformations consistently "Tunnel Vision" by the Dutch group Zonderling. In a similar manner to "Musique," there is a simplistic and very repetitive melodic motive in this track, so changes to the sound quality are much more important for this tracks' aesthetics than the traditionally-valued elements of melody, harmony, and rhythm. Unlike "Musique" however, the primary method of changing timbre in "Tunnel Vision" is adjustment to filter resonance, not the filter cutoff. Since it is used at such high levels, filter resonance is associated with harshness in this track. At its lowest levels, the sound is merely "resonant," but when it is turned up very high, the sound quality becomes quite harsh and distorted.

In much of the track, timbre changes to the four-note motive seem to happen suddenly and discretely. However, from 2:40 to 3:11 (when the lead motive of the track is put into retrograde), they are more continuous, especially toward the end of this section, when the resonance increases in the last two measures so that the timbre becomes more gritty and distorted. Multiple times in this section reverb is also continuously added and then suddenly taken away. This changes the timbre in a different way. The articulation of the pitches is also changed frequently, so that sometimes the notes are shorter or more staccato than other times when they are longer. Short continuous processes change the quality of the lead motive in many ways in "Tunnel Vision," adding interest despite the repetitiveness of the pitches and rhythms.

A different way in which timbre can be altered that I did not discuss in the previous chapter is through the addition of one or more copies of the original sound set to be delayed by very short time periods. Depending on the methods used to create the copy, the length of delay time, and whether it changes or not, the chorusing, flanging, or phasing effects can be produced.[30] The chorusing effect also modulates the pitch of the copied sound. Note that this method of changing the timbre is distinct from the delay/echo effect discussed in the previous chapter, which utilizes echoes that can be distinctly heard rather than those that blend in to the original sound.[31]

The chorus effect is used to change the timbre of the bass line starting at 2:29 in "Reworks: Solution" by Pentatonik.[32] Each time that a bass note sounds, the continuously-changing frequency content can be heard and seen in the spectrogram. For example, see Figure 3-10, which shows the color of frequencies up to about 2,000 hz changing as the sound quality of the bass changes. As with most other short continuous

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[30] For a more detailed description of these effects see Dodge (1997, 166, 303–304); Zak (2001, 71–74).
[31] Doyle (2004, 32).
[32] At first, I was not sure if the effect being used was chorusing, flanging, or phasing, but after discussing this section with music producer John Miller, he told me that the chorus effect is taking place. Miller (2018b).

processes discussed in this chapter, this one repeats many times, with the frequency content changing in up-and-down waves. The LFO tool is being used to modulate the pitch of the copied sound and thus to continuously change the timbre of the bass line. This large section of the chapter on categories of short continuous processes has shown that pitch slides, volume changes, panning, and timbre changes all occur frequently in the span of two measures or less in contemporary EDM.

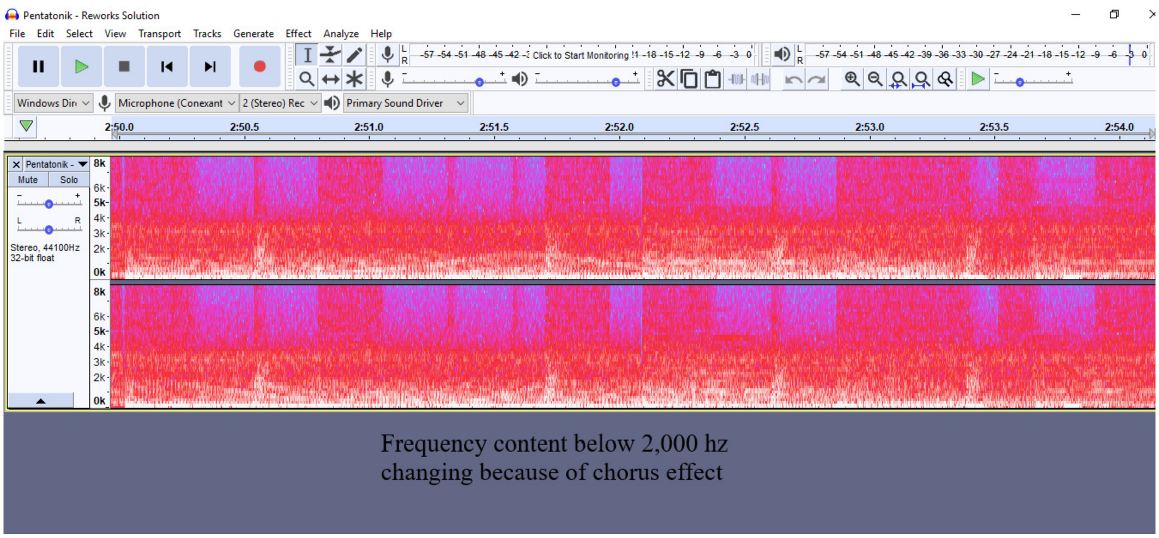

Figure 3-10: Spectrogram for 2:50–2:54 in "Reworks: Solution" by Pentatonik (1994).

Guidelines 1–5 for Comparing the Salience of Short Continuous Processes

In chapter 2 I outlined the first four analytical guidelines for comparing the salience of continuous musical processes within and across different EDM tracks, with salience meaning prominence, memorability, and/or significance. Now I will discuss how these four guidelines plus guideline 5 that I will introduce can provide useful tools for analyzing the usage of short continuous processes in EDM. Some of the examples studied in the previous section will be revisited, and one other piece that uses a variety of short continuous processes will be discussed as a summary example. The first five guidelines for comparing the salience of continuous processes are:

1) A continuous process that has an overall louder *volume* relative to the rest of the musical texture is more salient than a continuous process that has an overall softer volume relative to the rest of the texture.
2) A continuous process applied to a sound layer that is *distinctive* in some way (such as having a timbre, rhythmic pattern, or melodic motive that stands out in the texture) is more salient than a continuous process applied to a sound layer that is not distinctive in the texture.
3) A group of continuous processes that change a higher *number of parameters* in one sound layer at the same time is more salient than a group of continuous processes changing a lower number of parameters in one sound layer at the same time.
4) A group of continuous processes that change the same parameter in the same direction in a higher *number of sound layers* at the same time is more salient than a group of continuous processes changing the same parameter in the same direction in a lower number of sound layers at the same time.
5) Continuous processes that are frequently and consistently *repeated* are more salient than continuous processes that occur less frequently or less consistently.

Guidelines 3 and 4 are more relevant for long continuous processes such as risers and accelerations, however guidelines 1 and 2 are still highly applicable to short continuous processes, and guideline 5 is much more relevant for short ones rather than long ones. Guideline 5 says that the salience of a continuous process is dependent not only on its individual characteristics but also on how many times it occurs in the same way or a similar way within a track.

Sometimes a short crescendo or timbre change happens only once and is not repeated, or is only repeated discursively, every eight or sixteen measures. Examples of this include "articulative" or "atmospheric" sounds, as well as short uplifters and downlifters surrounding midway points of large sections.[33] Other times short continuous processes are only repeated as part of a wave cycle in one section of a track. Sometimes, however, a pitch slide or fade-in repeats itself multiple times within one measure and then is part of that measure looping throughout the track. The former two situations contain continuous processes that are much less salient than the latter, because the continuous processes in the latter situation are more prominent in the track as a whole and will be remembered more easily than those in the former.[34]

Furthermore, if a continuous process such as a short pitch slide is repeated frequently but in different ways (such as having different starting and ending points melodically or metrically within the measure, or having different salience levels according to other guidelines), then it is less salient compared with a more consistently repeated counterpart.[35] The more frequently and consistently a continuous process

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[33] For a discussion of articulative and atmospheric sounds in EDM, see Butler (2006, 180).
[34] Margulis (2014, 82).
[35] This is because in music, verbatim memory is stronger than gist memory. Ibid. (85–89).

happens, the more it will stand out and be remembered as an important feature of the music.

It could be argued that guideline 5 contradicts guideline 2, since a single continuous process or group of them, whether short or long, can be quite distinctive and be a crucial component of a track. For example, a riser in a buildup section or a cue that utilizes a short continuous process right before a beat drop can be highly salient according to guidelines 1–4. However, *another* way in which a group of continuous processes can be highly salient is through frequent and consistent repetition, and this does not nullify the salience of individual ones that are distinctive or occur at important structural moments. There are many ways in which musical material can be made prominent and memorable.

Several examples from this chapter illustrate the value in having these guidelines for comparing the salience of short continuous processes. The pitch slides that recur in "Space Junk" are part of melodic lines that loop throughout most of the track. Under guideline 5, these scoops and falls are more salient than the short uplifters and downlifters that occur occasionally in "Find a Way" to mark hypermetric downbeats. The latter are also soft in volume so they are not salient under guideline 1, however they do have a distinctive timbre that stands out in the texture, giving them some salience under guideline 2.

Continuous panning occurs in both "5AM Deep" and "Come to Daddy." In both of these examples the panning takes place in sound layers that are distinctive and at the foreground of the texture, and therefore they are salient under guidelines 1 and 2.

However, in “Come to Daddy” the panning of the car-engine sound only happens near the end of the track, for the last twenty seconds, whereas in “5AM Deep” it occurs in the chords layer throughout the piece, and is a more salient, fundamental component of the track as explained by guideline 5.

The timbre changes in “Musique” and “Tunnel Vision” are frequent but not consistent. They are varied in length and scope, sometimes adjusting the filter cutoff or filter resonance much more than other times, and do not occur consistently in the same metrical positions. Therefore under guideline 5 they are not as salient as consistent repetitive continuous processes such as the scoops and falls in “Space Junk.” However, the timbre changes in “Tunnel Vision” occur in the lead melodic line that is the hook of the piece, so they are quite salient under guideline 2 because they happen in a distinctive layer that stands out in the texture. Similarly, the timbre changes created with filter cutoff changes in “Musique” are applied to not only the main melodic line, but also its accompanying chords, so they are salient according to guidelines 2 and 4.

Another piece that utilizes many short continuous processes with varying levels of salience is “Be Strong (The Loops of Fury Mix)” by Elite Force. From the very beginning of the track the main melodic loop that lasts one measure is heard repeatedly. As shown in the transcription (Figure 3-11a), the downbeat is clearly articulated by a stable bass note, but the other beats contain many short ascending pitch slides. In addition to the scoops between each pair of sixteenth notes, the starting and ending points of each short scoop continuously get higher. So there are two scale levels of pitch slides going on here: one that takes place repeatedly over half a beat, and one that takes place over three beats.

Both these levels of scoops are part of the main melodic figure that loops in most of the track, including all the core sections, so they are highly salient under guideline 5 because they repeat frequently and consistently.

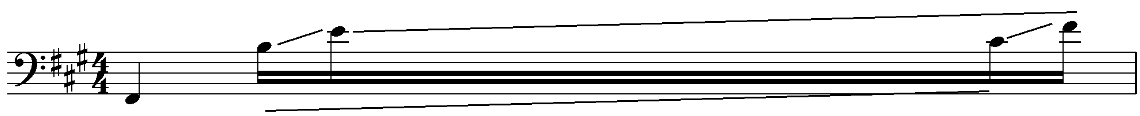

Figure 3-11a: Transcription of the opening loop in "Be Strong" (The Loops of Fury Mix) by Elite Force (2011).

Occasionally, a short pitch wave also happens in the middle of core sections (such as at 1:13, 2:13, and 3:59). Each time it is accompanied by four discrete iterations of the high vocal "woo." This pitch wave is less salient than the scoops in the main loop, because the wave happens less often and it also competes with the vocal part each time. A vocal part does occasionally happen at the same time as the scoops, but instead of saying "woo" at a very high pitch on four consecutive beats, it says "be strong" at the start of a four-measure loop and then continuously fades out over three measures.

In the first buildup section (0:45–1:00), repeated, multidirectional waves of pitch motion occur. Each ascending and descending cycle of the wave can be thought of as one short continuous process. As demonstrated in multiple examples in this chapter, short continuous processes are often embedded within longer ones. This is also true here, since the short pitch waves transform over the course of the buildup section. Firstly, the speed of the wave cycles increases through acceleration, and secondly, the pitches at the high and low points of the wave continuously ascend. The continuous pitch ascents at two different levels of length, such that shorter scoops are embedded within a longer ascent, mimics the processes in the main loop transcribed in Figure 3-11a. In the buildup section it is an expanded version of this technique. The anticipatory function of the buildup section is also aided by an ascending noise sweep. Under guideline 5, the continuous processes in the buildup section are not as salient as those in the core sections, since they only occur in this way in this single section. However, the continuous processes in the buildup are still quite salient, and this can be understood using guidelines 1–3, since the volume is loud, there is a distinctive timbre, and multiple types of continuous processes are being applied to the same sound layer at once.

Another type of short continuous process takes place repeatedly in the breakdown (2:45–3:15). First, notice that the section is preceded with an ascending noise sweep and starts with a descending noise sweep. These are uplifters and downlifters that highlight the sectional boundary, which is a very common technique that has been heard in previous examples. The short continuous process that repeats throughout the breakdown section though, is a filter sweep applied to the bass layer and the chords. The filter sweeps can be clearly seen on the spectrogram (Figure 3-11b). They continuously add or remove high frequencies in waves, and change the timbre and volume of the sounds. Since the filter sweeps have a prominent and distinctive place in the texture, and occur in both the bass and the chords, they are highly salient under guidelines 1, 2, and 4.

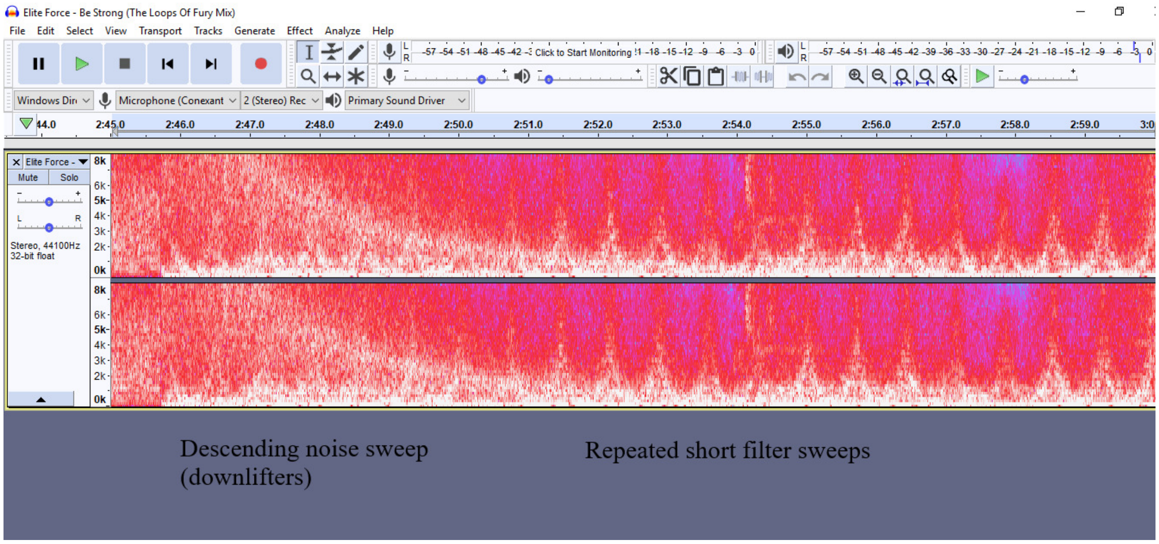

Figure 3-11b: Spectrogram of 2:45–3:00 in "Be Strong" (The Loops of Fury Mix) by Elite Force (2011).

As this section has shown, the five guidelines that have been outlined so far in this dissertation are useful for comparing the salience of both short and long continuous processes, and making explicit the kinds of foreground-background parsing involved in listening. Sometimes, however, it is difficult to tell whether a process is continuous or whether it is discrete. The following section discusses such cases, and how they can be approached analytically.

Borderline Cases: The Continuum between Discrete and Continuous

As I have shown in this chapter and the previous one, both discrete and continuous processes are important features in contemporary EDM. However, musical changes are not always easy to distinguish as clearly discrete or clearly continuous. There is value in upholding the distinction between discrete and continuous processes but it is also necessary to recognize that there is a continuum between the two types. The electroacoustic composer Denis Smalley puts it this way: “The continuity–discontinuity continuum runs from sustained motion at one extreme to iterative motion on the other."[36] In chapter 2 some examples were discussed that sounded continuous but had discrete components to them. The acceleration in "Thousand" and the deceleration in "Interferance" each have some parts where the tempo levels off in discrete stages, while being in the middle of a longer process that is perceived as mostly continuous. In this chapter on shorter processes, I will now discuss examples where the change between two musical states is achieved with continuous motion, but in such a fast way that it seems to almost happen instantaneously.

Figure 3-12 shows drawings that represent three musical situations. In each case, two discrete events are represented by horizontal lines, and a continuous process is represented by an ascending sloped line. For example, the first horizontal line could represent the pitch A, the second horizontal line could represent the pitch B, and the sloped line could represent a pitch slide. If the note A starts on beat one of a measure and B starts on beat three, and the pitch slide takes place over two beats in an EDM piece (which has a standard tempo of around 110–160 bpm), then the slide will be perceived as clearly continuous. This will also be true if the pitch slide lasts for one beat, a half beat, or maybe even a quarter of a beat depending on the tempo. However, once the pitch slide becomes so short that it becomes imperceptible, the process of moving between A and B will perceived as clearly discrete. If the length of the pitch slide is such that it is *almost* imperceptible, the process could be perceived as either discrete or continuous and it is a borderline case that falls under the category of microrhythm.

[36] Smalley (1997, 117).

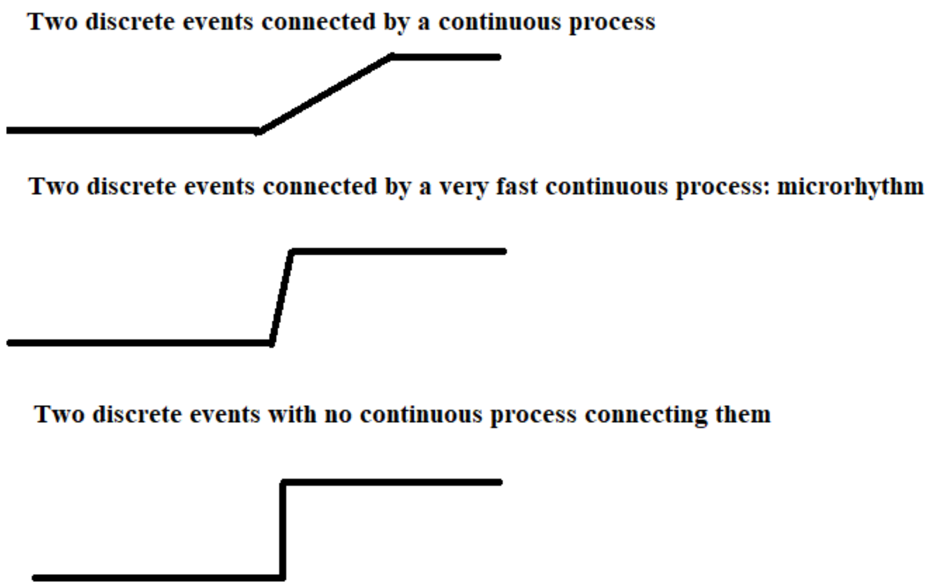

Figure 3-12: Drawings that represent three musical situations.

In general microrhythm refers to musical processes that take place at the "sub-syntax level," which staff notation cannot capture and traditional discourse has labeled as merely "expressive."[37] Microrhythm usually involves musical events that are closer together than the fastest possible perceived metric subdivisions, which are about 100 milliseconds (ms) apart.[38] The study of microrhythm analyzes how rhythm intersects with aspects of timbre, texture, dynamics and pitch to form short, unified "gestures."[39] A subset of microrhythm is microtiming, which deals only with temporal aspects.[40] Traditional studies on microtiming have argued that professional musicians in classical, jazz, and pop traditions naturally perform with "expressive microtiming," which involves

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[37] Danielsen (2010, 9).
[38] London (2012, 27–29).
[39] Danielsen (2010, 8–10).
[40] Ibid.

playing or singing notes that are slightly offset from the beat.[41] Charles Keil, who pioneered this line of thinking with his term "participatory discrepancies," goes as far as saying that "music, to be personally involving and socially valuable, must be 'out of time' and 'out of tune.'"[42] Along with this argument there is great value placed on the humanity of acoustic performances; a truly "musical" performance cannot be replicated by machines.

On the other hand, Anne Danielsen shows how digital technology can also be used to precisely control music with microtiming. Using contemporary studio-production techniques, composers can either hide or emphasize the music's machine-like qualities, and this has led to two different uses of micro-timing that Danielsen calls the "exaggerated rhythmic expressivity of the machine" and the "exaggerated virtuosity of the machine."[43] In the former category are techniques used in hip-hop, soul, and R&B that simulate as precisely as possible a "human" performance with traditional ideas of groove.[44] In the latter category are techniques used in "electronica" that highlight the non-humanity of the musical performer through extremely precise quantization of fast rhythms.[45] This "exaggerated virtuosity of the machine" is exemplified in the IDM genre and particularly in the music of Aphex Twin and Squarepusher. Both categories often come into play in contemporary EDM, partially because there is more and more blending between EDM and other styles of popular music, so extensive vocals are often

[41] Iyer (2002).
[42] Keil (1987, 275). Recently this notion has been challenged by many empirical studies, as discussed in Senn et al. (2016).
[43] Danielsen (2010, 1–2).
[44] Ibid.
[45] Ibid. A critique to this distinction is provided by Weheliye (2002).

incorporated into EDM tracks. The vocal samples that producers work with can be edited to varying degrees, but often the "humanity" will be kept in through slight deviations in tuning and rhythm from the standardized norms.[46] This helps generate notions of authenticity for performers.[47]

The particular kind of microrhythm I am highlighting in this chapter involves continuous processes happening very quickly, so that they are difficult to identify as continuous and may be heard as discrete. EDM creators sometimes utilize microrhythm in this way as part of a longer continuous process that changes the continuousness or discreteness of a repeated gesture. In these cases, the continuum between discrete and continuous processes is being traveled across musically.

In the section on timbre changes above, the use of filtering was highlighted in "Musique" by Daft Punk. From 1:14 to 1:19 in that track, the filter cutoff becomes continuously lower, and then at 1:19 the filter is suddenly removed so that all the frequencies can be heard. However, not all uses of filtering in this track are so clearly continuous or clearly discrete. Figure 3-13a shows a spectrogram of 1:23–1:29. At 1:23, the spectrogram shows a descending white line with a highly-negative slope that is not quite a vertical line. This indicates microrhythm since the filter cutoff is being lowered so quickly that it is almost instantaneous but not quite. From 1:26.3 to 1:27.3 a clearly continuous lowering of the cutoff takes place, in an example of a short continuous timbre change. For the rest of section shown on the spectrogram, the filtering is turned on and

[46] Some examples are "Undercover" by Mike Hawkins, "So Strong" by Outboxx f. Naomi Jeremy, "First House" by Sebastian Davidson, and "World To Me" by Tchami f. Luke James.
[47] For a discussion of scholarship on authenticity in pop and rock music see Leach (2001, 146–148).

off quite quickly, with more microrhythm. Another steep descending line can be seen from 1:28.4 to 1:28.6, indicating another continuous sweep of the filter cutoff that could be perceived as discrete because it happens so quickly. These quick instances of lowering the filter cutoff contrast with sections like 1:53–1:58, in which the filter cutoff is raised continuously over more than two whole measures, brightening the timbre in the process.

Microrhythm also occurs in instances of raising the filter cutoff though, as can be heard in 4:16–4:17 and seen on the accompanying spectrogram (Figure 3-13b). The two quickly-ascending lines at 4:16.5 and 4:16.8 indicate that the continuous filter sweeps take place at such a quick speed that they could be perceived as discrete. If they were perceived as discrete, their rhythm would create syncopation, since it would be a dotted-eighth note starting on beat four, followed by a sixteenth note that anticipates the next downbeat. The next measure repeats the same technique, with quickly-ascending filter sweeps generating syncopated rhythm.

Near the end of the track, a clearly continuous ascending filter cutoff is contrasted with another instance of microrhythm. Figure 3-13c shows the spectrogram for 5:53–5:57. This section occurs just before the final climax of the track. First there is a continuous ascent of the filter cutoff that is especially visible in the spectrogram due to the lack of hi-hat in this passage, and then just before all the frequencies return again to create a loud climax, there is a very short ascending filter sweep and another occurrence of microrhythm. What makes this effective is the contrast between all the versions of the filtering that have happened in this track. Sometimes the filter cutoff is lowered and sometimes it is raised, but the varying rates at which this occurs provide different perspectives on the same technique for listeners.

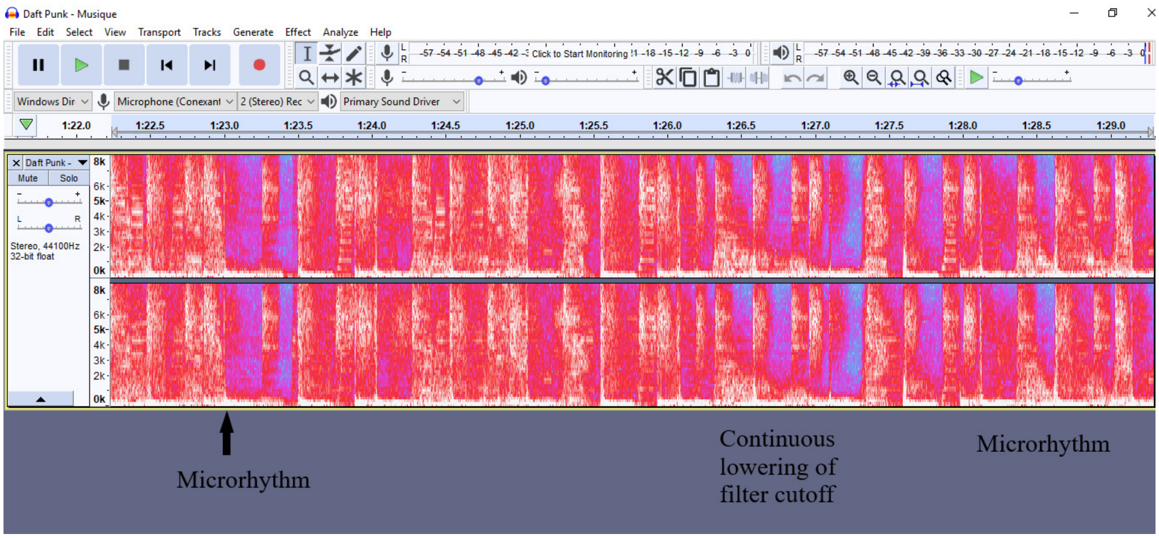

Figure 3-13a: Spectrogram of 1:22–1:29 in "Musique" by Daft Punk (1996).

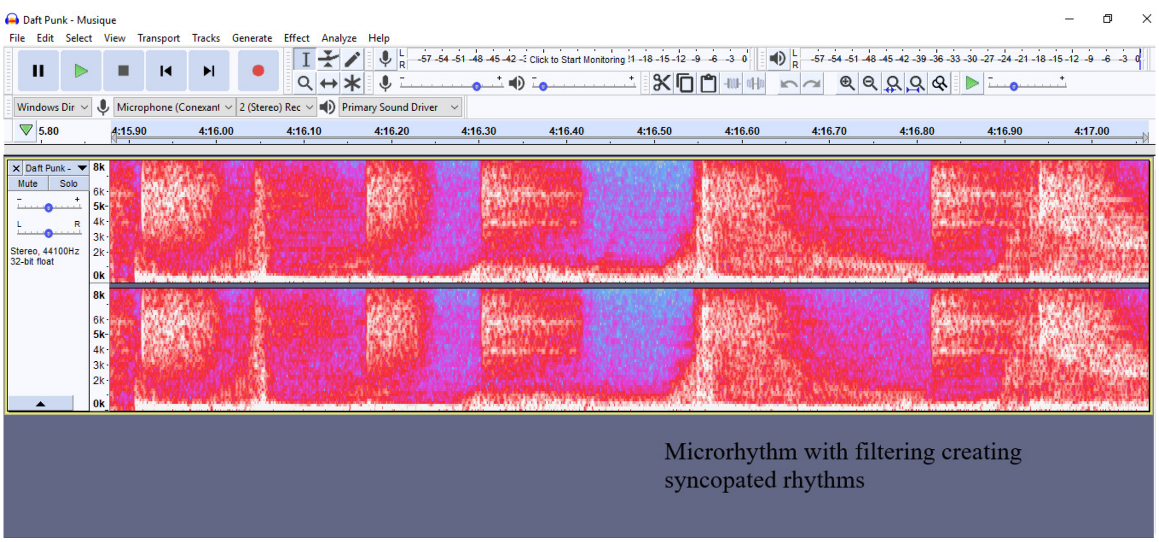

Figure 3-13b: Spectrogram of 4:15.9–4:17.1 in "Musique" by Daft Punk (1996).

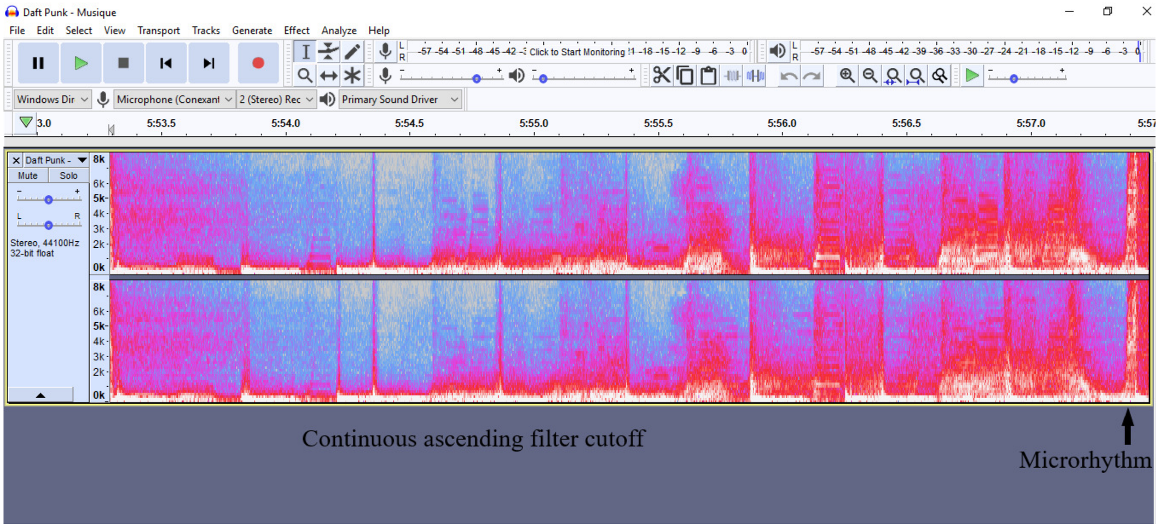

Figure 3-13c: Spectrogram of 5:53–5:58 in "Musique" by Daft Punk (1996).

In “The Key” by James Doman, there is a good example of a long continuous process that changes a sound layer from articulating single discrete pitches to repeated continuous pitch falls. From 2:04 to 2:19, the off-beat stabs transform from discrete to continuous. At first (2:04–2:06), this sound layer does not change its pitch when it sounds on each off beat: it is just a discretely-repeating rhythm. Then (2:06–2:09) microrhythm happens, so that some barely-noticeable pitch change occurs within each instance of the sound. By 2:10, it is clear that each repetition of this layer on the off-beats contains a short continuous pitch slide, specifically a pitch fall. This is also evident from the quick descending white lines that start to appear on the spectrogram (Figure 3-14). From 2:10 to 2:19, the continuous pitch slide only becomes more obvious since it becomes louder and the starting point of the fall ascends higher. The transformation of this sound layer was probably accomplished through a continuous filter sweep being applied to it, gradually allowing higher frequencies so that the pitch fall (which occurs in the high register) is eventually allowed to sound and become continuously more salient.

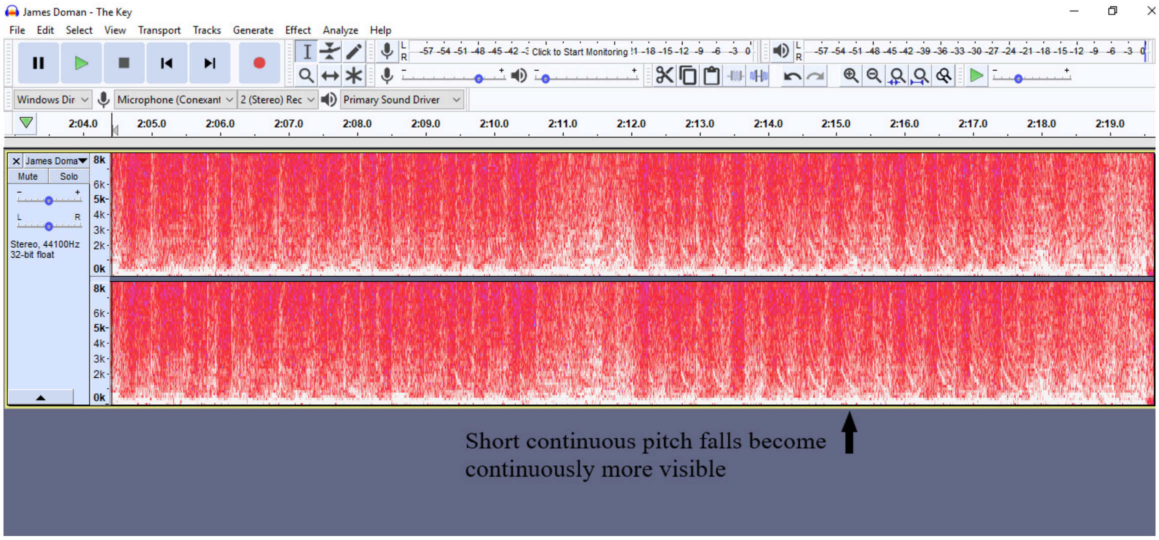

Figure 3-14: Spectrogram for 2:04–2:20 in "The Key" by James Doman (2013).

Microrhythm is used for a different effect in “Electronic Battle Weapon 3 (Under the Influence)” by The Chemical Brothers. The breakdown in this track starts at 2:08, with only the bass layer sounding. When listening to it at full speed, it is difficult to tell if continuous processes are happening in the bass or not, and if so, what kind they are. It sounds like the tremolo effect could be taking place, but the pitch is also unstable. When listening to the piece at a significantly slower tempo, it becomes apparent that it is not the tremolo effect being used to continuously alter the volume on a sustained note, but rather separate, repeated notes are being articulated, each with a short descending pitch slide and a diminuendo. This is shown in the first part of the transcription (Figure 3-15). Each pitch slide and diminuendo lasts almost exactly 100 ms, so they can easily be classified as examples of microrhythm. The pitch fall moves roughly from C-flat to B-flat.

At 2:22, the loop changes so that no pitch slides are being used and the rhythm is clear eighth notes, but short continuous diminuendos are still being used, and now B-flat is louder than C-flat, which is the opposite of the previous section. Taken together, both of these loops utilize short continuous processes and microrhythm to destabilize the music. The metrical dissonance of repeated dotted eighth notes in the first loop adds to this instability. The very short pitch slides and diminuendos used in this section of the track demonstrate how microrhythm can be used as an expressive tool to modify the music at a sub-syntax level.

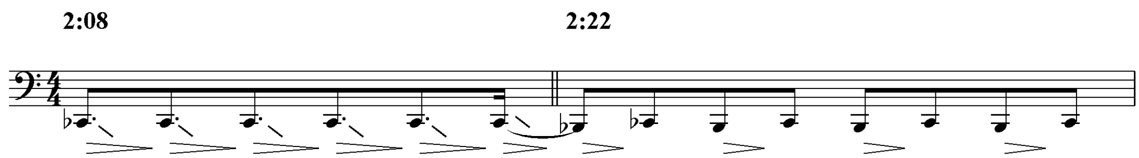

Figure 3-15: Transcription of two different bass loops in "Electronic Battle Weapon 3 (Under the Influence)" by The Chemical Brothers (1998).

A final example that demonstrates the use of microrhythm comes from Aphex Twin’s remix of “Debase (Soft Palate)” by The Mike Flowers Pops. At 2:04, a short continuous effect is heard that sounds like an engine starting up, or a lawn-mower cord being pulled. After this, a bass line is featured for the next minute, repeating itself three times over four ten-measure loops until 3:04. It is soft, but it is constantly moving, so it is salient within the relatively sparse texture. The pitches in this bass line are roughly moving up and down the chromatic scale in a step-by-step, discrete fashion, but the articulation on each note is either very soft or not present at all, so that the notes are slurred together. The combination of this slurred style with the fast rhythm makes the ascending and descending pitch movement sound almost continuous, especially in the first part of each ten-measure loop when the articulation is the weakest (the first and second loops start at 2:05 and 2:20). It is particularly easy to hear the pitch movement as a continuous glissando if the music is being played at a quiet volume level or with a small amount of bass coming from the speakers.

At 2:36, the third loop of the bass line starts, and a piercing sound doubles its pitch content several octaves higher with clearer articulation. This makes the ascending and descending pitch movement more salient and allows the chromatic bass line to be heard as discrete more easily. However, the contrast in articulation could still be heard as a contrast between discrete pitch movement in the high part and continuous pitch movement in the bass.

Even though the high chromatic sound layer mostly sounds discrete though, it also utilizes microrhythm and changes between being clearly discrete, clearly continuous, or neither, in a similar manner to the off-beat stabs in "The Key." In the third ten-measure loop (starting at 2:36), microrhythm is consistently used, since there is a barely-perceptible pitch slide at the start of each of its notes that lasts about 70 ms. When the chromatic scale is ascending this slide is a scoop and when the scale is descending the slide is a fall. Notably, each pitch slide moves only a semitone or less, and in the timespan of 70 ms, this is well below the "glissando threshold" defined by Hart et al., so microrhythm is clearly in use here.[48]

[48] Based on the information from several empirical studies, Hart et al. define the glissando threshold as $g_{thr} = 0.16/T^2$, where g is the minimum number of semitones per second that need to be moved in order for the pitch movement to be considered a glissando, and T is the timespan of the glissando in seconds. In this example, in order to be perceived as a clear glissando at full speed, each pitch slide would need to move approximately 2.3 semitones over its 0.07 seconds, and since they do not, they are not clear pitch slides. Hart, Collier, and Cohen (1990, 32).

During the fourth ten-measure loop (starting at 2:51), the very short pitch slide at the start of each note in the high sound layer changes its depth. From 2:54 to 2:57, the pitch change is so narrow that the layer sounds clearly discrete, but from 2:58 to 3:00, the pitch change becomes deeper and therefore the slide at the beginning of each eighth note becomes more noticeable. At 3:01, the pitch slide becomes narrower again, so that microrhythm is being used as before. Over the course of this final ten-measure loop, Aphex Twin varies the level of continuousness for this high-pitched layer, so that different expressive effects are created. When combined with the lack of clear articulation in the bass line, the overall aesthetic of these two featured sound layers in this section is one of intense instability.

Conclusion

This chapter has discussed the categories and salience of short continuous processes, which last for two measures or less. These processes are generally described as "effects," and can be 1) repeated effects that provide ornamentation to discrete melodies and rhythms, 2) repeated wave-shaped undulations in pitch, volume, or timbre, or 3) individual effects that are articulative, atmospheric,[49] or are part of uplifters or downlifters, which precede or follow hypermetric downbeats. The categories of short continuous processes that were explored in this chapter include: pitch scoops, falls, and waves, ascending and descending noise sweeps, crescendos and decrescendos (including the wave-like tremolo effect that creates rhythmic pulsations through repeated volume

[49] Butler (2006, 180).

changes), circular spatial effects created with panning, and timbre changes created with filter sweeps and echo/delay effects.

Following the categorization of short continuous processes by parameters, the first five analytical guidelines for comparing the salience of continuous processes were used to show how some short continuous processes are more prominent than others in EDM tracks, for reasons such as being in a sound layer that is distinctive in the texture or being repeated frequently and consistently. Finally, processes utilizing microrhythm that could be perceived as either continuous or discrete were discussed, and the idea of moving across the discrete to continuous continuum was shown to have been implemented in some musical examples. In general, this chapter has shown that the different ways in which a repeated gesture can be heard throughout a track contribute to the interpretive multiplicity that is a crucial part of EDM's aesthetics.[50]

At the end of the first major section of this dissertation, it is important to take stock of the ontological implications that continuous processes (both long and short) have for EDM. Continuous processes are not usually considered to be defining features of an EDM "work," but only of a particular text or performance.[51] This is evidenced by the fact that they are generally added after the discrete melodic and rhythmic loops during the production of a track, and are often improvised by DJs during live performance with continuous controllers on a mixing board or effects processor.[52] Remixes often change many of the continuous processes in original versions of tracks, since the "stems" that are

[50] Ibid. (6).
[51] For definitions of these terms see chapter 1 and also Butler (2014, chap. 1).
[52] Butler (2006, 51–57).

shared only contain basic versions of the drums, melodies, and harmonies, which are seen as the most fundamental aspects of a work that listeners will recognize as belonging to the same piece even in different performances. In his masterclass.com series Deadmau5 says:

> I can write a whole song in less than sixteen bars. Really, truly. I can do a whole track in less than sixteen bars. And then, once those sixteen bars – which is like, what, 23 seconds of music? – is done, then it's all about arrangement. It's arranging that sixteen, or even eight, or shit if you're Eric Prydz it's four, it's all about, just, lengthening or duplicating that whole thing across the board and then arranging it, saying: *What comes in? What goes out? What gets modified? What gets unmodified?* But it's all the same thing.[53]

> So you've made your eight bars of loopy, loopy goodness, and it just sounds really good if you just let the thing play for hours on end. *Making it interesting is about minor, sometimes major variations to that same bar and then carrying that on and adding really interesting breaks or swells and dips*. Taking out all the percussion and the drums, and then doing something completely different, but in the same key as your main theme. That's what keeps something interesting.[54]

> So basically, once you have a rough arrangement of how you want it, then you go back, well I do, and go from the beginning again and just start adding all the *little weird effects and small variations*.[55]

These three quotations show that Deadmau5 thinks of the core section, when the track is at its fullest, as the main identifying part of the song, and that the continuous processes such as "swells and dips" or "little weird effects and small variations" are added after the primary melodies, harmonies, and rhythms have been added.[56] This does not mean that continuous processes are not salient or structurally important. As the

[53] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 2, starting at 7:38). Emphasis mine.
[54] Ibid. (lesson 13, starting at 0:07). Emphasis mine.
[55] Ibid. (lesson 13, starting at 4:52). Emphasis mine.
[56] The process may be different depending on genre too, since house and trance are known for involving more harmony whereas techno and "drum and bass" use less clearly-pitched elements.

numerous examples in chapters 2 and 3 show, they are immense contributors to EDM's aesthetics of tension followed by release and ambiguity followed by clarity. Furthermore, the ontological fluidity of works is a distinctive and cherished part of EDM, and different versions of the same work are evaluated on their own merit. It is as if continuous processes are part of the details that give life to sculptures. Without them, the basic shapes (in EDM, the recognizable melodic and rhythmic patterns in the core) are still there, but without them, the sculpture (or track) is not a true work of art.[57]

Even short continuous processes, which are generally less structurally important than long ones, are highly valued by EDM listeners and creators. As some other parts of his masterclass show, Deadmau5 spends hours working on them with modular synthesizers because he prizes originality in his studio-produced tracks. "That's why I really like modular synthesis for making even just 'one-shots' or one little synth blip that goes in there, because you won't hear that blip anywhere in the world."[58] Some of the highest amounts of creativity are required to make the short effects original.

Continuous processes are highly important features of EDM tracks and live performances. They can be categorized in many ways that have been explained in these two chapters, such as by their length or by their musical parameters altered. However, they can also be categorized by their *shape* and by their *function*, which will be the topics of chapters 5 and 6. First, however, chapter 4 provides a brief interlude in this dissertation

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[57] In a similar way, a middleground Schenkerian graph can provide a valuable representation of the core elements of a work, but it does not fully represent a piece of music and all of its salient details.
[58] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 8, starting at 17:44).

to explore the history of mathematical and philosophical thinking about continuous musical processes, and show how music theory has long had a discrete bias.

Chapter 4 (Interlude) – The Discrete Bias in Music Theory: Historical, Philosophical, and Psychological Perspectives on Continuous Processes

> At least in our culture it seems extremely difficult to achieve a balance between morphological and lattice-based architecture. For many musicians, lattice structure is what differentiates music from non-music and morphological architecture will be perceived as either chaos and no architecture at all or at least of no concern to the musician. Hopefully as we approach the end of the twentieth century we are growing out of this culturally ingrained habit.[1]

It is well known that the rules and systems of Western music theory typically depend on staff notation, scalar logic, and arithmetic precision. Trevor Wishart calls this "lattice sonics," which includes "dealing with the organisation of pitch in finite sets, rhythms using summative notation and most usually in fixed tempi, and sets of instruments grouped into clearly differentiated timbre-classes."[2] Lattice sonics is contrasted with "dynamic morphology," which occurs in a sound object "if all, or most, of its properties are in a state of change."[3] Wishart is one of many composers who have theorized about continuous processes with electronic sounds,[4] but there is still a discrete bias in the field of music theory.

In many people's minds, learning "music theory" and even "learning music" is synonymous with reading and writing on the discrete lines of staff notation. Lerdahl has

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[1] Wishart (1996, 108).
[2] Ibid. (8).
[3] Ibid. (93).
[4] For example, Schaeffer discusses continuous oscillations in volume, pitch, and timbre as "allure." Erickson discusses continuous timbre changes as "spectral glide." Callender analyzes continuous processes as "continuous transformations" in the music of Saariaho, Nancarrow, and Ligeti. Schaeffer (2017, 437–438); Erickson (1975, 72–75); Callender (2004).

argued that music must be separated into discrete, hierarchical events in order to be comprehensible,[5] and that "comprehensibility is a necessary if not sufficient condition for value."[6] The discrete bias in our field is also evidenced by our historical reliance on the black and white piano keyboard as a default technology. Emily Dolan has argued, for example, that "the keyboard is imbricated with the very *idea* of Western Art Music."[7] By tracing the development of musical instruments in the Enlightenment period and beyond, she shows how the keyboard, which is discrete in nature, became a "default interface."[8]

In most electronic music (subsets of which are EDM and most contemporary popular music), both discrete and continuous processes (i.e. both lattice sonics and dynamic morphology) are highly important. This is made clear when listening to the music (such as the many examples heard in the previous two chapters), and when examining the visual interfaces in a DAW. As seen in Figure 1-4 in chapter 1, discrete clips of sound are presented like building blocks that can change in size, but are almost always quantized to the tempo and key of the music, and the piano roll is used to create melodies from discrete pitches. Continuous processes are represented with automation curves, and also the virtual knobs and sliders that can create them.

Since both discrete and continuous processes are highly important in electronic music and also many kinds of acoustic music, we need analytical tools to describe them and their functions; the goal of this dissertation is to begin developing those tools for

[5] Lerdahl (1992, 104–115).
[6] Ibid. (118).
[7] Dolan (2012, 4).
[8] Ibid. (6).

continuous processes, and processes that are neither clearly discrete nor clearly continuous, in EDM. Yet, as this chapter will show, studies of discrete processes with discrete methodologies have long had a hegemony in musical scholarship. In contemporary times, many composers have theorized about continuous musical processes, but most scholarship in the institutionalized discipline of North American music theory has focused on discrete systems, such as those found in pitch-class set theory, Schenkerian analysis, and Lewinian transformation theory, which uses continuous lines to represent abstract connections between musical objects, not sounding continuous gestures.[9] Granted, much scholarship in the field has also studied phenomena that can be described as continuous, such as form and narrative or the nature of time and teleology,[10] but as discussed in chapter 1, the kind of continuousness I am referring to in this chapter and this dissertation has to do with continuous alterations of musical parameters to create gradual gestures, rather than continuousness in the sense of repetitive flow in minimalism or a harmonic progression driving toward a cadence.

The bias toward discrete thinking in music theory and analysis is not new however. It has deep historical roots. This chapter will basically be a chronological overview and discussion of both discrete and continuous thinking about music in scholarship from ancient Greece to the present. The interaction between *musica theorica* (also known as the speculative tradition, concerned with ontological questions about music) and *musica practica* (also known as the regulative tradition, concerned with

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[9] The topics focused on in "flagship music theory journals" from 1979–2014 are the subject of a recent corpus study, which gives an indication of the discrete bias in the field. Duinker and Gauvin (2017).
[10] For examples, see Fink (2005); Hepokoski and Darcy (2006); Kramer (1988); Maus (1988); Schmalfeldt (2017).

explaining normative patterns and systems of musical practice) will be a thread throughout the chapter, as I show that up until around the fifteenth century both were based very much on discrete principles.[11]

In the sixteenth–nineteenth centuries *musica practica* became even more discretized while *musica theorica* began to understand pitch and music in general as a continuous phenomenon thanks to important developments in mathematics. In the twentieth century the split between *musica theorica* and *musica practica* led to the forming of two different worlds with different ontological and epistemological frameworks that rarely interact institutionally, and this is a split that my research is trying to reconcile. The concluding section of this chapter will discuss the role of psychology in addressing why we have a natural tendency to discretize things, why this is problematic for analyzing electronic music, and how we can do so better by acknowledging the importance of continuous processes in the repertoire.

From Ancient Greece to the Middle Ages: *Musica Theorica* and *Musica Practica* Both Based on Discrete Principles

In musical thought the idea of dividing up sounds into fixed, repeatable notes, intervals, and scales is very old, even existing in ancient Greece. The Pythagorean tradition describes numbers as the "ultimate reality," and uses precise ratios of integers to define a set number of musical intervals.[12] A hierarchy was also defined: the simpler the ratio, the more consonant the interval. Pythagoras's theories were not only significant for understanding music, but also for understanding the world in general. Wishart says "It

[11] For more discussion of these historical terms see Christensen (2002, 2–14).
[12] Mathiesen (2002, 114).

was the first clear demonstration that qualitative aspects of nature could be reduced (apparently) to simple numerical relationships."[13] After Pythagoras, Plato discussed different *harmoniai* (what we might today call modes) and their mimetic natures in *Republic*.[14] Later, the Aristoxenian line of thinking created many definitions and categories in an attempt to paint a complete picture of musical reality. These categories included genera, notes, intervals, scales, *tonoi*, modulation, and melic composition.[15]

Even this early in history, there was a divide between musical scholarship that focused on the abstract ideals of ratios as a means to help understand the world at large through *theory*, and musical scholarship that focused on ideals of musical *practice*. Yet an assumed part of *all* these ancient Greek traditions is the labeling of various musical pitches or intervals in some form, which is a discrete phenomenon of separation. From the earliest conceptions of music theory that we have recorded, sounds have been divided discretely into fixed things that are *being*, not *becoming*.

In the sixth century BC, Heraclitus articulated the ontological concept of becoming by saying that "all things are in flux."[16] His view of the world was that all things flow and change. This is in stark contrast with Pythagoras's view. Pythagoras "set in opposition to this ceaselessly changing world of sensible realities an eternal and incorruptible world."[17] He saw the world as static, and motion as an illusion.[18] In the

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[13] Wishart (1996, 45–46).
[14] Strunk and Treitlor (1998, 10–11).
[15] Mathiesen (2002, 120).
[16] Karatani (2017, 88).
[17] Ibid. (84).
[18] Ibid. (88).

nineteenth century, Hegel adopted the philosophy of Heraclitus and emphasized process in the concept of becoming.[19] In the twentieth century, Whitehead continued to build on Hegel's ideas in outlining a philosophy of *process*,[20] and Deleuze and Guattari discussed *flux* as "reality itself."[21] These ideas were adopted for theories and philosophies of music specifically by Adorno, Jankelevitch, and others,[22] before becoming more widespread in recent times.[23] For much of music theory's history in the West, however, the Pythagorean and Aristoxenian traditions of dividing musical objects into fixed entities have predominated.

The historical development of staff notation in the Middle Ages was also a function of this discrete theoretical thinking, and still unto today it propagates a specific kind of discrete bias in musical thought. Heller-Roazen says that the concepts in staff notation "rest on the principle that to be musically intelligible, sounds must be essentially discrete in quantity, like the old multitudes of arithmetic."[24] It is a part of the systematic discrete bias in music theory that Wishart calls "lattice sonics." Even though staff notation is based on discrete and quantitative principles like the ancient Greek music theories, its initial development and utilization in the Middle Ages created an even stronger separation between musical theory (which was based on medieval canonics, continuing in the Pythagorean tradition), and practice (the *cantus* tradition of Gregorian

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[19] Hegel and Miller (2004).
[20] Whitehead (1978).
[21] Deleuze and Guattari (1987, 361).
[22] Adorno (2002, 135–180); Jankélévitch (2003).
[23] Hasty (1997); Schmalfeldt (2017, 3–4).
[24] Heller-Roazen (2011, 47).

chants sung in church modes) that medieval scholars such as Hucbald and Guido had to reconcile.[25]

This reconciliation also happened in medieval Arabic music theory. Al-Fārābī was a proto-ethnographer in the tenth century who studied the musical instruments being used in folk traditions in an attempt to connect music theory with music practice.[26] He wrote about how native instruments worked and described their frets, which had intervals that did not always match the theoretically "perfect" ratios described in traditional music theory. Yet even though the voice was the primary and lead aspect of the musical traditions he was describing, Al-Fārābī specifically sought out instruments to describe in his studies because they were discrete and therefore easier to write about theoretically.[27] Analyzing vocal music based on the theories of its discrete accompanying instruments is a long-standing tradition that continues in the "keyboardification" of Western musical culture today.[28]

The voice is one "instrument" that is capable of easily producing continuous processes, and therefore it is hard to write about with discrete theories. It has been viewed as the epitome of continuousness and humanity, and "the supreme index of subjectivity."[29] Wishart says that vocal music, when it is not interfered with by hegemonic "lattice sonics," is "the most sensitive carrier of gestural information."[30]

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[25] Bower (2002, 158–164).
[26] Klein (2008).
[27] Klein (2018).
[28] Dolan (2012, 11–12).
[29] Mosely, 97.
[30] Wishart 17-18.

Recently, more theories of the voice have been undertaken, especially in the burgeoning field of sound studies,[31] but historically, music theory has used discrete instruments, staff notation, and writing (as opposed to speaking), as tools to uphold the hegemony of idealized, formalized, and fixed musical practice.[32]

In the Middle Ages, both the traditions of *musica theorica* and *musica practica* dealt mostly with discrete theories and discrete instruments. In the *theorica* tradition, the monochord was divided up into different string lengths in order to show the different integer ratios and their corresponding intervals.[33] In the *practica* tradition, staff notation and fretted instruments were used to establish systems of scales.

From the Fourteenth to Nineteenth Centuries: *Musica Theorica* becomes Continuous

Throughout the Middle Ages, the study of music theory (*musica theorica*) was taught as part of the Boethian quadrivium, along with geometry, astronomy, and arithmetic. Boethius, following Pythagoras and Aristotle (whose model was slightly different), divided the quadrivium into sciences that studied continuous quantities or "magnitudes" (geometry and astronomy) and those that dealt with discrete ones or "multitudes" (arithmetic and, notably, music).[34] It was not until the fourteenth century that sound was first posited as a continuous phenomenon by the French philosopher Nicole Oresme. In the second book of his *Treatise on the Configuration of Qualities and Motions* Oresme claims that "sonorous qualities are in truth of the order of magnitude,

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[31] Barthes (1977); Dolar (2006); Fink, Latour, and Wallmark (2018, pt. 2); Heidemann (2016); Moore (2012); Sterne (2012b, pt. 6).
[32] Wishart (1996, 11–17).
[33] Herlinger (2002).
[34] Grant (2013, 63–64); Moseley (2016, 79).

not multitude."[35] Heller-Roazen notes how revolutionary this was: "That principle called into question a thousand-year tradition, which maintained, by contrast, that, to be intelligible, sounds must be essentially arithmetical in kind. To define musical entities as magnitudes, not multitudes, was to overturn the foundations of the art of music."[36] Oresme was ahead of his time in thinking about magnitudes in terms of an infinite variety in degrees of intensity.[37] For him, this applied not only to musical pitch, but also volume and timbre.[38]

Over the next four centuries a broad change took place in musical and mathematical thought that reframed sound and especially pitch as continuous, not discrete, because it is made up of infinitely many divisions. In 1561, Zarlino wrote that the numbers representing pitches could be "multiplied to infinity."[39] In the seventeenth and eighteenth centuries music theorists divided the octave into more and more equal parts,[40] and eventually Descartes, Mercator, and Newton applied the newly-invented concept of logarithms to musical pitch, which implied that musical pitch was continuous and that a larger interval could be divided into infinitely many smaller ones.[41] These scholars made the notion of pitch as a continuous quantity implicit, but it was Johannes Kepler who first made a specific argument for the study of harmony to be reclassified as

[35] Heller-Roazen (2011, 53).
[36] Ibid.
[37] Ibid. (49).
[38] Ibid. (53).
[39] Grant (2013, 65).
[40] Wardhaugh notes that Kircher (1650), Rossi (1666), and Neidhart (1724) divided the octave into 24 parts, Rossi (1666) and Huygens (1691) into 31 parts, and Sauveur (1697) into 43 parts. Wardhaugh (2008, 37–39).
[41] Ibid. (43–56).

a continuous science and not a discrete one in his *Harmonice mundi* (1619).[42] Euler went even further, stating that the degree of consonance of an interval could also be described as on a continuum.[43] Kepler's profound reformulation of music theory as a continuous discipline was a change between seeing it arithmetically vs. seeing it geometrically.[44]

These views also reflect a broader epistemological change that gradually took place over the seventeenth and eighteenth centuries. Roger Matthew Grant summarizes this, stating:

> While knowledge in the burgeoning field of acoustics grew during the seventeenth century, the concept of number itself underwent a fundamental redefinition in mathematics. Whereas classical and Scholastic traditions held that number was a discrete quantity, seventeenth-century mathematicians and philosophers experimented with procedures that would have them consider number a continuous quantity—infinitely divisible between whole integers. This slow re-envisioning of the concept of number went hand in hand with the reception of algebra and the development of new techniques such as the quadrature of curves and the use of infinite series. These new techniques were simultaneously involved in new representations of musical knowledge—such as the statement of the harmonic series and the definition of consonance—and also played a role in the tumultuous battles that raged over matters in natural philosophy.[45]

Alongside these reformulations of the concepts of number and pitch, philosophers and mathematicians questioned the nature of space and time in general as either continuous or discrete. The atomist tradition of Epicurus says that space is a vacuum of empty space that is filled with small particles of matter (atoms), whereas the plenist tradition of Aristotle says that space is infinitely divisible and always completely full.[46]

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[42] Grant (2013, 66).
[43] Ibid. (70).
[44] Heller-Roazen (2011, 113–140).
[45] Grant (2013, 63).
[46] Ibid. (70–71); Heller-Roazen (2011, 131–140).

The two founders of calculus, Leibniz and Newton, had different opinions on this matter. Leibniz accepted neither position, although he did agree with the plenists such as Descartes that matter could be divided infinitely, while Newton explicitly rejected plenism.[47] Leibniz also firmly believed in digital binaries as a way of explaining the world, but his "binary thought was dialectically entwined with his principle of continuity, founded on the premise that noticeable perceptions arise by degrees from phenomena that are too minute to be registered, but that can nonetheless be divided into innumerable monadic constituents."[48]

It is noteworthy that during this time period the "keyboardification" of Western musical practice was growing stronger.[49] *Musica theorica* was becoming more continuous, but *musica practica* was becoming even more discrete. In fact, by the time Kepler was arguing for the study of harmony to be a continuous discipline in his *Harmonice mundi* (1619), there were already figured-bass treatises outlining general rules for how to harmonize a melody with a keyboard.[50]

In the eighteenth and nineteenth centuries this dichotomy was borne out in the development of acoustics and *Tonpsychologie* on the *theorica* side, and analytical models of tonality such as scale-degree theory and dualism on the *practica* side.[51] These models and systems of tonal analysis were highly discretized, with many of them utilizing Arabic

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[47] Grant (2013, 71–72).
[48] Moseley (2016, 76–77, 113).
[49] Dolan (2012, 4–7).
[50] Barnett (2002, 442).
[51] Some of the most important theorists of acoustics and *Tonpsychologie* during this time period were Helmholtz (1821–1894) and Stumpf (1848–1936). Some of the most important theorists of tonal models during this time period were Rameau (1683–1764), Weber (1779–1839), and Riemann (1849–1919). Christensen (2002, chaps. 9, 24, 25).

and Roman numerals for labeling scale degrees, intervals, and chords in a variety of ways.[52] Another example of a highly discretized system in contrapuntal theory is Fux's species counterpoint as outlined in *Gradus ad Parnassum* (1725), which, aside from explicitly mentioning discrete "steps" in the title, develops the five species of counterpoint step by step with strict rules.[53] Today, the discrete bias from these methods lives on since both species counterpoint and Roman-numeral analysis are hallmarks of contemporary Western music-theory instruction.

There were ways, though, in which the *theorica* and *practica* traditions informed each other and were in dialogue with each other during this time period. Even though the models for tonality were based on discrete principles, they depended on discoveries made by the *theorica* tradition using continuous mathematics. For example, Rameau and Capellen both based their theories of harmony on the foundations of the acoustic overtone series.[54] In the twentieth century, Hindemith and Schoenberg would do the same.[55] Furthermore, it was logarithms (which earlier had led to the reformulation of pitch as continuous) that led to the development of equal temperament as a standard for musical practice in the twentieth century,[56] and equal temperament allowed for enharmonic tonal equivalence,[57] which in turn led to practical models for tonality in the

[52] Damschroder (2008, chap. 1).
[53] Fux (1965).
[54] Christensen (2002, 253, 801).
[55] Hindemith (1941); Schoenberg (2010).
[56] Grant (2013, 68). For a comprehensive history of tuning and temperament from the eighteenth through the twentieth centuries, see Jorgensen (1991).
[57] Proctor (1978, 132).

musica practica tradition that are based on enharmonic equivalence, such as neo-Riemannian theory.[58]

So there are some connections between *musica theorica* and *musica practica*. However, from the fourteenth through nineteenth centuries, the relationship between the two traditions changed, because *musica theorica* became based on continuous mathematics and the understanding of sound as continuous waveforms, while *musica practica* was still based on highly discrete principles.

The Twentieth Century to the Present: Further Splintering into Two Worlds

This split has had even larger ramifications in the twentieth and twenty-first centuries. The study of sound as a continuous phenomenon that developed with the *theorica* tradition paved the way for the development of sound-reproduction technologies and electronic music in the late nineteenth and early twentieth centuries, when the widespread utilization of electricity fundamentally changed music and its creation as well as reception.[59] There are many books documenting the history of electronic and electroacoustic music,[60] so I will not review that in detail here, but it is important to note that with electronic music new methods of controlling and sculpting sound waves led to questions like: What are the various components of a single sound and stages of its realization? How can these components and stages be manipulated electronically? What

[58] Cohn (1998); Hyer (1995).
[59] Kittler (1999, 21–37); Sterne (2003).
[60] Chadabe (1997); Collins, Schedel, and Wilson (2013); Dodge (1997); Holmes (2012); Pinch and Trocco (2002); Puckette (2007); Schrader (1982); Théberge (1997).

is music and what is noise or "distortion?" Is music "real" and "authentic" if it is not performed live by a human?

The Theremin is a good example of an early-twentieth-century electronic instrument that raised these kinds of questions. The music produced on the Theremin is certainly performed by a human in the sense that frequency and volume oscillators are controlled by each hand, yet it is also eerily disembodied because the sounds are being created with electronic means and with no physical touches by the performer. Instead, continuous hand gestures through the air control the sound. Thus, in a sense the Theremin is the epitome of continuousness; like the human voice it is not easily bound by discrete "lattice sonics."[61] But unlike the voice, which is a symbol of humanity and authenticity, the Theremin symbolizes the uncanny and the alien. Perhaps this is because of its generally unstable frequencies, its apparent separation from the body, and its usage representing unfamiliar, uncomfortable, and/or unearthly situations in film music.[62] In any case, the noteworthy point here is that the Theremin is a highly-continuous electronic instrument, and that it was largely neglected by the Western art music tradition (after an initial short-lived boom)[63] and embraced by the film music community as a symbol of the uncanny.

When the Theremin was reaching its peak utility in Hollywood film scores in the 1950s, other types of electronic music were emerging, such as *musique concrète* in Paris

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[61] Pinch & Trocco also compare the Theremin with the voice, noting that both are controlled with continuous motion and produce continuous motion. Pinch and Trocco (2002, 14).
[62] Wierzbicki (2002).
[63] Ibid. (127–128).

and *electronische Musik* in Cologne. *Musique concrète*, as exemplified in the music of Pierre Schaeffer, utilized continuous processes significantly, manipulating the speed of sound recordings,[64] and although many composers of *electronische Musik* were interested in applying discrete serial techniques to electronically-produced music, some began utilizing the continuous manipulation of sounds as well.[65] Eventually, a large new branch of music was developed using electronic techniques such as analog synthesis. One particularly famous and important analog synthesizer was the Moog synthesizer. Although the instrument was named after Robert Moog, he had many collaborators when designing it in the 1960s. These collaborators ensured that the synthesizer was easily capable of both continuous and discrete processes, and that there were both continuous and discrete interfaces on the instrument. For example, Wendy Carlos urged Moog to include continuous pitch controls, and Herb Deutsch advocated for him to include a keyboard.[66]

Many who were working on experimental electronic compositions at the time opposed the use of the keyboard interface, but Moog and Deutsch recognized how important it was to the marketing of the instrument.[67] If the instrument was to have general appeal, consumers would have to see something they recognize and are familiar with, which was the completely discrete keyboard. According to Pinch and Trocco in their historical book on the subject, the inclusion of the keyboard interface was a huge

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[64] Schrader (1982, 15).
[65] Holmes (2012, 64–76).
[66] Pinch and Trocco (2002, 57–60).
[67] Ibid. (60–62).

part of why the Moog synthesizer succeeded and the competitor, Buchla's box, did not.[68] Moog himself also recognized the creative potential of the discrete keyboard interface for doing more than just producing one stable pitch, so in some ways his synthesizer was more like a reinvention of a pre-existing product.[69] Buchla's instrument encouraged the use of continuous musical processes more than Moog's, and it was favored by avant-garde composers for its precision and complexity, but it was not as versatile.[70]

The best of the original Buchla box and Moog synthesizers were combined in the Minimoog (first sold in 1970), which was extremely popular and influential.[71] This instrument utilized both Buchla's invention of the sequencer, and Moog's patented invention of the low-pass filter that gave his instruments their unique sound.[72] The Minimoog also included both a pitch wheel and a modulation wheel to the left of the keyboard (which has become the standard in almost all synthesizers to this day), and in later versions on/off switches for glide and decay.[73] With its combination of continuous and discrete interfaces and abilities, the Minimoog set a precedent for contemporary popular music and EDM in particular, which utilizes both continuous and discrete musical processes in very important ways, as shown in the previous two chapters. Thanks to the Minimoog, the world of electronic music continued to grow, and since the 1970s, it

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[68] Ibid. (309–311).
[69] Ibid. (60). The creative potential of the keyboard interface beyond producing individual pitches is also highlighted in Dolan (2012); Moseley (2016).
[70] Pinch and Trocco (2002, 44–47).
[71] Ibid. (214).
[72] Ibid. (42, 64–65).
[73] Ibid. (229).

has not only been used for artistic compositions performed in concert halls, but also in popular songs performed at clubs and festivals.[74]

All of these developments in electronic music have their origins in the *musica theorica* tradition, which recognized the continuous nature of sound in the preceding centuries. Contrastingly, the *musica practica* tradition for the most part continued to increase its levels of discrete "keyboardification" for music performance, composition, and analysis in the twentieth century. This tradition reached a formalist peak when both the composition and analysis of atonal and serial music became based on the principles that would eventually be articulated in pitch-class set theory. This system is based on the breaking down of traditional tonal hierarchies using the twelve unique "pitch-classes" of the equally-tempered chromatic scale in specialized combinations and permutations. In the first half of the twentieth century, the "second Viennese school" forged the path with free atonal works and then twelve-tone pieces, and then in the second half of the century Pierre Boulez in Europe and Milton Babbitt in America added new complexities to serialist composition.[75]

When electronic and electroacoustic music that incorporated the significant use of continuous processes was becoming more widespread in the 1970s thanks to synthesizers, the field of music theory was also burgeoning in North America. In 1977 the Society for Music Theory (SMT) was founded, establishing music theory as an independent

[74] For a history of how electronic music was first incorporated into mainstream popular music, see Brend (2012).
[75] There were many other important serialist composers of course. For a detailed history of set theory as an analytical tool for atonal music, see Schuijer (2008).

discipline from musicology that focused on the analysis of scores using discrete techniques like set theory and Schenkerian analysis.[76] The development of this field in North America is in large part due to the work of Allen Forte, who also authored the seminal book *The Structure of Atonal Music* (1973) that explicates much of the pitch-class set theory still used in post-tonal analysis today.

This discipline has largely separated itself from electronic music, so that two different worlds have emerged. Theories of electronic music and of continuous processes have mostly been left to composers and not music theorists, and the discipline of music theory in North America has marginalized this scholarship, as evidenced by the content of "flagship" journals in the field.[77] Subsequently, in many contemporary music theory departments, continuous aspects of music theory (such as the mathematics involved in acoustics and continuous transformations of sounds) are downplayed if taught at all.

The two worlds are grounded in different ontological and epistemological frameworks. In scholarship on the composition and analysis of electronic music, sound is perceived as fundamentally continuous. The basic unit is the periodic sound wave, which can repeat indefinitely, and continuous transformations of sounds (continuous processes) are readily recognized as a normal aspect of the music. In this framework, the discrete segmentation of sounds into notes, rhythms, loops, and samples is perceived as a "chopping up" of something continuous. Butler's ethnographic work with EDM

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[76] In the same year, the IRCAM institute for electronic music was founded. Born has shown how IRCAM institutionalized avant-garde electronic music, and how the IRCAM school of composers utilized "timbral transitions" and "continuous mutations of timbre." Born (1995, 194–202, 235–251).
[77] Duinker and Gauvin's corpus study shows that electronic music has been discussed very rarely in music theory journals and textbooks. Duinker and Gauvin (2017, paras. 6.6, 9.6).

musicians shows that they perceive sound this way, as a continuous phenomenon that "runs" on its own until it is "played with."[78]

Contrastingly, most traditional scholarship in the discipline of music theory and analysis is grounded in an ontology and epistemology of discreteness. From this perspective, sound and music is fundamentally (not secondarily or by choice) divided into discrete units such as pitches and rhythmic values that can be grouped together to form scales, melodies, harmonies, measures, motives, themes, etc. The scores that represent music in this way through staff notation are also divided according to different instruments and "timbre classes."[79] A typical analysis within this ontological framework could discuss the function of "the quarter-note B in the first violin in m. 4." This makes four discrete classifications, and exemplifies lattice sonics as Wishart describes it.[80]

The cultural foundations for these two separate worlds can be seen in two different narrative trajectories for music that were postulated in the mid-twentieth century. Speaking of the inordinate number of new possibilities with electronics, the musicologist H. H. Stuckenschmidt (1901-88) called electronic music the "Third Stage in the aesthetic history of music" after vocal and instrumental music.[81] In 1955 he said "Music has developed further and further away from its human origins; now, at what we define as its Third Stage, the Electronic, we are astonished and not without pride, to have before us an art, totally controlled by the spirit of man, in a way not previously

[78] Butler (2014, 105, 219–223).
[79] Wishart (1996, 8).
[80] Ibid.
[81] Holmes (2012, 154).

imaginable."[82] This historical narrative is interesting because it contrasts with an alternative story of musical "evolution" put forward in the twentieth century by Donald Tovey and others, which chronicles the development and dissolution of tonality, culminating with serialist music.[83] The contrast in teleological views here reflects the polarization between the two worlds I have been discussing.

However, it is also important to note that in the late twentieth century electronics and electronic music became less and less separated from discreteness, at least in terms of its technical means of production. The development of computers and their inherent digitalization meant that electronic music could also be digitized, as is the case with digital synthesizers and MIDI instruments.[84] So the mapping between electronic vs. acoustic and the continuous vs. discrete binary is far from perfect. In this context it is interesting to note that much of the pitch-class set theory we use and teach today was initially formulated for computer-aided analysis in the 1960s.[85] This is why the language of set theory is like that of a computer program, with specific "operations" that transform one set into another.

Nevertheless, unlike in traditional North American music theory and analysis, in the performance, composition, and theory of electronic music, even if it is digital, continuous processes are not ignored and also not seen as an "issue" that needs to be explained. They are other options for musical processes that provide more variety and

[82] Ibid.
[83] Hyer (2002, 745–746).
[84] Holmes (2012, 269–346); Théberge (1997).
[85] Schuijer (2008, 236–250).

different aesthetic possibilities than discrete processes like clear melodies and rhythms. The representation and understanding of continuous processes geometrically (which will be explored further in the next chapter) is a normal part of compositional and analytical practice for electronic music. In the music-theory world, however, geometric shapes have been used far more often to represent abstract connections between discrete nodes of pitches or rhythms, rather than real sounding connections between the nodes.[86]

Breaking Down the Barrier between Continuous and Discrete Thinking

In some ways this splitting of worlds is similar to the momentous divide in physics between quantum mechanics and general relativity, which also took place in the twentieth century.[87] The former views the world and its processes as discrete and quantized, while the latter describes the world continuously, existing in a space-time continuum. These contrasting theories are the descendants of atomism and plenism, respectively. In fact, this dichotomy between discrete and continuous ways of thinking has been hypostatized in many forms throughout history, including the terms digital and analog.

In the last few decades the binary between digital and analog sounds has been cemented in the minds of audio engineers, producers, DJs, and the like. Although the etymology of the terms suggests that something which is "analog" is an analogy for the real based on our sensory perceptions of it, in modern times digital sound has come to be associated with a mere approximation of the analog thanks to Lacan, Kittler, and Sterne.[88]

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[86] Cohn (1996); Lewin (1987); Toussaint (2016); Tymoczko (2011).
[87] Petkov (2007).
[88] Moseley (2016, 84).

For example, digital synthesizers can only approximate the true sine waves that analog synthesizers (such as the Moog) can create.[89] There is still a debate, however, about whether the stimuli in the world are digital and our perception of it is analog, or the world is analog and our perception of it is digitally quantized.[90]

What I am trying to suggest is that music theory today has positioned itself firmly in one camp of the dichotomy, viewing the musical world as fundamentally comprising discrete units. Instead our discipline should be taking the best of both camps, and utilizing both discrete and continuous analytical techniques to discuss both discrete and continuous processes in not just acoustic but also electronic music in all its forms.

However, at the same time as I am upholding this dichotomy, I also want to break it down and emphasize that it all comes down to perception. If one views the world through the lens of atomism, then everything in music, even pitch slides on a string instrument, will be considered to be not only made up of individual parts but also constituting one individual part of a larger whole. On the other hand, anything, even the turning on and off of a light switch or the sudden sounding of a short musical note, can be viewed as continuous at some infinitesimal level because it takes place in time, and the

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[89] Digital audio is predominant in the industry today, but some EDM artists still have a preference or even a fetish for the analog rather than the digital, because it is viewed as more authentic. This is evidenced in Deadmau5's masterclass when he uses digital instruments for most background instruments but for important featured sounds he highly prizes the originality of techniques created through continuous motions involving knobs and sliders on an analog synthesizer. Knowing that the sounds cannot be replicated by any digital synthesizer is important for him. "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 8).

[90] Moseley (2016, 70).

process only seems to happen instantaneously because we do not live our lives in slow motion.

This apparent paradox is explained nicely with Heisenberg's "uncertainty principle" in quantum physics, which states that "the position and momentum of a particle cannot both simultaneously be known exactly."[91] Viewing the world with everything as discrete and atomistic is akin to only knowing the position of something, whereas viewing the world with everything as continuous is akin to only knowing the momentum of something, and not its exact position, because things would be always moving in the continuum.

Every day we subconsciously make decisions about which procedures/processes to interpret in discrete, separated parts, and which procedures/processes to interpret in one continuous whole. Some musical processes are much more likely to be perceived as continuous or discrete than others, and therefore the dichotomy is worth upholding, as I am doing for my analytical methods in this dissertation. However, the perception can be influenced by a variety of factors, including the philosophical viewpoint of the perceiver, the visual representation of the sounds, and the interfaces and technologies we may interact with in order to create the sounds and listen to them.[92] It becomes confusing when musical processes that sound discrete can be created with continuous gestures like physical or virtual swipes or slides, and processes that sound continuous can be created with discrete methods like turning an on/off switch or typing integers into a computer.

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[91] Wishart (1996, 54).
[92] Latour (1987).

Furthermore, it is important to recognize that there are many musical processes which are difficult to clearly interpret as either discrete or continuous, and this is especially relevant for electronic music, as evidenced by the discussion on micro-rhythm in the previous chapter.

Electronic music that is produced digitally *reveals* these truths because in that world, as producers know, there is an easy back-and-forth flow between arithmetic (which was part of the discrete multitudes in the Boethian quadrivium) and geometry (which was part of the continuous magnitudes in the Boethian quadrivium). In digital music, integers easily convert into lines or curves and vice versa. In this world, arithmetic and geometry produce the same sonic results and therefore can be thought of as the same thing. Mosely breaks down the binary between digital and analog through what he calls "digital analogies,"[93] and in the same way I am attempting to break down the binary between discrete and continuous by showing that in EDM there are important musical techniques that are clearly discrete, clearly continuous, and those that are neither, falling somewhere in the discrete–continuous continuum.

Conclusion

Why do we as music theorists often ignore continuous processes in analysis and view music as fundamentally discrete? As outlined above, there are many historical and cultural reasons for this, and those who are trained in electronic music production do not

[93] "Caught between these seemingly unanswerable questions, we find ourselves bound once more by the binary logic of either-or. Thinking in terms of digital analogies, however, we might apprehend digitality by sliding it along a continuum that registers its metaphorical, musical, and mathematical meaning, which will in turn reveal how digital processes can elucidate the techniques by which analogies are materialized, embodied, and collated." Moseley (2016, 70).

ignore continuous processes as much or actually focus on them. However, there are also psychological reasons why we have a tendency to ignore continuous processes and discretize everything in musical analysis. This concluding section attempts to answer three questions: 1) Why are we as humans so inclined to be discrete when thinking about, aurally processing, and analyzing music? 2) Why is this a problem for music analysis, especially of electronic music that significantly utilizes continuous processes? 3) How do we fix this problem?

Continuous processes are intuitively understood visually when represented with geometric lines and shapes that have no breaks or tiered steps. However, some techniques that I am calling continuous may be more naturally aurally perceived as continuous than others. Pitch is not inherently divided up into discrete intervals, but our human brains naturally divide the infinite variety of frequencies into categories of discrete pitches. We group frequencies that are very close to each other (within the same "critical band") into one category that we call one pitch.[94] Tan, Pfordresher and Harré put it this way: "Frequency is a continuous variable, with an infinite number of possible values, and so it would be inefficient for our auditory system to respond selectively to every possible value. So instead, it seems that our auditory system responds similarly (e.g., with a similar cochlear response) to frequencies in close proximity to each other."[95]

We have also created systems out of these divisions and incorporated them into both musical theory and practice. There is no system of pitch divisions that is inherently

[94] Tan, Pfordresher, and Harré (2018, 31).
[95] Ibid.

"truer" or "more accurate" than others. It is true that the harmonic partials of a fundamental frequency can be used to create a series of intervals that is "natural" because the overtones are integer multiples of the fundamental, and this is the basis of just intonation.[96] However, there are many different systems of musical tuning, each of which has been devised by humans through the imposition of discrete theory onto sounds.[97] Ethnomusicology has shown that there are a multitude of musical scales that are seen as "natural" in different parts of the world, each of which divides larger intervals into smaller ones in a discrete manner.[98] This makes it all the more interesting that some people develop absolute pitch associated with specific "chroma" that correspond to the equally-tempered chromatic scale used in Western music and music theory.[99]

The continuum of frequency, measured in hertz (cycles per second), can also be used to link the concepts of rhythm, pitch, and timbre. Perceptually, rhythms turn into pitch around 20 hz (cycles per second), and pitch turns into timbre around 4,000 hz. [100] This means that when we hear a continuous increase in frequency from 0 hz to 5,000 hz, even though it could be framed theoretically as one continuous acceleration, it would be perceived by a human as two separate continuous processes: first an acceleration into seemingly "infinite" tempo, then a pitch ascent into a seemingly "infinitely high" pitch.

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[96] Jorgensen (1991, 10); Rasch (2002, 198–201).
[97] For a fuller explanation of different tuning systems throughout history, see Jorgensen (1991); Rasch (2002).
[98] There is a long history of describing the scales of various non-Western nations in ethnomusicology, dating back to Ellis (1885). Recently, Justus & Hutsler compiled a list of tonal systems and scales of various regions of the world. Justus and Hutsler (2005, 13).
[99] Tan, Pfordresher, and Harré (2018, 86–87).
[100] Above a certain frequency threshold (about 4,000 hz) we cannot perceive differences in "pitch," but "frequency information above this threshold can be very important in our perception of timbre." Wishart (1996, 53–54).

Many electronic pieces explore the boundaries between the separate concepts of rhythm, pitch, and timbre through continuous processes.[101] These relationships are not intuitive to us, however; they are not easy to understand. It is easier to separate things into categories, as we usually do in music analysis.

On a smaller scale, in order for a pitch to be perceived as changing continuously, the frequency must change by a certain number of (equally-tempered) semitones per second, and this is the "glissando threshold" that was briefly discussed in the previous chapter.[102] If the pitch does not change enough, or changes too quickly, then the process will not be perceived as continuous. In the latter case a discrete process will be perceived.

What about other continuous processes involving changes to volume, timbre, spatialization (e.g. panning), or attack length/articulation? The neuroscientist Aniruddh Patel, who researches the similarities and differences in how human brains perceive music vs. speech, writes that pitch changes in music and timbre changes in speech are more easily discretized and placed into different categories than volume changes, which are more easily perceived as continuous (to say nothing of spatial processes like panning).[103] It makes sense intuitively that volume changes are more easily perceived as continuous because their method of production usually utilizes a very fine scale of increments. Within one sound layer with a distinct timbre, crescendos and decrescendos

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[101] Probably the most famous of these is *Kontakte* by Stockhausen (1958).

[102] Based on the information from several empirical studies, Hart et al. define the glissando threshold as $g_{thr} = 0.16/T^2$, where g is the minimum number of semitones per second that need to be moved in order for the pitch movement to be considered a glissando, and T is the timespan of the glissando in seconds. Hart, Collier, and Cohen (1990, 32).

[103] Patel (2008, 86).

that gradually change volume in small increments are much more common in music, and especially EDM, than obvious shifts like "terraced dynamics."

Patel also states that there is a debate among psychologists today about whether rhythm is naturally discretized into "rhythmic classes" like pitch is.[104] This fits with my discussion of the accelerations and decelerations heard in the previous chapters, since most are perceived as truly continuous but some are perceived as discrete at a fine level. In other words, rhythm and tempo changes can sometimes be "predictable" in their rate of change because our brains can perceive the process in discrete steps, whereas other times the changes are at too fine a level to be interpreted as separate events and we perceive them together as one process using Gestalt psychology. Even in accelerations that are perceived as continuous however, the tactus pulse can discretely switch to a rhythmic value that was twice as long as before.[105] For example, in "Fn Pig" (discussed in chapter 2) the original tactus pulse eventually became an eighth-note subdivision in the middle of a continuous acceleration.

Changes to other parameters that can be altered in EDM such as attack length or articulation can also be difficult to discuss as either clearly discrete or continuous. For example, the topics of "onset detection," where an "attack" is, how long it is according to both humans and computers, and what changes to attack length mean, have been explored

[104] Ibid. (124).
[105] London (2012, 30–46).

in musical-scientific research and these questions fall under the category of micro-rhythm that is at the middle of the continuum between discrete and continuous.[106]

In fact, even though some musical parameters are more easily perceived as continuous than others, with electronic technology it is possible to conceive of changes in any parameter as discrete or continuous if they are made that way obviously enough. I hope to have shown this with many examples in the previous chapters. As stated at the end of the previous section, in digital music the integers used in arithmetic easily convert into the lines and curves used in geometry. Nevertheless, our tendency to discretize and categorize musical processes remains strong due to our innate psychology.

It is this psychological tendency that led to staff notation in the Middle Ages, to keyboardification and our lattice-based analytical systems in the seventeenth–nineteenth centuries, and to computerization in the twentieth century. Even in the nineteenth century the relationship between the discretization of music (specifically pitch) through our bodies (our brains and our ears) and the keyboardification of musical culture was clear to some thinkers. As Mosely writes:

> For Ernst Kapp, in whose philosophy of technology all tools and media were apprehensible as prosthetic projections of their physiological origins, Helmholtz's anatomical explanation of music's Pythagorean mysteries revealed that *the key to the form and function of the modern piano had been held all along as a secret within the innermost recesses of the ear*. If Helmholtz were right, music would prove to be a hidden arithmetic exercise of the body rather than the soul.[107]

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[106] Brøvig-Hanssen and Danielsen (2016); Danielsen (2010); Gifford and Brown (2008).
[107] Moseley (2016, 111). Emphasis mine.

The last part of this quotation is noteworthy because the distinction between arithmetic and geometry is similar to the distinction between discrete and continuous mathematics, and as shown in the history section above, these concepts were linked. It also draws a distinction between Helmholtz and Leibniz, whose famous definition of music was "a hidden arithmetic exercise of the soul, which is unaware of its own counting."[108] Perhaps somewhat humorously, a parallel distinction can be made between Helmholtz, who trusted the body completely, and Pythagoras, who (according to Heller-Roazen in the first sentence of the first chapter of his book), "knew not to trust his ears."[109]

The cognitive discretization that I have been discussing can be problematic however, because it easily leads to a hegemony of lattice-based systems that creates a significant problem for the analysis of continuous musical processes, which have important roles in many styles of music. Lattice systems cannot easily explain how continuous processes work by breaking them down into their components. According to our analytical system built on staff notation, there is no difference between a glissando in the voice and a glissando on the keyboard. Using our lattice-based system, we cannot make sense of pitch rising so fast that it breaks all of our categories by fluidly moving in between them. The only way that our discrete pitch system can describe this is as a movement between two nodes.

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[108] Rehding et al. (2017, 222).
[109] Heller-Roazen (2011, 11).

It is difficult to process things that are constantly changing except as one continuous gesture moving from point A to point B. For example, a pitch slide – whether it is a portamento used in a Mahler symphony or part of a riser in an EDM buildup – is easily understood as a single continuous gesture, because of Gestalt principles and the brain's natural tendency of chunking and "recoding."[110] This leads us to making sense of continuous movement between discrete nodes analytically with geometry (which will be the focus of the next chapter).

Yet even though continuous processes are easily understood geometrically, they are uncomfortable to experience in any aspect of life because when things are constantly in motion there are no points of rest or stability. Meyer notes that "the mind is constantly striving toward completeness and stability," and that there is a "tendency of the mind toward regularity and simplicity of organization."[111] When you are in the middle of a period of continuous change or movement, there is often no clear end goal in sight or no indication of when you will arrive at a goal. Walking step-by-step on the ground is much more comfortable than free-flying through the air after jumping out of a plane. Adrenaline is a powerful hormone, however, and many people seek out the thrill of skydiving to get an adrenaline rush. The oscillation between being comfortable and uncomfortable, stable and unstable in varying degrees is an important part of life, and this is mirrored in all kinds of music. In EDM, continuous processes significantly contribute

[110] Bregman (1990, 133–136); Miller (1956, 93–95).
[111] Meyer (1956, 87).

to this oscillation (as will be discussed more in chapter 6), for example in risers that lead to beat drops.

Understanding various historical, philosophical, and psychological perspectives on continuous musical processes (such as the ones that have been discussed in this chapter) can encourage us to move beyond the discrete bias and recognize why continuous processes are an important part of various kinds of music, especially electronic music. Part of how we fix the problem of the discrete bias in music analysis is by making sure that musical theories and practices are mutually informed. By recognizing that both discrete and continuous processes play significant roles in EDM (the focus of chapter 6) and applying analytical tools such as geometric graphs (the focus of chapter 5), this dissertation attempts to overcome part of the discrete bias in music theory and work towards the balance between discrete and continuous methodologies that Wishart called for in the block quotation that started this chapter.

Chapter 5 – Geometric Shapes of Continuous Processes

Music is inherently processual. It exists in time and often has multiple processes going on at the same time with different rates of change, such as short processes within a measure and long processes that take place during an entire piece.[1] Butler says that compared with other styles of music, EDM has a "heightened emphasis on process," especially with regards to the construction of meter.[2] One important type of process in EDM is what Spicer has termed "(ac)cumulative form," where instruments are added one by one into the texture, building up stratified layers. This is an example of a discrete process, but as has been shown in the previous chapters of this dissertation, continuous processes are important in EDM as well. They can be used as parts of long "risers" or as short "effects" that have varying degrees of salience, as shown in chapters 2 and 3. Another interesting way to discuss continuous processes and their aesthetic impact is through *shapes*.

Thinking about music visually and geometrically with various shapes has been an important part of music theory throughout history. However, most of the visual representations have focused on connections between discrete nodes of pitches, chords, or keys, since music theory has a bias toward the discrete as discussed in chapter 4. Julian Hook provides a useful historical overview of these visual representations in his paper "Hearing with our Eyes: The Geometry of Tonal Space."[3]

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[1] These ideas have manifest themselves in many ways in music theory throughout history. For example, in Schenkerian theory, a $\hat{3}$-$\hat{2}$-$\hat{1}$ descent can take place within a measure and also over an entire piece.
[2] Butler (2006, 111, 201).
[3] Hook (2002).

The use of visual depictions other than staff notation for music has become even more popular in recent decades of music-theory scholarship, particularly in transformational theory as developed by David Lewin and his successors. This system is built on discrete set theory, focusing on the relationships or "intervals" between objects in sets. Lewin laid the groundwork for discussing sets not only of pitches but of rhythms, timbres, and other phenomena that can be easily (if not always most accurately or effectively) classified into discrete categories. In transformational theory and other discrete representations of music, the lines connecting the points in the geometric shapes do not represent sounding musical processes, but are only abstract notions of connection between discrete points on a lattice. Figure 5-1 reproduces Figure 3 from Lewin's seminal 1992 article, showing how he connects two passages in analysis because they are isographic in shape under his system. Figure 5-2 and Figure 5-3 show other, more recent examples of discrete visual models based on transformational theory.

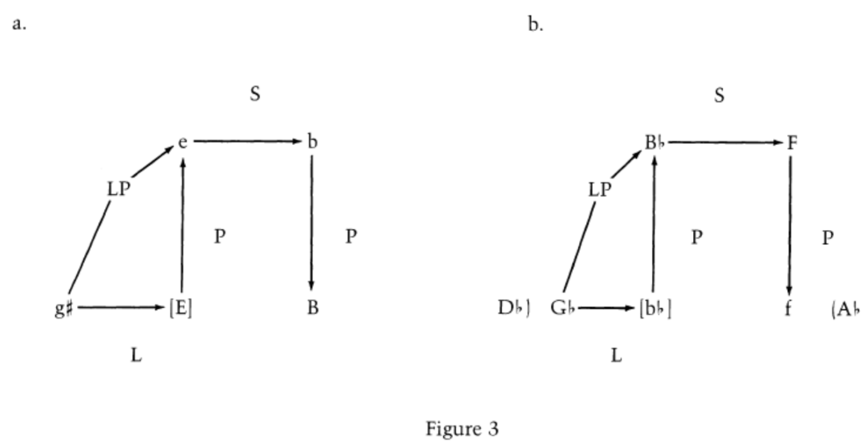

Figure 5-1: Reproduction of Figure 3 from Lewin (1992).[4]

[4] Lewin (1992, 52). This figure shows the "isographic" connection between two passages in Wagner's *Das Rheingold*. They are represented by the same shape in this system because the harmonies in each passage undergo the same neo-Riemannian transformations in the same order.

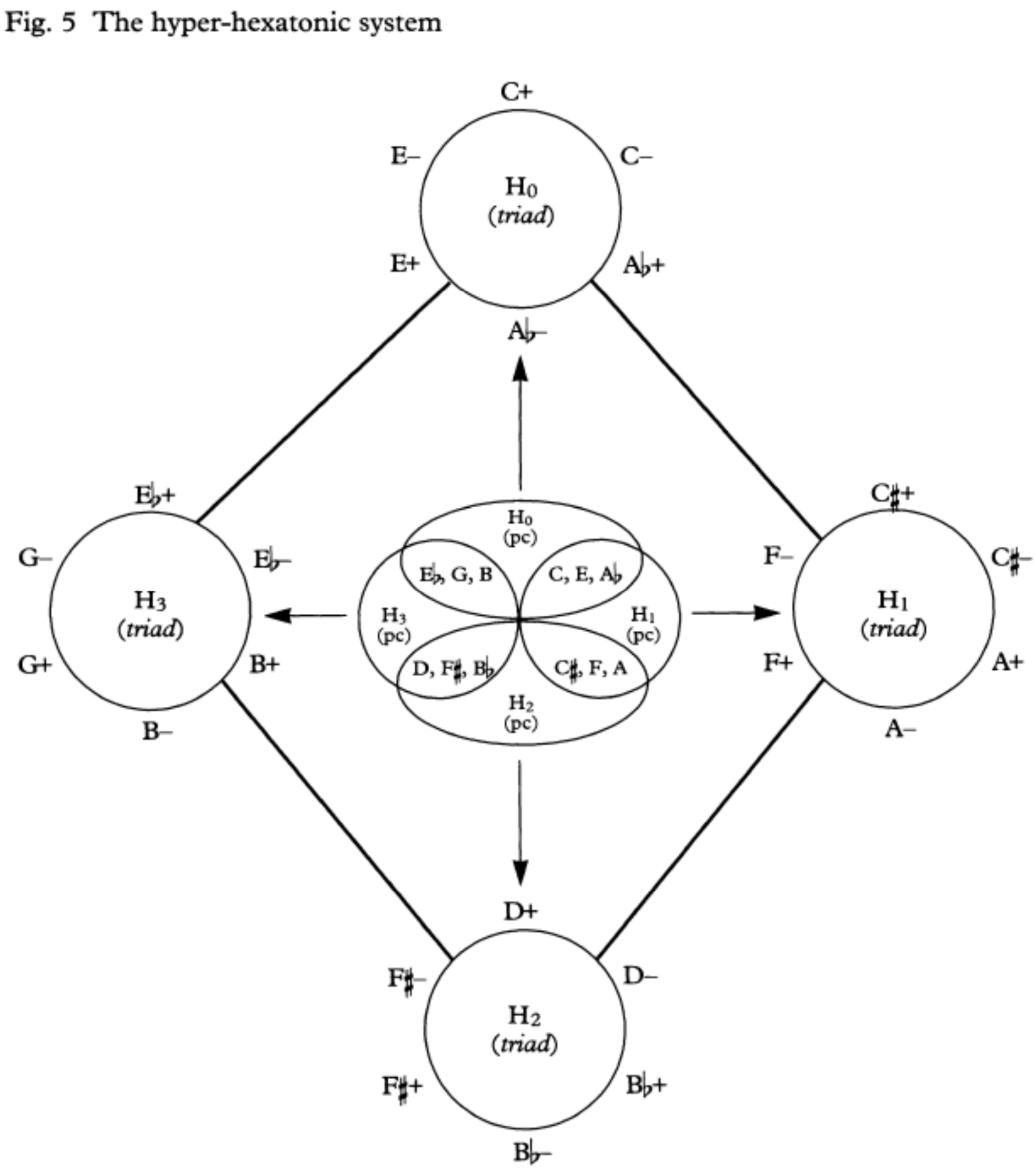

Figure 5-2: Reproduction of Figure 5 from Cohn (1996).[5]

[5] Cohn (1996, 24). This figure shows Cohn's "hyper-hexatonic system" that combines the four hexatonic systems of major and minor triads (on the periphery of the figure). All the pitch classes used in one hexatonic system form one of the four hexatonic collections, shown in the middle of the figure.

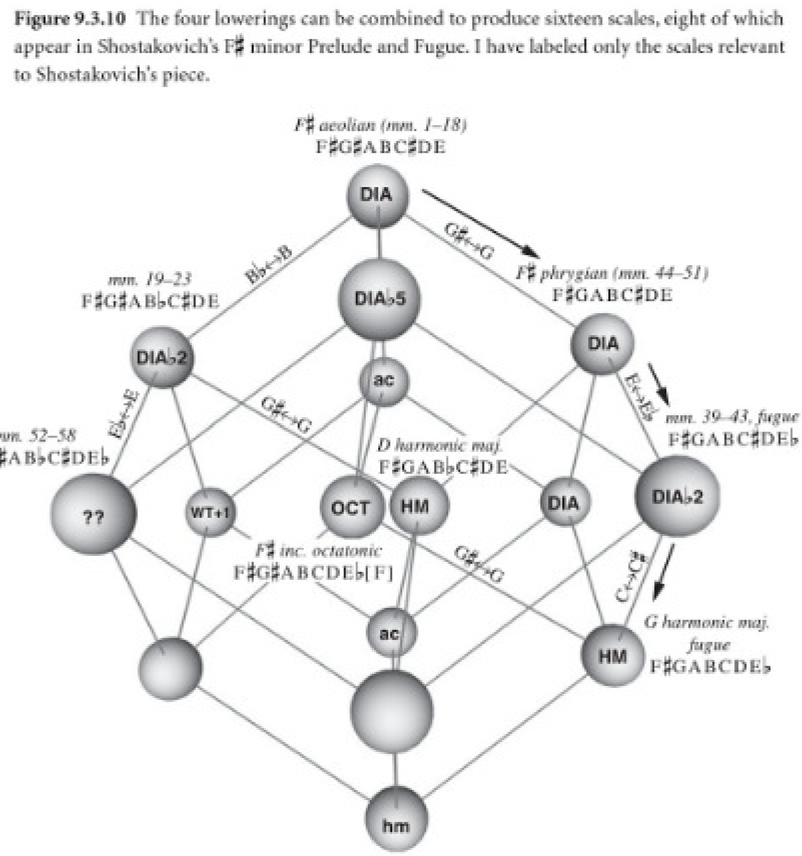

Figure 5-3: Reproduction of Figure 9.3.10 from Tymoczko (2011).[6]

Another method that uses continuous shapes to represent abstract connections between discrete nodes of pitch or rhythm was developed by Cogan & Escot in 1976 and can be seen in Figure 5-4. Roig-Francoli calls this a "spatial grid graph."[7] It utilizes a grid where discrete rhythms are represented horizontally and discrete pitches are represented vertically. Figure 5-5 is slightly different, with vertical steps representing rhythmic

[6] Tymoczko (2011, 330). This figure shows a four-dimensional tesseract with sixteen nodes (vertices) that each represent a different scale derived by lowering one of the pitch classes of the F-sharp natural minor scale by a semitone. Tymoczko uses the tesseract to show the similarities between eight different scales used in Shostakovich's F-sharp minor Prelude and Fugue.

[7] Roig-Francolí (2017, 54).

activity but no specific measuring tool that is consistent and thus no squares in a grid. In both cases, these graphs still work firmly within the discrete analytical tradition that analyzes scores, but they use ascending and descending continuous lines to indicate processual change.[8] These kinds of graphs were later adopted by Bernard (1981), Roig-Francoli (2008), and Mailman (2013).[9] These graphical methods are closer to the use of lines and curves that I will be implementing in this chapter than other methods in the "transformation theory" tradition described above, but they still do not describe continuous processes in the way that I define them for this dissertation in electronic music.

[8] For more examples from this book see Cogan and Escot (1984, chaps. 1, 3).
[9] Bernard (1981, 15–23); Roig-Francolí (2008, 290); Mailman (2013, 135). Similar techniques were also used in Berry (1976).

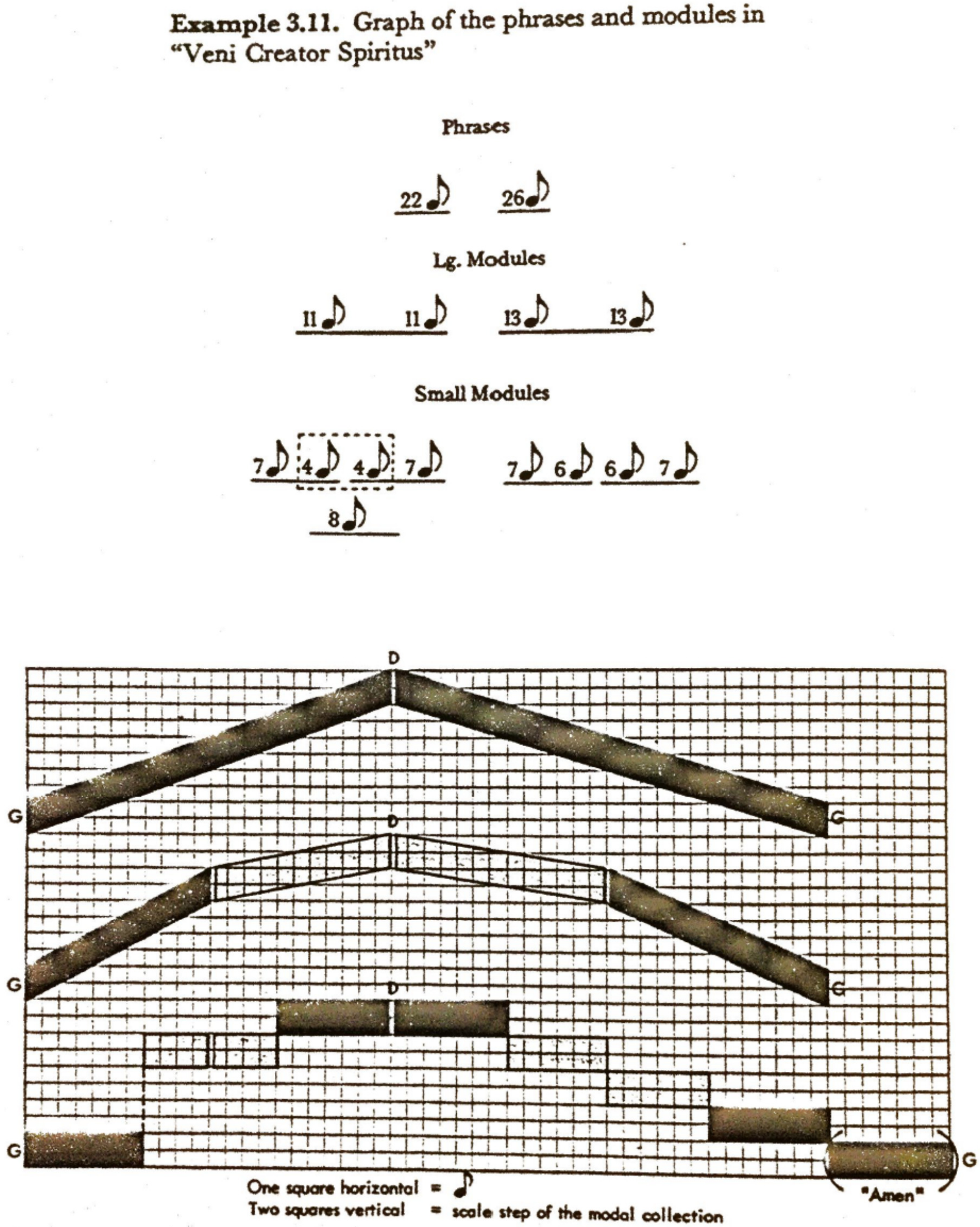

Figure 5-4: Reproduction of Example 3.11 from Cogan (1984). [10]

[10] Cogan and Escot (1984, 246). This figure is reproduced from the second edition but the first edition was published in 1976. The graph shows the phrase structure of the Gregorian chant "Veni Creator Spiritus" in

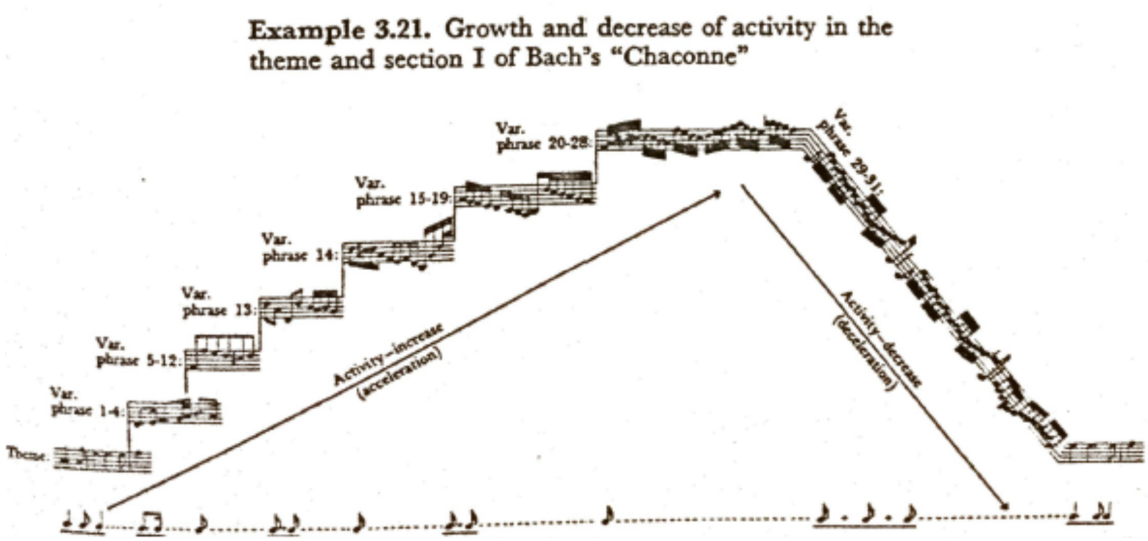

Figure 5-5: Reproduction of Example 3.21 from Cogan (1984).[11]

The graphical methods of composers such as Trevor Wishart come much closer to representing continuous processes the way this dissertation does. In Wishart's book *On Sonic Art* he explains his theoretical ideas about music and uses lines and curves to specifically talk about continuous processes.[12] He developed a series of shapes and symbols that he uses as graphic notation in his compositions and analyses.[13] His method of notation separates sound objects from sound processes. Describing this system, he says "I have developed a number of notation conventions which are particularly useful for

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three hierarchical levels. Closest to the surface is the bottom level, which takes one pitch in each small module as the primary pitch and graphs that pitch on the vertical scale. The middle level shows four sections. The top level condenses the chant into two phrases, one that ascends from G to D and one that descends from D to G. In the top and middle levels the ascents and descents are shown with continuous lines.

[11] Ibid. (263). This figure shows the increase and decrease in rhythmic activity with each variation in Bach's "Chaconne" in D minor. The increase in rhythmic activity is labeled as an acceleration and represented with a continuously ascending line, and the decrease in rhythmic activity is shown as a deceleration with a continuously descending line.

[12] Wishart (1996).

[13] Ibid. (96–102, 119, 124). Graphic notation has also been used in similar ways by many other composers. For a compilation of graphic scores by various composers see Sauer (2009).

dealing with continuum phenomena and unstable acoustic objects. These notation conventions may be applied both to long-term transitions in the timbre (or in fact in any) field and also to the detailed, inner articulation of brief sound-objects."[14] This sets a precedent for analyzing both long and short continuous processes and their changing shapes, or as Wishart terms it, their "dynamic morphologies."[15] Wishart also lists a useful set of gestural archetypes for "first order" and "second order" morphologies, shown in Figure 5-6. The former includes archetypes of change such as increasing, decreasing, stable, unstable, increasing-decreasing, stable-unstable, etc. The latter includes only three archetypes: direct, accelerating, and decelerating, based on the rate of change of the first-order morphologies.

[14] Wishart (1996, 96).
[15] Ibid. (93).

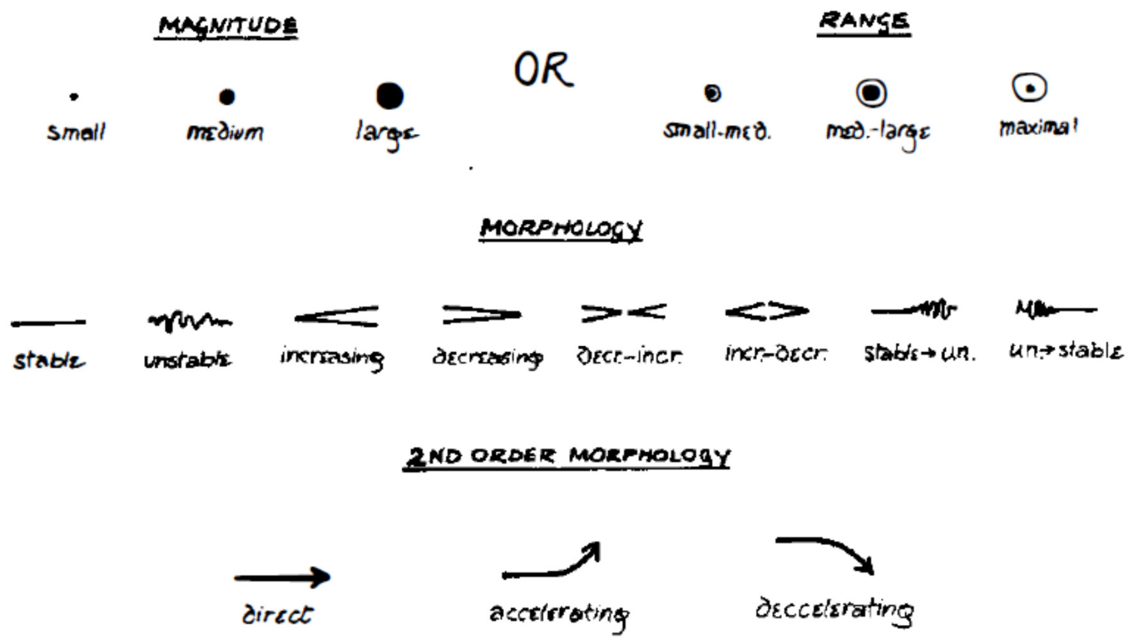

Figure 6.5 Morphological archetypes for gestural articulation.

Figure 5-6: Reproduction of Figure 6.5 from Wishart (1996).[16]

This chapter will focus on the general shapes of continuous processes in EDM in a manner similar to Wishart, but including concepts from differential calculus to show how certain types of curve shapes have different effects than others when used for continuous processes. These concepts will be explained in the first section of the chapter. The next section analyzes the shapes of continuous processes in several excerpts, discussing which curve types are more common than others for processes that change different parameters and are different lengths. Following this, three new guidelines for comparing the salience of continuous processes are outlined and applied to musical examples. Guidelines 6 and 7 have to do with a continuous process's *length* of time (represented by distance on the x-axis in two-dimensional graphs), and *depth* of change in

[16] Ibid. (119–120).

parameter (represented by distance on the y-axis). Guideline 8 compares the *rates of change* of continuous processes (represented by the slope of lines or curves, utilizing both the axes), saying that a continuous process is more salient when its rate of change is faster than when it is slower. For processes with non-linear shapes, this helps explain why they become more or less salient over the course of their length. The concluding section briefly discusses the more general aesthetic implications of the various shapes shown in this chapter, and how they are applied in other repertoires of music and other arts.

I will also discuss the techniques used to create the different shapes in the excerpts analyzed, when it is relevant to the perception of the music. For example, the shapes of long continuous processes are usually determined by automation curves, but the shapes of short continuous processes that repeat periodically are often determined by the shape of the low-frequency sound wave used in LFOs. In these cases the shape of the processes can significantly impact not only salience, but also perceived rhythm, articulation, and the discreteness or continuousness of short repeating gestures. Since I do not have access to DAW files of the tracks I am analyzing, however, I have created my own graphs based on how I hear the music in most cases, and also used spectrograms or amplitude graphs when appropriate, such as for analyzing the shapes of filter sweeps or crescendos. There may be cases where the way I hear it is different than the way the computer "hears" it and the DAW represents it, and there are certain situations where I know there is a mismatch and they will be interesting to discuss as they come up. The geometric analysis in this chapter provides another way of thinking about continuous processes and their utilization in contemporary EDM, in addition to the categories discussed in chapters 2 and 3 and the formal functions that will be discussed in chapter 6.

The Visual Representation of Continuous Processes: A Variety of Mathematical Shapes

Continuous processes can be visually represented by lines and curves in two-dimensional space, where time is on the x-axis and another parameter such as frequency or tempo is on the y-axis. Many continuous processes are created with these representations in DAWs, using automation curves or LFO tools as referenced in previous chapters. Automation curves automatically (that is, not manually but according to pre-programmed directions) change a musical parameter pertaining to one sound layer.[17] The parameter changed can be anything the DAW can manipulate, leading to a huge variety of possibilities, and of course a composer could add many different automation curves to one sound layer or many sound layers.

Automation curves can be in any shape, including preset ones or ones created by manually dragging the curve around with the mouse.[18] They can create changes for any sound channel(s), and for any parameter(s) or even threshold limits. The shapes that are created, especially for continuous processes that are prominent in the track, significantly influence the aesthetic impact of the music. Specifically, the shapes of the curves affect the rate of change for the continuous processes and therefore affect their salience.

[17] For an in-depth discussion of automation curves by a producer, see "The Joy Of Automation" (2015).
[18] As shown in this video (around 2:35), the preset shapes in FL Studio (another DAW) include "smooth," "single curve," "double curve," "stairs," "smooth stairs," "pulse," "wave," and "half sine." https://www.youtube.com/watch?v=_FhYmrp4Too. In The Mix (2018).

We can never know all the specific types of curves used since they can be customized, however based on the rate of change that we hear their shapes can be discussed in general terms. Most continuous processes used in EDM behave in at least some sense like linear, exponential, sinusoidal, or sigmoidal functions. Basic graphs of these functions and their derivatives are in Figure 5-7a–d. The derivative functions are important because they represent the rate of change (the slope of their tangent lines) of the original functions, as described in differential calculus.

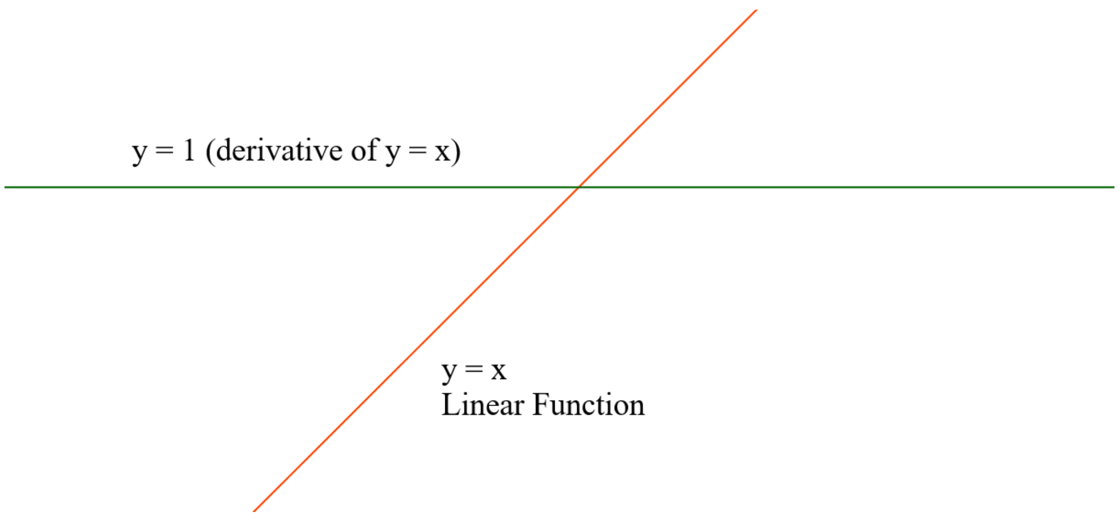

Figure 5-7a: A simple linear function and its derivative.

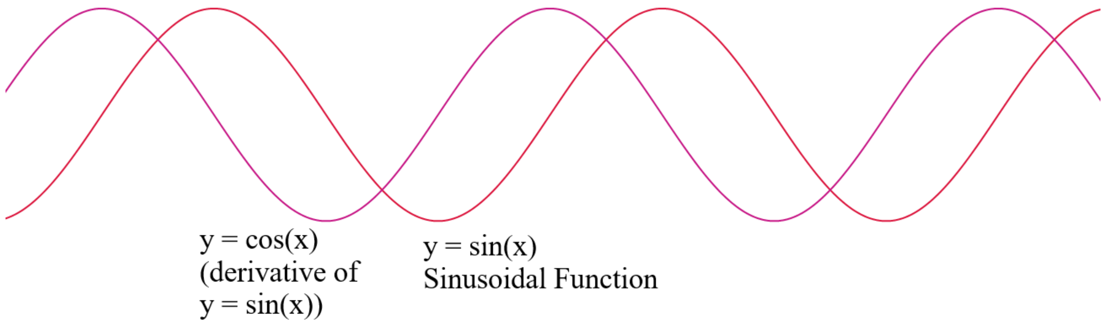

Figure 5-7b: A simple sinusoidal function and its derivative.

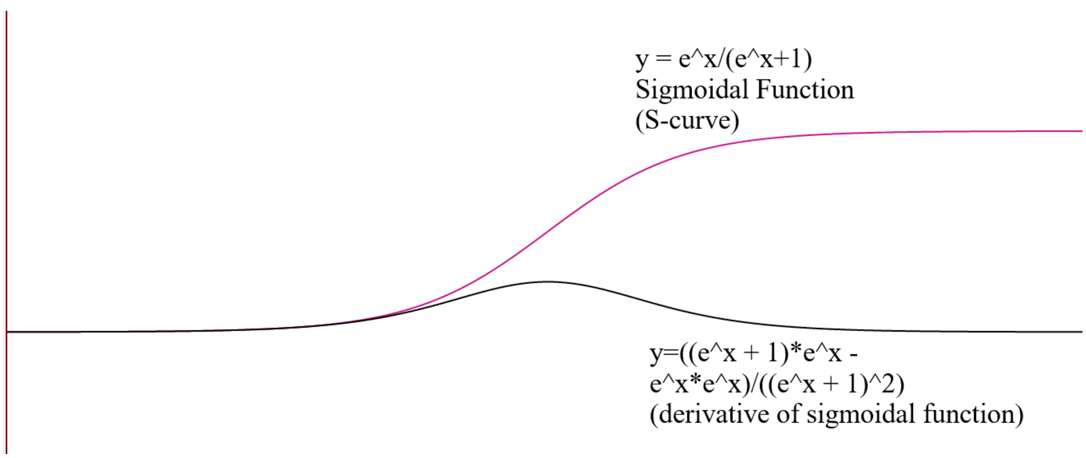

Figure 5-7c: A simple sigmoid function and its derivative.

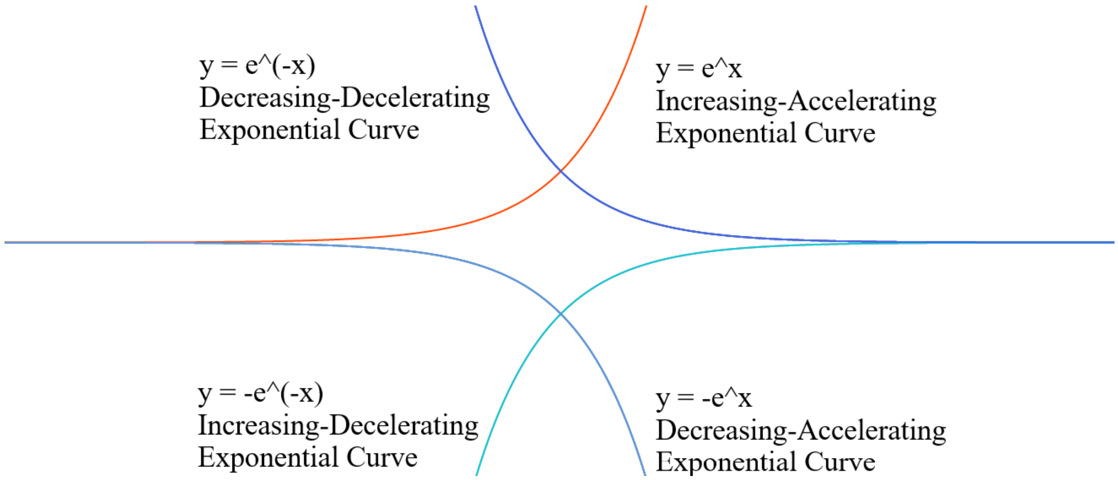

Figure 5-7d: The four basic types of exponential functions.[19]

Many of the general shapes used in EDM can be easily represented by one of the four basic types of exponential functions (based on horizontal and vertical flipping of the simplest exponential function). This is shown in Figure 5-7d.[20] Although each of these shapes could also be approximated with logarithmic functions, rational functions, or even radical functions, I am choosing to think about the shapes as varieties of exponential functions because they contain horizontal asymptotes and not vertical asymptotes. An asymptote is a line that is approached more and more closely but never touched by a curve. In musical perception, horizontal asymptotes make sense as models of our listening experiences, since it often sounds like volume or pitch is approaching a plateau or a threshold, when the differences in the amount of change are becoming less and less

[19] The derivatives of the increasing-accelerating exponential function and the decreasing-accelerating function are themselves. The increasing-decelerating function and the decreasing-decelerating functions are derivatives of each other.
[20] Technically, according to scientific definitions, all four of these graphs are "accelerating" because they are changing their velocity. However, I find it more useful to describe those with increasing rate of change as accelerating and those with decreasing rate of change as decelerating.

noticeable. A vertical asymptote would not make sense in musical perception, since the x-axis represents time, and time cannot be stopped.

As shown in the graphs of Figure 5-7a and Figure 5-7d, linear functions have a constant rate of change, and exponential functions increase or decrease their rate of change over time (in magnitude, a.k.a. absolute value). Sinusoidal and sigmoidal functions have their rate of change sometimes increasing and sometimes decreasing. Specifically, it increases in between peaks and valleys, and decreases as the peaks and valleys are approached. Sinusoidal curves do not hold their highest and lowest values for more than a moment, whereas sigmoidal curves almost reach a plateau. In fact, sigmoidal curves are bounded by two horizontal asymptotes, and they can be thought of as two exponential curves (that are horizontally and vertically mirrored) glued together. Some continuous processes that I describe as sigmoidal in this chapter may have been created this way, by combining two different types of exponential curves, but as discussed in chapter 1, I may describe it as a single continuous process if I hear it as a single gesture due to musical factors such as the beginning and ending points of phrases, measures, or hypermeasures. Sigmoid curves are sometimes called "S-curves," and increasing-accelerating exponential curves are sometimes called "J-curves." This distinction has long been used in biology to model two different types of population growth.[21]

Some of the continuous processes I will discuss in EDM pieces can be mapped onto common mathematical formulae more precisely than others, but even if they are not

[21] Shestopaloff (2013, 501).

a perfect match, applying different shapes to them gives us a better idea of how the continuous processes that influence our hearing and our dancing work, and why composers may choose specific rates of change over others for different parameters such as pitch, tempo, or volume.

Some simple examples of continuous processes that I created with different curve types can be seen and heard in Video 5-1.[22] The first part of the video shows a fade-in which is originally linear, and then altered to become similar to an increasing-accelerating exponential curve. The second part of the video (starting at 1:00) shows a pitch slide of an octave three different ways: linear, then increasing-accelerating, then increasing-decelerating. Starting at 1:51 multiple pitch slides are shown in a sinusoidal pattern, ascending and descending. At 2:04 in the video tempo accelerations are shown in the kick drum part, first lasting four measures then only two measures. The two-measure accelerations are heard first as a linear curve, then increasing-accelerating, then increasing-decelerating. Finally, at 3:05 the video shows the comprehensive list of parameters that can be automated for one particular MIDI cello instrument. In the video the different aesthetic effects of different curve types and their rates of change can be clearly heard for these basic examples. Since many different shapes can be added and combined, for many different parameters, in many different sound layers, it is easy for groups of continuous processes to become quite complex when implemented in real musical pieces. The possibilities are virtually limitless for EDM creators.

[22] This video was created Ableton Live 10, which is a DAW that is highly regarded in the industry.

There are some general correlations between the various types of curves and the parameters they alter in EDM. Linear shapes are most common in general, especially for long volume changes and filter sweeps.[23] Perhaps straight lines are most common because they are the default setting for automation curves in DAWs, or because they feature constant change, which is easily recognizable and can be discomforting. Even though they are in some senses the simplest shape, the slope of the lines (the rate of change) can be adjusted at different points in the track to generate greater or lesser salience for continuous processes.

Most volume changes such as fade-ins and fade-outs are achieved with linear automation curves (although they are easier to be perceived as different kinds of exponential curves, as I will discuss below). However, the tremolo effect, which involves short, repeated volume changes, is usually created with an LFO generating a sinusoidal curve shape through amplitude modulation. Tempo changes (accelerations and decelerations) most often use increasing-accelerating exponential shapes (J-curves), which grow more and more with time. This may be because it has the most psychological impact. Pitch slides come in a variety of different shapes, including linear, sinusoidal, and various types of exponential curves. They often almost reach a plateau after their main ascent or descent, and commonly slow their rate of change down before reaching it, as if approaching a horizontal asymptote in a sigmoidal curve. Filter sweeps also come in a variety of shapes that can be seen on spectrograms, although they are quite often linear. I will now examine the shapes of many continuous processes, most of which are taken

[23] "The Joy Of Automation" (2015).

from tracks examined in previous chapters, with the altered parameters as a guide for the organization of the chapter.

Volume Changes

In Video 5-1 (discussed above), the automation curve modeling the volume change was first linear, then exponential (increasing-accelerating). After the linear process played I hovered over the automation line to show the different values for volume in terms of decibels on each half-beat. It is important to notice here that even though the volume of the pitch is not increasing at a constant rate in terms of the decibel scale, it actually is increasing linearly in terms of volume (amplitude), because the decibel scale is itself logarithmic. The decibel scale represents how we hear volume changes and "loudness" more accurately than pure amplitude readings. For this reason, it is a good measure of "sound intensity level."[24]

This is important for automation curves in EDM because even if an artist inputs a linear automation curve for a volume change (which is the most common type of curve for the most commonly automated parameter)[25], it will be perceived logarithmically, and basic logarithmic functions have the same general shape as increasing-decelerating exponential curves. In other words, even though a fade-in is actually increasing volume with a constant rate of change, we will hear its rate of change slowing over time. In the video example of the linear fade-in, we hear the crescendo according to the decibel

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[24] A more formal mathematical discussion of this occurs in McCall (2010, 128–130).
[25] Miller (2018a); "The Joy Of Automation" (2015).

system, where there is less and less increase between decibel values between each eighth note (half beat).

It is also interesting to note that the Ableton Live 10 software used in the video describes the starting point of the fade-in (the lowest possible volume setting) as "negative infinity" decibels. What does this mean? What does a "fade-in" mean anyway? The question may be asked, "fade-in from what?" When does a fade-in actually start, and when does a fade-out actually end? If the answer is when there is no volume at all, represented by 0 on the amplitude scale or "negative infinity" on the decibel scale, then how is the process still ongoing? There is nothing lower than 0 on the amplitude scale, and nothing quieter than silence. But how does growth begin from a fixed, frozen place of silence, of nothingness? Volume is definitely changing right before or after silence is reached, but how can the point of silence be represented as part of the continuous process? The answers to these questions can be represented again by asymptotes, with the horizontal asymptote line representing silence. The amplitude of the sound approaches the line of silence, but it can never touch that line because something cannot be both sounding and silent at the same time.

A good example of this kind of fade-in occurs from 2:45 to 3:00 in "Turning Point" by Deadmau5, first discussed in chapter 2. This track heavily features the bass line, transcribed in Figure 5-8a. For most of the track the bass line is multi-layered with different timbres, including a dull one with very little if any attack/articulation, and a harsh one with distortion and sharp attack points. In the breakdown (2:30–2:45) only the dull bass sound is featured, with the drums dropping out. The lack of clear attack points plus the syncopated, metrically dissonant rhythm make it easy for the listener to lose the beat, a common feature of breakdown sections. In the ensuing buildup section (2:45–3:00) the harsher bass sound fades in, creating the illusion of a timbre change in the single bass layer, and then a short filter sweep is heard before the drums reenter at the start of the next core section. The fade-in sounds like it increases its loudness a great deal at the beginning and then less and less as the process continues, so it could be modeled with an increasing-decelerating exponential curve. The graph in Figure 5-8b shows my perceptual hearing of the fade-in for "Turning Point," and it closely models an increasing-decelerating exponential curve. However, the fade-in could easily have been created with a linear automation curve because that would create this perceptual effect.

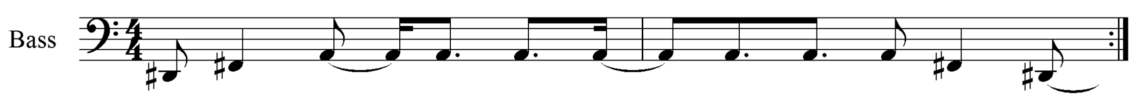

Figure 5-8a: Transcription of the bass line in "Turning Point" by Deadmau5 (2007).

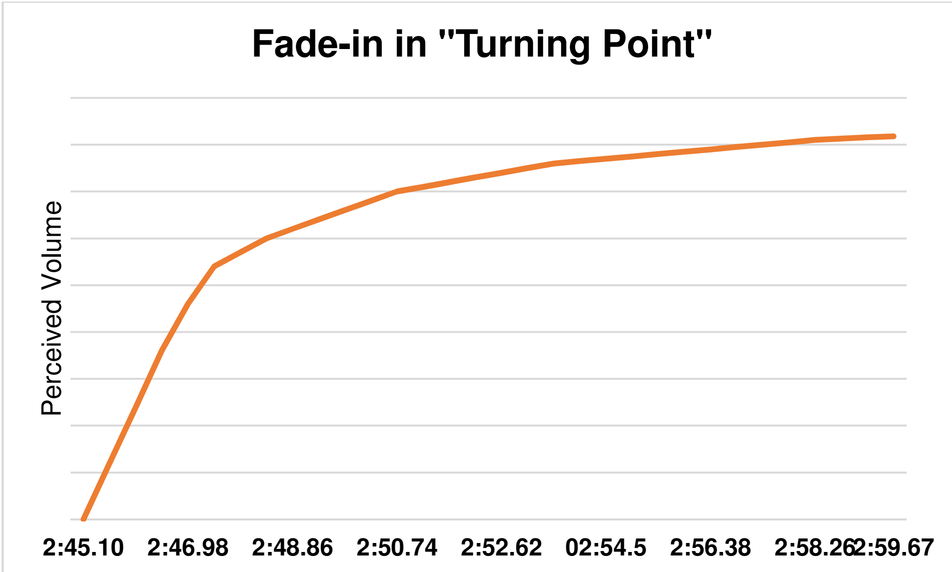

Figure 5-8b: A perceptual model of the fade-in of the harsher bass sound as an increasing-decelerating curve in "Turning Point" by Deadmau5 (2007).

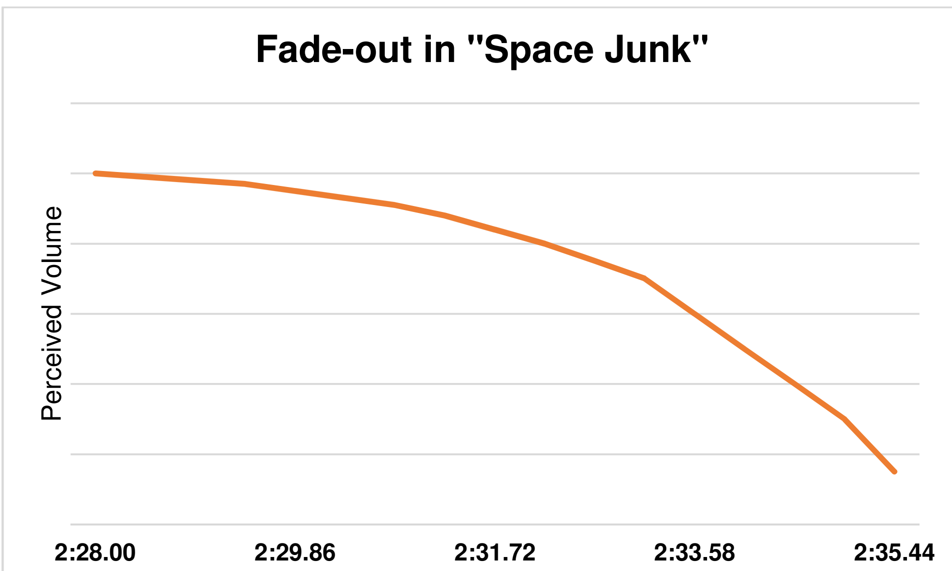

Figure 5-9: A perceptual model of a fade-out as a decreasing-accelerating curve in "Space Junk" by Wolfgang Gartner (2010).

If fade-ins are best modeled with increasing-decelerating exponential curves, then what kind of curve would be a beneficial mathematical model for how we perceive fade-outs? One good example of a fade-out occurs from 2:28 to 2:36 in Wolfgang Gartner's

“Space Junk,” first studied in chapter 3. In this case, the loudness seems to diminish only slightly at first, and then very significantly towards the end, as shown in the perceptual model of Figure 5-9. This is consistent with the decibel system, and can be modeled with a decreasing-accelerating exponential curve.

It is important to remember though, that these continuous processes were most likely inputted with linear automation curves, so that the amplitude is increasing or decreasing linearly. For continuous volume changes that are not strict fade-ins or fade-outs but merely crescendos or diminuendos, it is easier to perceive them linearly. This is because as the graphs approach their horizontal asymptotes (and are far away from silence) they approximate a straight line more and more closely. One track that makes this evident is Aback’s remix of “Everything is Bright” by Stoned Butterflies (also discussed in chapter 3), since the repeated eight-measure crescendos in the percussive vocal line (heard most clearly at 2:00) can easily be perceived as linear.

Another way that continuous volume changes are commonly used in EDM is for the tremolo effect. This was studied in chapter 3 on short continuous processes, with examples including Aback’s remix of “Everything is Bright” and “Imaginary Friends” by Deadmau5. The tremolo effect in electronic music refers to short, repetitive crescendos and diminuendos on a single pitch, usually generated with an LFO creating amplitude modulation.

Sinusoidal curves usually provide a good representation of how we perceive this effect because the low-frequency sound wave used in the LFO is often a sine wave.[26] However, it could also be a sawtooth, triangle, or square wave, and this impacts the effect of the continuous volume changes, especially when the rate of the tremolo effect is slow, for example if the period of each volume wave lasts for an eighth note or longer.[27] Visual representations of these four kinds of sound waves are shown in Figure 5-10. When joined together in repetitions, the period of each wave type has only an ascending and a descending part. The triangle wave has both a linear ascent and descent, while the sawtooth wave has a linear ascent but an instantaneous descent, and the square wave has instantaneous ascents and descents (represented with vertical lines). The square wave contains only discrete processes, not continuous ones, and when it is used for the tremolo effect, only sudden volume changes are created. In "Imaginary Friends," the shape of the volume changes is sinusoidal. This can be seen in the continuous curves of both the amplitude graph and spectrogram (Figure 5-11a and Figure 5-11b). Notably, the timbre of the sounds in this section seems as if it was generated with a sawtooth wave, not a sinusoidal one, but the shape of the volume changes (generated with an LFO) is sinusoidal.

[26] For further explanation of LFOs, see chapter 3.

[27] If the frequency of the input signal were higher, the type of wave would also affect the timbre of the sound because the different wave types have different harmonic spectra, as shown in Figure 5-10.

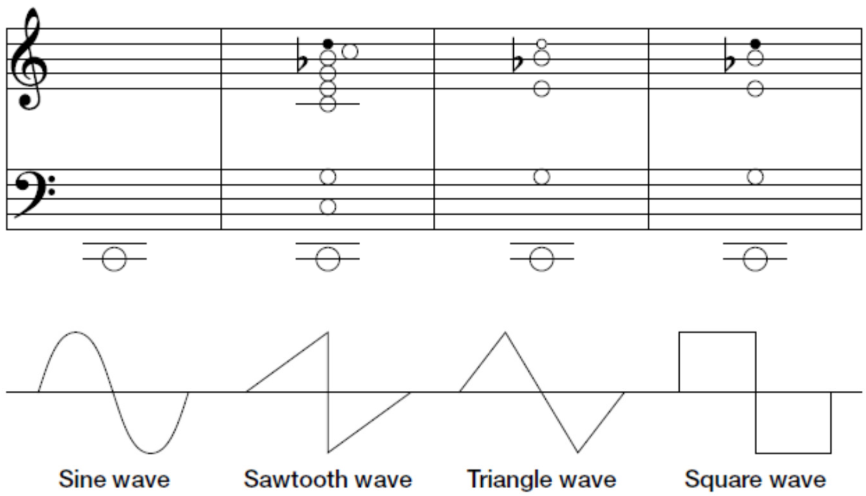

Figure 7.3 Harmonic spectra of sine, sawtooth, triangle, and square waves, shown using musical notation. (After Strange, 1983)

Figure 5-10: Reproduction of Figure 7.3 from Holmes (2012).[28]

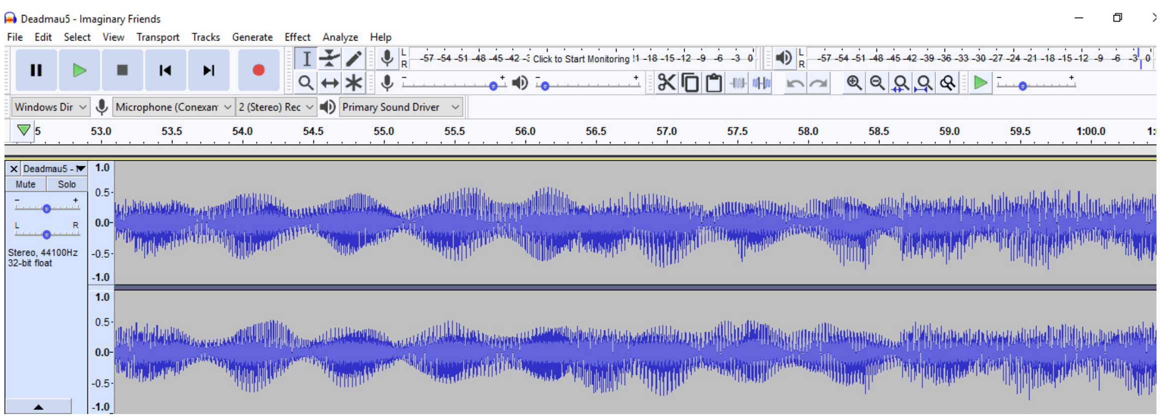

Figure 5-11a: Amplitude graph showing a sinusoidal wave shape for the tremolo effect from 0:53–1:01 in "Imaginary Friends" by Deadmau5 (2016).

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[28] Holmes (2012, 208). This figure shows not only the different shapes of sound waves but also their harmonic spectra. The sawtooth wave contains all the harmonics, whereas the triangle and square waves only contain the odd-numbered harmonics.

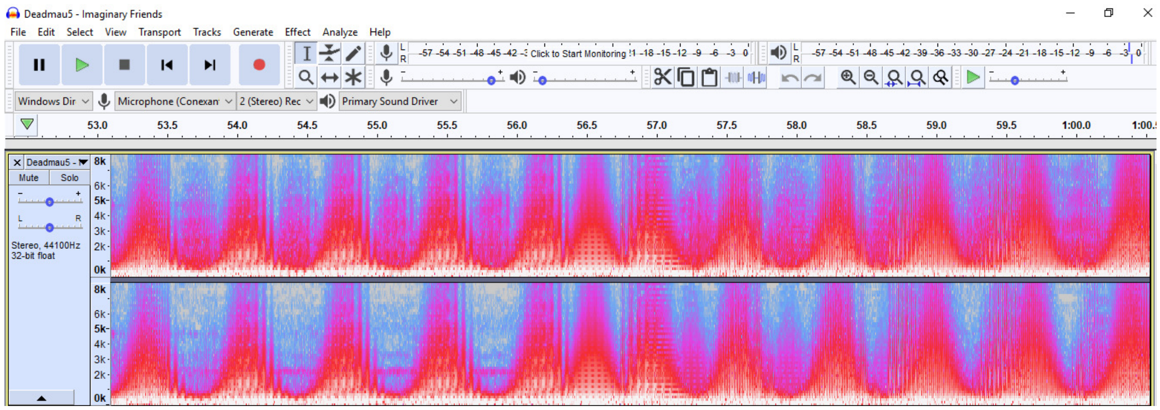

Figure 5-11b: Spectrogram showing a sinusoidal wave shape for the tremolo effect from 0:53–1:01 in "Imaginary Friends" by Deadmau5 (2016).

The tremolo effect usually generates rhythmic pulsations. When the volume is at its peak, a rhythmic articulation is perceived. In the intro of "Some Chords" by Deadmau5, the tremolo effect is used to create rhythmic pulsations that are metrically dissonant with the beat. Both the harmonic synth layer with the chords and the melodic synth layer that fades in on the tonic use the tremolo effect, but the period of each wave is slightly less than one beat.[29]

At first, early in the piece when the high synth is fading in, the rhythmic pulsations are almost exactly aligned with the beats, as shown in Figure 5-12a. As the high synth continues to fade in, however, it becomes misaligned with the beats, creating metrical dissonance (specifically grouping dissonance),[30] which is particularly noticeable from 0:30 to 0:45 and can be seen in Figure 5-12b. The misalignment is highlighted further because there are four short continuous pitch waves embedded within each of the

[29] The length of one period of the tremolo wave is about 0.455 seconds, whereas the length of a beat in the track is about 0.481 seconds.
[30] Krebs (1999, 31).

volume waves generated by the tremolo effect. The pitch waves move between the leading tone and the tonic of the key and each last about 114 ms, around the threshold of perception,[31] meaning that the pitch movement exhibits microrhythm. Furthermore, the metrical dissonance combines with the syncopation in the chords to obscure the beat in this opening section of the track. Later, in the breakdown (starting at 3:45), the same techniques used in the intro repeat, but now another layer is gradually added, fading in to the texture. This new layer uses repeated octave leaps in a quarter-note-triplet rhythm, creating even more metrical dissonance. In this section, both discrete and continuous aspects of the music contribute to generating a sense of instability and metric disorientation.

In both the intro and breakdown of "Some Chords," metrical dissonance is created by the *shape* of the volume wave generated by the tremolo effect, specifically its rate/speed. Generally, the shape of a wave generated by the tremolo effect as determined by the wave type of its input and its rate/speed can affect not only the salience of short continuous processes, but also the rhythm, articulation, and degree of discreteness or continuousness for a sound layer. If the rate is fast enough, it can seem as if discrete rhythms are being clearly articulated, but if it is slow enough, rhythmic pulsations will not be perceived at all because there will not be one perceived point at which a rhythmic articulation occurs. Often the tremolo effect is used to create a sense of rhythm without clear attack points/articulations. Sinusoidal functions are particularly effective for the

[31] London (2012, 27–29).

tremolo effect when it is used in this way to create a dull or muted sense of rhythm, since they have smooth curves rather than straight edges.

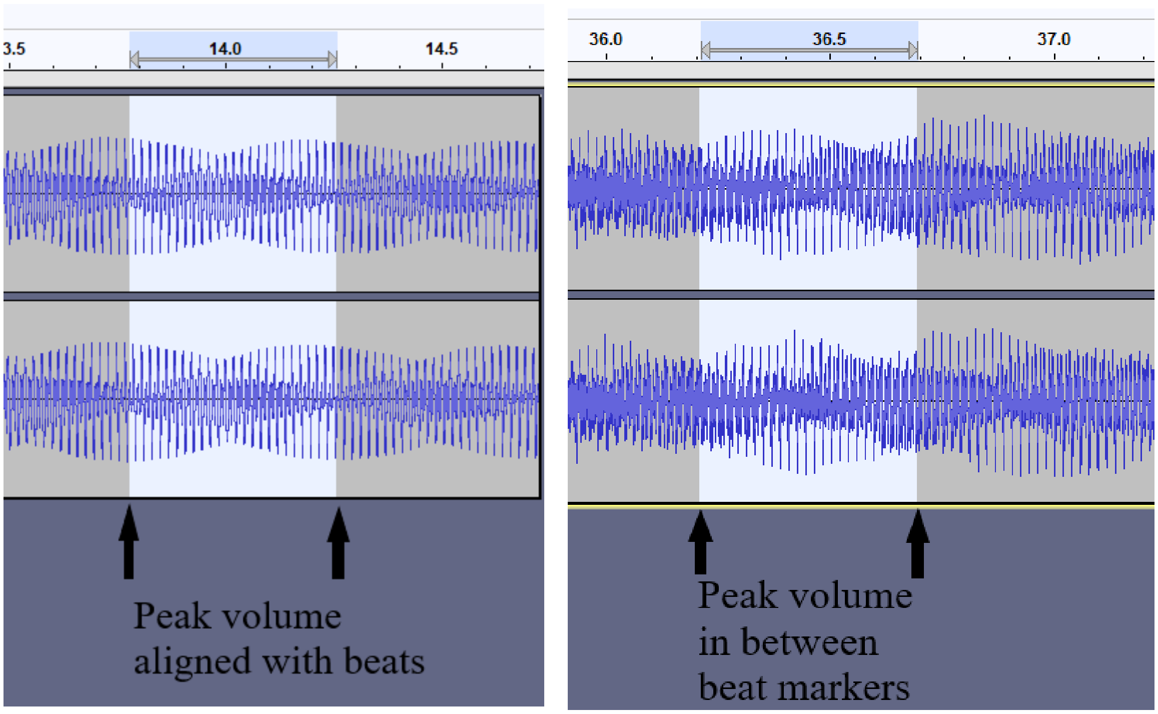

Figure 5-12a Figure 5-12b: Amplitude graphs showing the alignment (at 0:13–0:14) and misalignment (at 0:36) of the rhythmic pulsations generated by the tremolo effect with the beat in "Some Chords" by Deadmau5 (2010).

Rhythm and Tempo

Unlike volume changes, tempo accelerations and decelerations are often exponential, meaning the tempo grows or decays much more significantly as time goes on. Of the four examples of (perceived) continuous rhythm or tempo changes in chapter 2, three can be best modeled by exponential curves. I discovered this by listening closely to the tracks and if necessary slowing down very fast parts to record the number of attacks in the timespan of each beat or measure. For accelerations, an increasing-accelerating exponential growth curve (a J-curve) usually models the continuous process best. For decelerations, however, an exponential decay curve (a decreasing-decelerating exponential curve) usually models it best.[32]

One track that features significant acceleration and deceleration is “Cthulhu Sleeps” by Deadmau5. In chapter 2 I discussed how there are three different sound layers from 2:00 to 3:00 in the track (the second part of the three-part intro), two of which accelerate at different rates and one of which remains constant. The “pitched synth” accelerates only slightly, but the “rhythmic synth” (that represents the Cthulhu monster) features significant and prominent acceleration and deceleration. A graph of the rhythmic changes for only the “rhythmic synth” is shown in Figure 5-13. This shows how the continuous processes can be represented by exponential growth and exponential decay.[33] During the acceleration both the tempo and the rate of change keep increasing towards the peak tempo rather than tapering off. This also makes sense geometrically since the derivative of the exponential growth function is itself. During the deceleration the tempo sharply decreases and the rate of change quickly becomes less negative (in a way “increasing,” but not in terms of magnitude, as shown in the derivative of the exponential decay function which is the increasing-decelerating exponential curve).

[32] With curves that model tempo, there should also be a component of vertical translation added to the equation where a positive constant k is added to the right side, so that the horizontal asymptote is not y=0. This is because tempo rarely approaches 0, especially in EDM.
[33] If the acceleration and deceleration was thought of in terms of the length between attacks getting smaller and then larger, the continuous processes would be represented by their inverse shapes, first decreasing-decelerating (exponential decay) then increasing-accelerating (exponential growth). I represent them with growth followed by decay though, because it is most intuitive to hear acceleration as a “speeding *up*.”

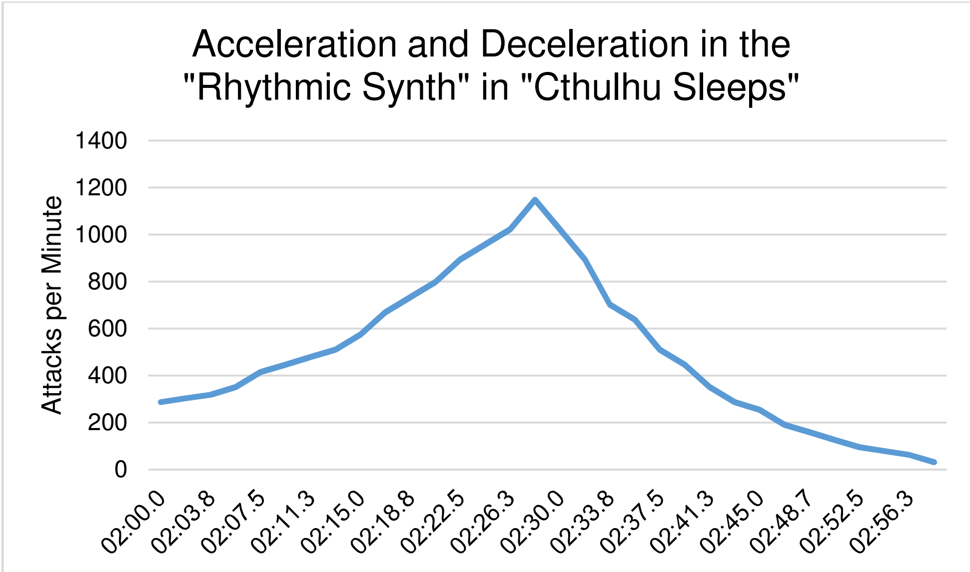

Figure 5-13: The acceleration and deceleration of the "Rhythmic Synth" in "Cthulhu Sleeps" by Deadmau5 (2010), shown in attacks per minute.

Another track by Deadmau5 that features prominent acceleration in the intro is "Fn Pig," also discussed in chapter 2. There I noted that the acceleration is quite salient, and that it causes the listener to reinterpret what once were quarter notes as eighth notes, so the actual perceived tempo does not simply increase continuously in BPM. However, if one assumed that each note continues to represent one beat, as it did in the beginning, then the resulting acceleration can be represented in Figure 5-14a, and the rate of change is represented in Figure 5-14b. These graphs are far from mathematically perfect curves, but they still tell us something interesting about the shape of the tempo changes. When looking at the graph of the tempo itself, it appears as if the acceleration is mostly linear with a constant rate of change. Examining the graph of the rate of change, however, it is evident that there is at least *some* increase of the rate of change as the process continues. This means that the acceleration is behaving to at least some degree like an exponential J-curve, peaking just before the two-minute mark in the track, and there is some sense in which the shape of the continuous process is like exponential growth. Deadmau5 may have wanted the effect to sound primarily linear, but to slightly increase the intensity of the process and the energy of the track towards the end, before it falls apart with a quick deceleration.

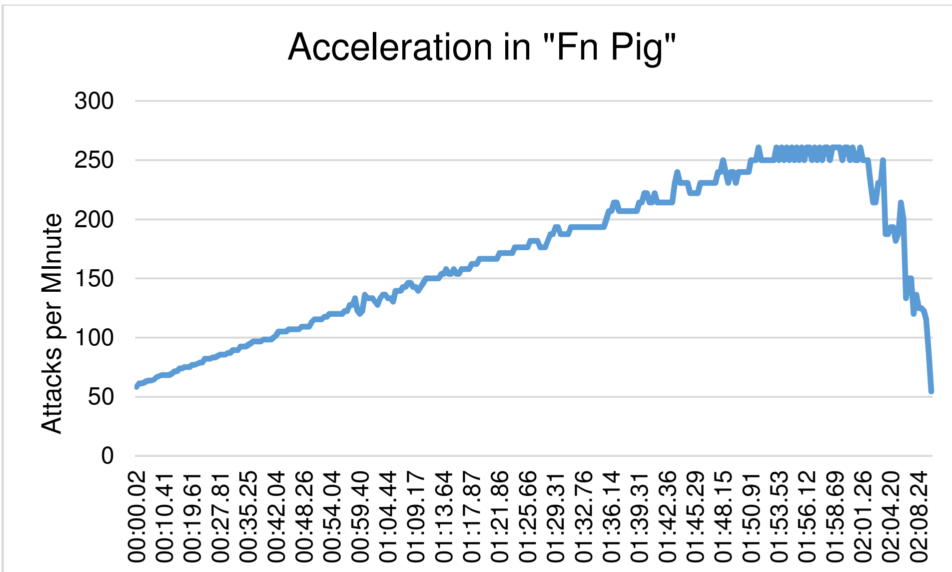

Figure 5-14a: Tempo acceleration in “Fn Pig” by Deadmau5 (2012).

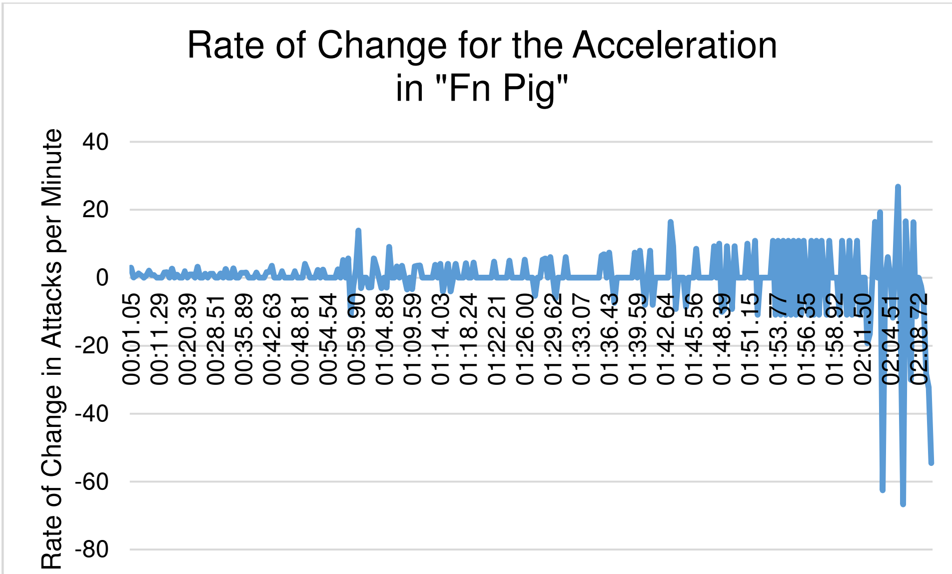

Figure 5-14b: Rate of Change for the acceleration in "Fn Pig" by Deadmau5 (2012).

A third track that I studied in the same section in chapter 2 is "Interferance" by Chunda Munki. In this track, the first breakdown section is signaled by the introduction of the harsh cell-phone-interference sound effect on the pitch A3. From 1:03 to 1:18 in the track, the rhythm of this sound seems to be continuously slowing down. In chapter 2 I discussed how the process sounds continuous because there are no drums or beat markers so it is easy to perceptually lose the beat. The deceleration is actually discrete, however, following a step-by-step process of different levels of "tempo." It is interesting though, that the deceleration can still be represented well by the shape of exponential decay (decreasing-decelerating), as shown in Figure 5-15 and compared with Figure 5-7d. The difference between levels of tempo is greater at the beginning and becomes less toward the end of the process. For a transcription of this passage see Figure 2-8a.

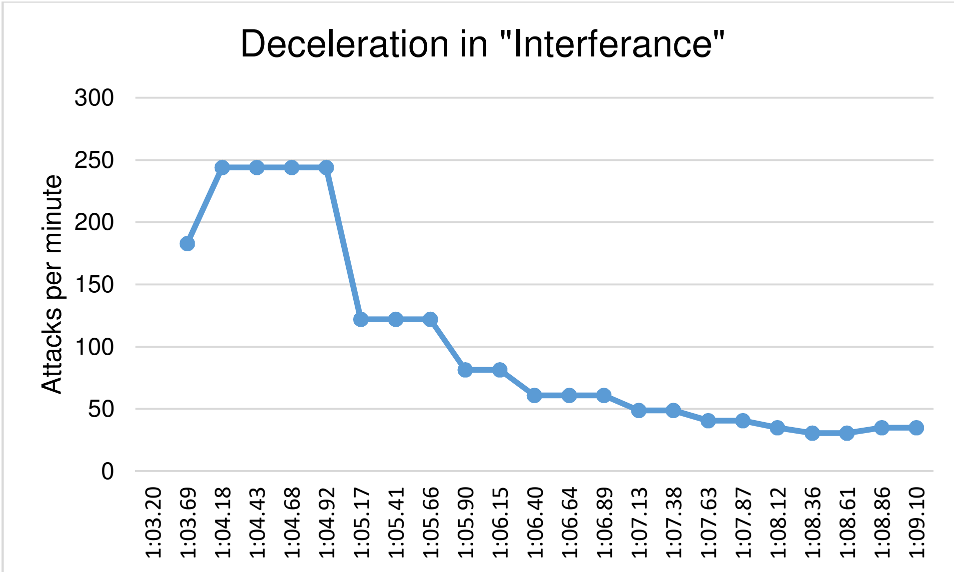

Figure 5-15: Deceleration in the cell-phone interference sound in "Interferance" by Chunda Munki (2017).

All three of the above tracks utilize exponential shapes in some way for their rhythm/tempo changes. This is noticeably different than the main acceleration in the second half of Moby's "Thousand" (first discussed in chapter 2), which tapers off towards the peak, modeling a sigmoid curve (an S-curve) rather than a J-curve. This is shown in Figure 5-16, which has a graph created from my listening to the piece slowed down overlaid with a mathematically perfect S-curve. Unlike with a J-curve, the rate of change is highest in the middle part of the process, and lowest at the beginning and the end.

Why might the shape of this process in Moby's "Thousand" be different than the others by Deadmau5 and Chunda Munki? Perhaps the difference in acceleration curves is because "Thousand" is from a different time period, roughly two decades before the other pieces. It is also in a different genre than the other three pieces discussed here; one might describe "Thousand" as a work in electronica whereas the others are house tracks.

However, I think the main difference is that the accelerations in Moby's piece are simplistic and gimmicky when heard in comparison with the others. For example, in both "Thousand" and "Cthulhu Sleeps" the fastest musical line reaches over 1,000 "beats" per minute, but in "Thousand" this is the entire point of the track and the acceleration is applied to the global tempo of all sound layers. Contrastingly, in "Cthulhu Sleeps" the extreme acceleration is used just in this one section, and in one sound layer that works noticeably against the tempos of two other layers, one of which accelerates a bit and one of which remains steady. Put together, this creates a more complex track and a greater effect of disorientation. Nevertheless, it is interesting to examine the different shapes used for continuous processes in all of these tracks, and to note that none of them are simply linear.

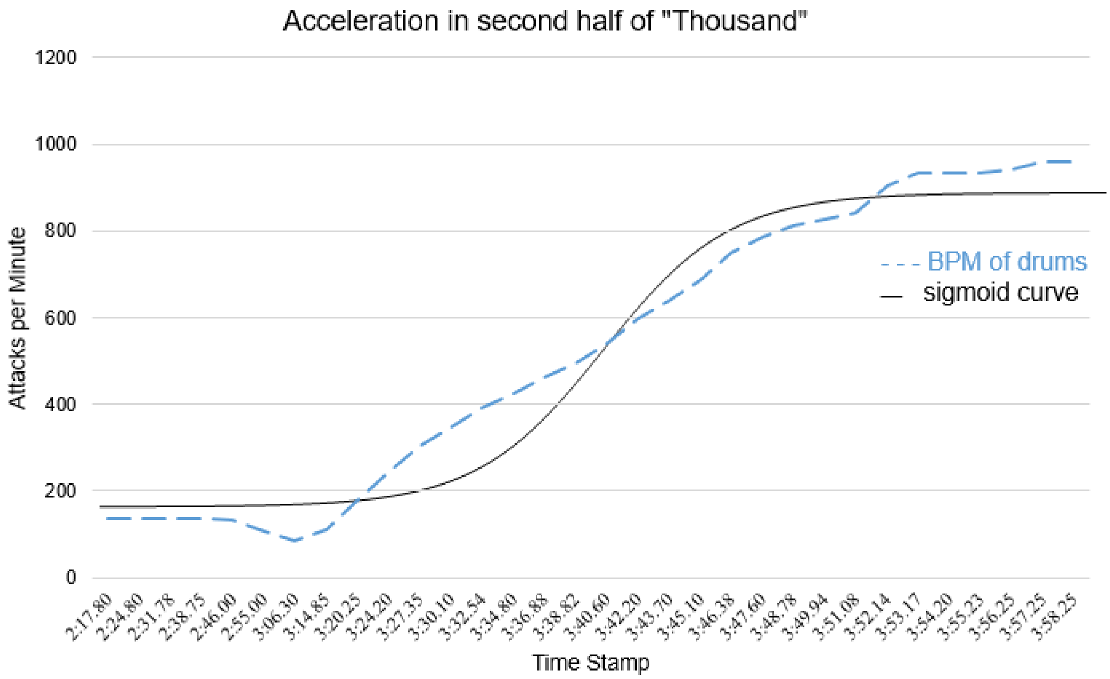

Figure 5-16: Acceleration in the second half of "Thousand" by Moby (1993), compared with a sigmoid curve.

Pitch Slides

Pitch slides come in a wide variety of shapes, as this section will show with examples from seven different tracks. As mentioned previously, the simplest shape for continuous processes is also the most often used, and that is a straight line. For instance, the two types of pitch slides in "Tissot" by Bolivaro are both linear. In chapter 2 I discussed these as pitch slides Type A and Type B, and created a form chart (Figure 2-10). Type A is a pitch slide from F4 to F5 that occurs over eight measures in the highest and most prominent part of the texture.[34] It has a constant rate of change of 0.375

[34] Recall that the lower part of the texture also features ascending scoops, but these are not what I am discussing here.

semitones per beat.[35] I figured this out by first writing down the pitches I could hear (in equal temperament) at specific beat points when it was clear, and then comparing the results with the hypothetical line for the pitch slide that would perfectly span one octave (twelve semitones) in thirty-two beats. The results almost perfectly lined up, so it can be assumed that the rate of change is constant for the entire process. A graph of pitch slide Type A is shown in Figure 5-17a. The lighter-colored parts of the line represent parts of the continuous process that are not literally sounding because the lower pitch scoops are present instead.

I did the same work for pitch slide Type B in "Tissot," which moves from C4 to (almost) C6 over only four measures. The linear motion is harder to hear in this slide because it also fades in, so the first couple notes are basically inaudible. Yet when one assumes that the pitch slide starts on C4 at the beginning (even though it is inaudible) and moves up 1.5 semitones every beat, the pitches line up so that after sixteen beats the next pitch (on beat seventeen, which never comes) is C6. Since the consonant target of C (the dominant scale degree in the key of F minor) is never reached, the aesthetic effect of this glissando is one of incompleteness. It sounds as if the process is slowing down towards the end and the goal will never be reached. In the graph of pitch slide Type B (Figure 5-17b), the last part of the line, that reaches C6, is in a lighter color to represent the fact that C6 is never actually reached.

[35] For measuring pitch slides I use the scale of semitones (rather than frequency in hertz) since it is the scale that most easily and accurately reflects musical perceptions of distance (at least for Western listeners). It does reinforce discrete "keyboardification," but the graphs would look quite different and be more difficult to follow if they had frequency in hertz along the y-axis.

Pitch slide Type B not only has a much higher rate of change than Type A, but also a different effect. Type A in fact *does* reach the consonant target pitch of F, the tonic, and in fact it even *breaks* the linear pattern in order to do so, as can be seen in the sudden increase in steepness at the end of the graph. If the pitch was to keep increasing at the constant rate of 0.375 semitones per beat, then the last note would be just below F, but in order to give the continuous process a sense of completeness, Bolivaro chose to have the last beat, just before the start of the next section, emphasize the tonic pitch.

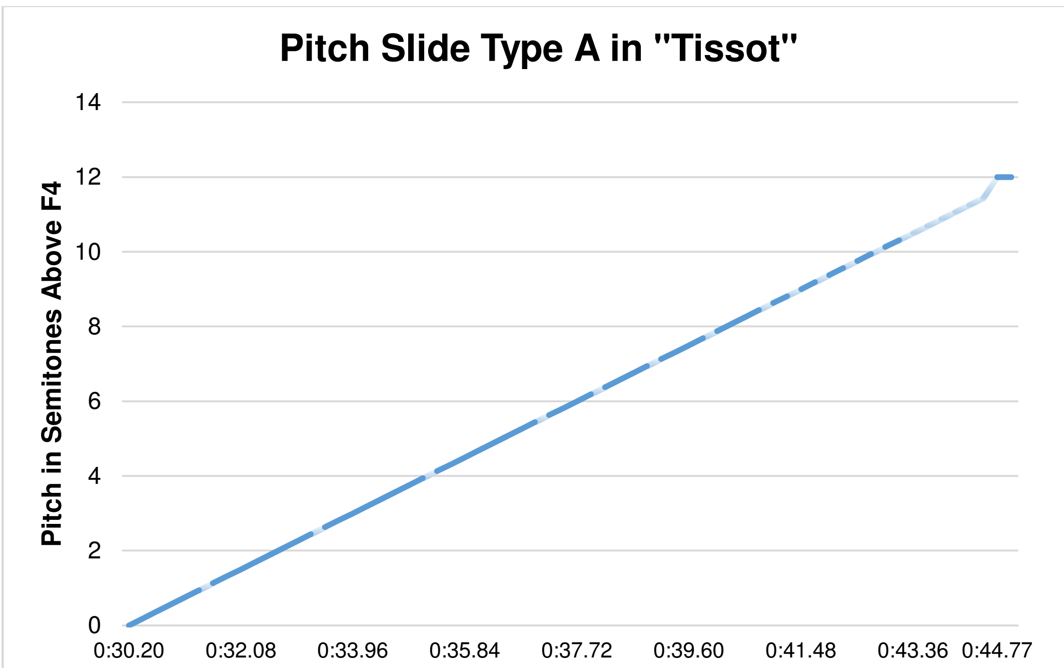

Figure 5-17a: Pitch slide type A in "Tissot" by Bolivaro (2013).

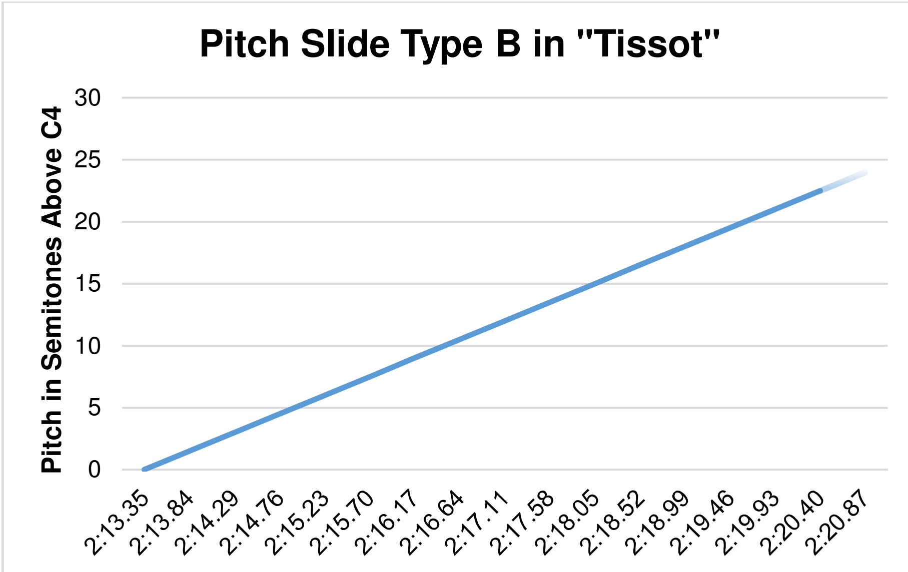

Figure 5-17b: Pitch slide type B in "Tissot" by Bolivaro (2013).

A different track that also features clearly linear pitch slides is "Can You See" by Paris & Simo feat. Errol Reid. In the first buildup (0:34–1:04), the pitch rises two octaves from G#4 to G#6. This is shown in the linear graph of Figure 5-18. As with pitch slide Type A in "Tissot," the rate of change is constant at 0.375 semitones per beat, but as with pitch slide Type B in "Tissot," the goal pitch is never reached. In this case, it is because the pitch slide is not present for the last two beats before the beat drop at the start of the next core; it has been replaced with a vocal cue. This is a common technique in EDM that I will discuss further in the next chapter, but for now it is interesting to note that in "Tissot" there is no vocal cue, so the last beat of the instrumental part that reaches the tonic in pitch slide Type A fulfills the anacrustic function instead. In "Can You See" a linear pitch slide also occurs in other places in the track, most noticeably in the last part of the final core (3:34–3:49) when it ascends from G#5 to G#6 and in the first part of the outro (3:49–4:19) when it descends from G#6 to G#4. This all takes place with the same rate of change (although it is negative instead of positive for the descent).

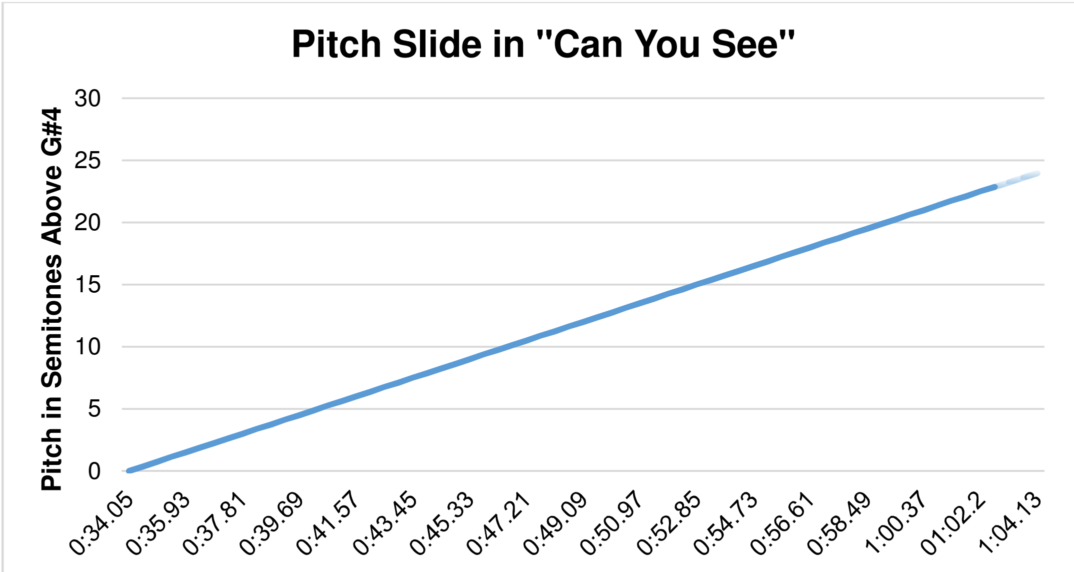

Figure 5-18: Pitch slide in "Can you See" by Paris & Simo feat. Errol Reid (2015).

Another common feature of pitch slides is what seems like a plateau at the top and/or bottom of the slide. The highest and lowest points can serve as goals that are emphasized in various ways, including being held for a significant length of time. The timbre of the pitch-slide layer can also be kept for the next section and become part of a discrete melodic or harmonic progression. The ascending and descending parts of the process that lead toward or away from the plateau can be linear, exponential like a J-curve, or sigmoidal like an S-curve. In "Space Junk" by Wolfgang Gartner, which served as an initial example of short continuous processes in chapter 3, there are obvious pitch waves in the buildup section that have a span of an octave (for example at 2:58 and 3:13). Some of these are represented very well in the spectrogram because they are isolated with nothing else going on in the texture. A close-up of the spectrogram at 2:58 is shown in

Figure 5-19, and it shows that there is a plateau in the middle of the wave, with exponential growth to the plateau and exponential decay from it. For such a short continuous process, it would be difficult to hear the difference between exponential shapes and other kinds, but it is possible that the shapes used here are more impactful, and perhaps more shocking, for this short gesture because it has seemingly more sudden growth and decay than a linear slide would have.

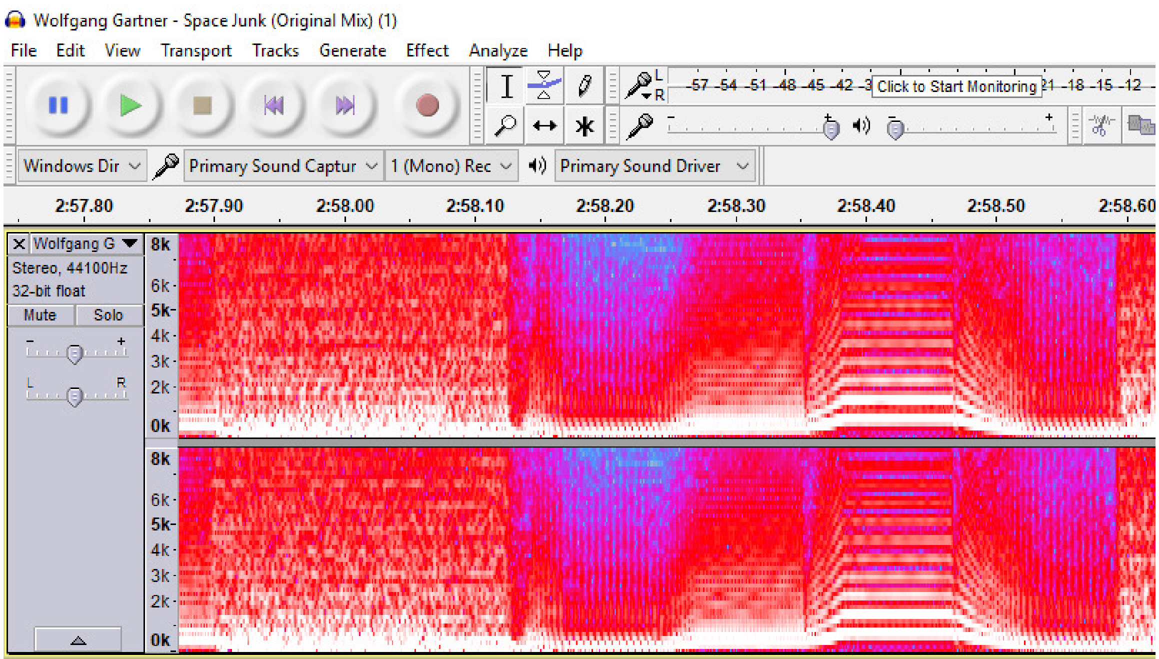

Figure 5-19: A short pitch wave represented by exponential growth and decay curves with a plateau in the middle at 2:58, in the buildup section of "Space Junk" by Wolfgang Gartner (2010).

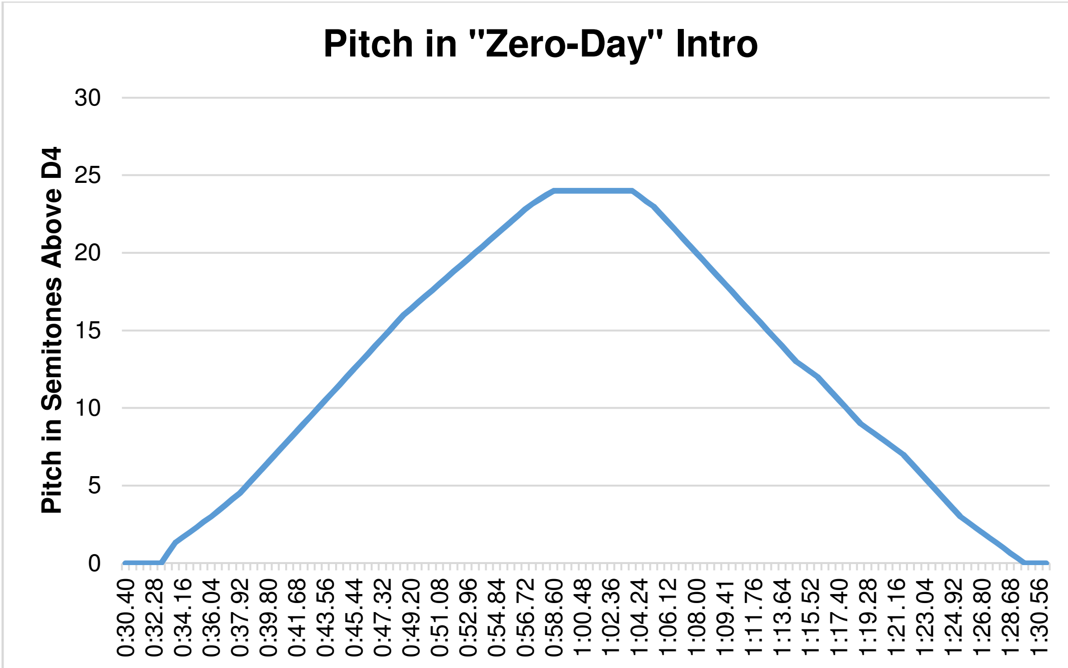

Figure 5-20a: Quasi-sigmoidal pitch slides in the Intro (parts 2 and 3) of "Zero-Day" by Judah (2017).

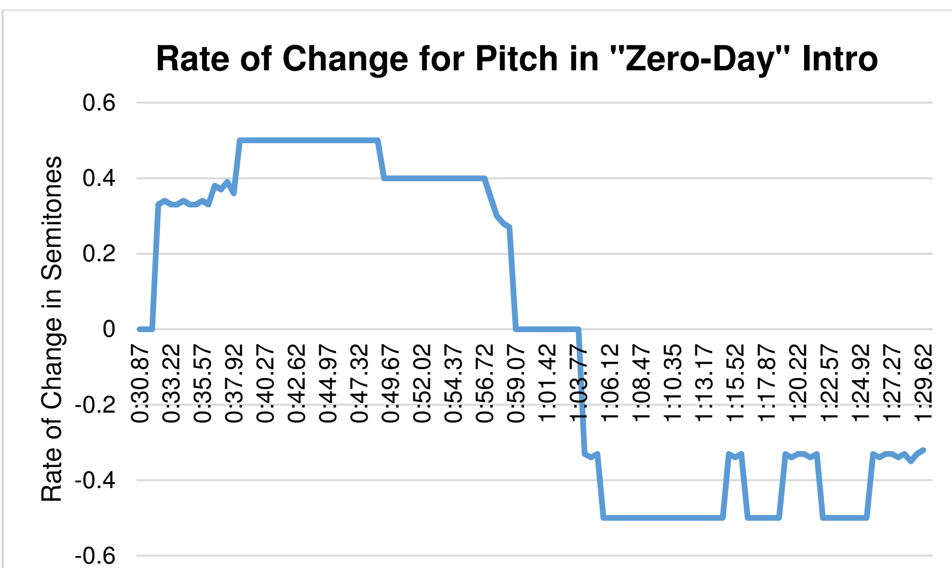

Figure 5-20b: Rate of change for pitch in the Intro (parts 2 and 3) of "Zero-Day" by Judah (2017). This shows how the previous graph behaves like a sigmoid curve.

A much more extended use of pitch slides leading to and from plateaus occurs in "Zero-Day" by Judah. This track was first studied in chapter 2, and it is notable for its utilization of long pitch slides throughout almost the entire track, as shown in the form chart (Figure 2-11). The shapes of two of these extended glissandos are shown in Figure 5-20a, and they are close to the shapes of two sigmoidal curves, one ascending and one descending. After closely listening to the track many times in slow motion, I heard that the rate of change is lowest (in magnitude) near the peaks and valleys, and highest in between them. This is also characteristic of sigmoidal (S-shaped) curves. A graph of the rate of change based on how I hear the pitch slides is shown in Figure 5-20b. Even though technically S-curves do not actually reach plateaus because they are bounded by two horizontal asymptotes, the S-curves are good models of these processes because it visually looks like plateaus happen, and musically, there is an extended amount of time spent at the plateau points of D4 and D6.

It is also interesting to note how the pitch slides in this track interact with sectional and hypermetric marking points. The highest and lowest pitches are reached a few beats before these boundaries, and held over across them before they move again. Therefore the psychological gratification of reaching the high and low goals, with their constancy and lack of change, is misaligned with the gratification of starting a new hypermetric section. This technique is common and is very important for EDM aesthetics, as I will discuss more in the next chapter on the functions of "risers" and other groups of continuous processes.

Another track that has a different shape of pitch slide is “Everything is Bright” (Aback Remix), which was discussed in chapter 3 and briefly in this chapter in the section on volume changes. Pitch slides play an important role in the eight-measure sections of 1:30–1:45 and 3:00–3:15. In the key of C-sharp minor, I hear the tonic pitch softly entering on beat six of this section (at 1:32.90, as shown in the graph of Figure 5-21), and then slowly ascending a ninth up to D-sharp. The ascent seems to happen linearly up until the note B is reached, at which point the rate of change significantly slows down moving towards D-sharp. After this supertonic scale degree is reached, a fast and repetitive pitch wave is generated, which increases its depth very much and very quickly as the music leads toward the next section.

Figure 5-21 shows the shape of the pitch slide from C-sharp up to D-sharp. The fact that the rate of change slows down with time means that the process could be represented with an increasing-decelerating exponential curve, which is different than the other kinds of pitch slides heard in this chapter so far. It is in some ways similar to the S-curve in “Zero-Day” because the pitch ascends less and less before reaching its goal, although it is a goal pitch in a different, less obvious way. However, the ascent in “Everything is Bright” does not start slowly, as an S-curve does, and this makes the two processes have different shapes and different effects.

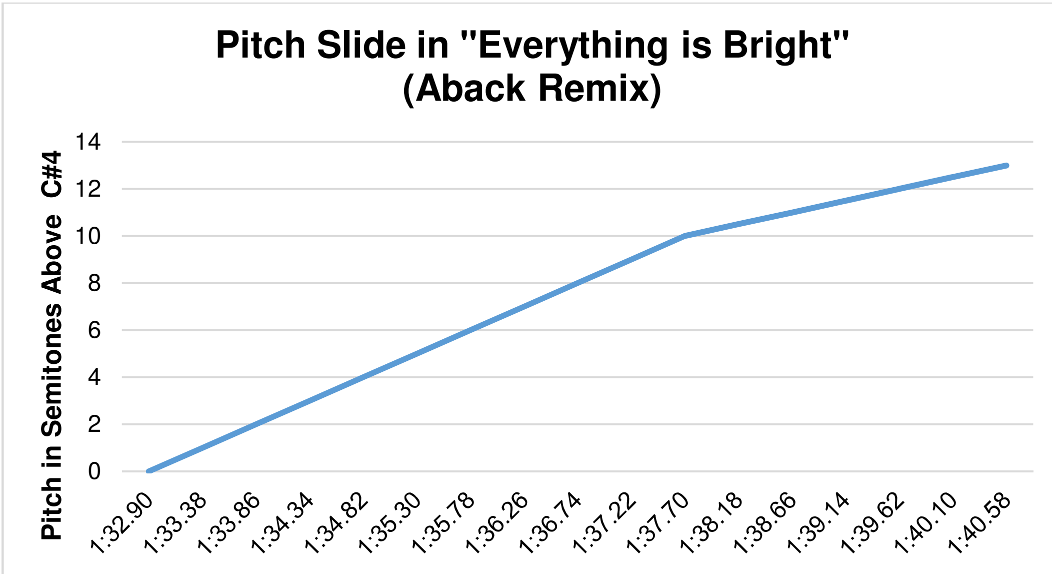

Figure 5-21: An increasing-decelerating pitch slide in "Everything is Bright" (Aback Remix) by Stoned Butterflies (2012).

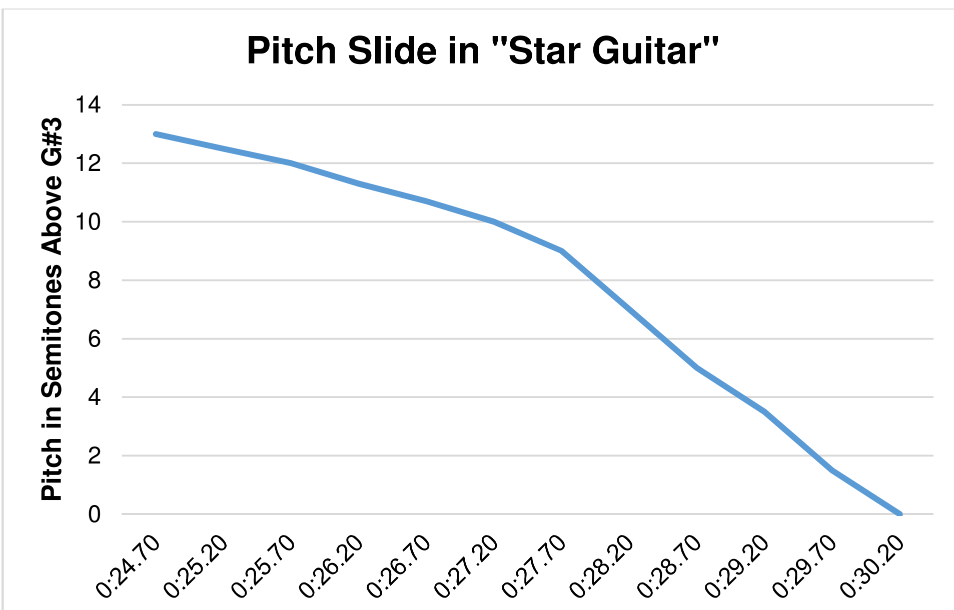

Figure 5-22: A decreasing-accelerating pitch slide in "Star Guitar" by The Chemical Brothers (2008).

The next example can be represented well with a decreasing-accelerating exponential curve. I discussed this shape earlier as a good model for how we perceive fade-outs, but it is also applicable here. Figure 5-22 shows the graph for the first of several three-measure pitch slides in “Star Guitar” by The Chemical Brothers, which was first discussed in chapter 3. The other instances of this process occur at 1:55, 3:56, 4:42, 4:57, 5:42, and 5:57. It seems to have an anacrustic function throughout the track, leading up to important sectional markers, often where new elements are introduced to the texture, as is typical for a core section. The decreasing-accelerating shape makes the descending pitch slide generate a sense of dropping or falling faster and faster, just like the acceleration of gravity. This is an intense experience that helps the process feel anacrustic and goal-oriented despite the more usual goal-oriented pitch slides being ascending rather than descending.

The last example in this section is also by The Chemical Brothers, but it uses an increasing-accelerating shape like a J-curve. “Electronic Battle Weapon 9” is a complex track that has many salient continuous processes. Both dissonant, discrete melodies and harmonies and continuous processes create a harsh, uncomfortable sonic environment in this piece. During the initial buildup there is an extended ascending pitch slide that is shaped like a J-curve. This can be seen clearly in the spectrogram (Figure 5-23), since it is one of only two layers in the texture from 0:29 to 0:45. The other layer is a discrete sixteenth-note melodic motive that was first presented at 0:15. This motive fades out while the exponential pitch slide is taking place above it.

The timbre of the layer that is doing the pitch slide sounds like a DJ scratching on a turntable. The sound has many overtones, and this also helps it be seen on the spectrogram. It seems to fade-in to the texture in the background, while a robotic voice creepily says “making calculations” (beginning at 0:22). After the voice stops, the scratching sound remains in the texture and becomes more exposed, rising fairly steadily until 0:38 when the ascent begins to take off. The pitch becomes extremely high very quickly between 0:38 and 0:45, and then holds at a plateau for roughly two measures while the drums are introduced to provide a discrete contrast, before beginning to descend again. The descent only takes eleven seconds (from 0:49 to 1:00) whereas the ascent lasts for over twenty seconds (from approximately 0:22 to 0:45). During the descent the sixteenth-note melodic motive fades back in, providing a nice mirroring effect with the previous section, albeit not a simple, exact inversion. It is also interesting that the melodic motive and the scratching turntable sound (which also has a rhythm of sixteenth notes) seem to merge together at the end of this section, as the pitch descends again. This ties them together in the listener’s mind. Following this, the main section of the piece begins at 1:00.

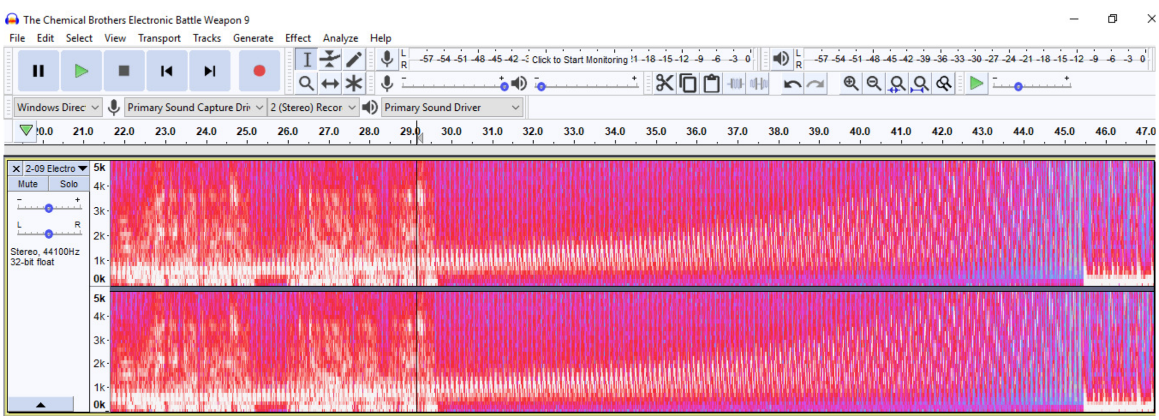

Figure 5-23: An increasing-accelerating exponential pitch slide in “Electronic Battle Weapon 9” by The Chemical Brothers (2006).

Filter Sweeps

Filter sweeps are an important part of contemporary EDM that are used to continuously add or remove high or low frequencies in sound layer(s). Adding higher frequencies to a single sound layer changes its timbre and usually creates the effect of a crescendo as well. The shapes for filter sweeps are well represented in spectrograms because they are based on filtering out frequencies above, below, or within a certain threshold. In chapter 2 I discussed the use of two filter sweeps in the buildup sections of "Smash" by Exodus. Figure 5-24 shows the spectrogram for the first part of buildup 1, and it is annotated with a black line drawn over the shapes of the filter sweeps for the left speaker (on the top).

The first filter sweep used in this section is a descending noise sweep that acts as a downlifter at the start of the buildup. This helps decrease the tension level of the music so that it can be built up again. The noise sweep is linear in shape, happening quickly so that other processes can be heard more clearly, including the increasing-accelerating filter sweep. As the filer cutoff increases, the rate at which it does so accelerates. At first, the timbre only slightly changes, but then from 1:34 to 1:38 it changes to become significantly harsher and the filter sweep also creates a crescendo.

Another noise sweep that is linear occurs in "Turning Point" by Deadmau5. Earlier in this chapter and in chapter 2 I explained how a crescendo in the bass layer with a harsh timbre contributes to the increasing tension in the buildup section. There is also a short, two-measure noise sweep that occurs just before the new core section. Figure 5-25 shows that this short ascending noise sweep has a linear shape, with the filter cutoff being continuously raised at a constant rate of change.

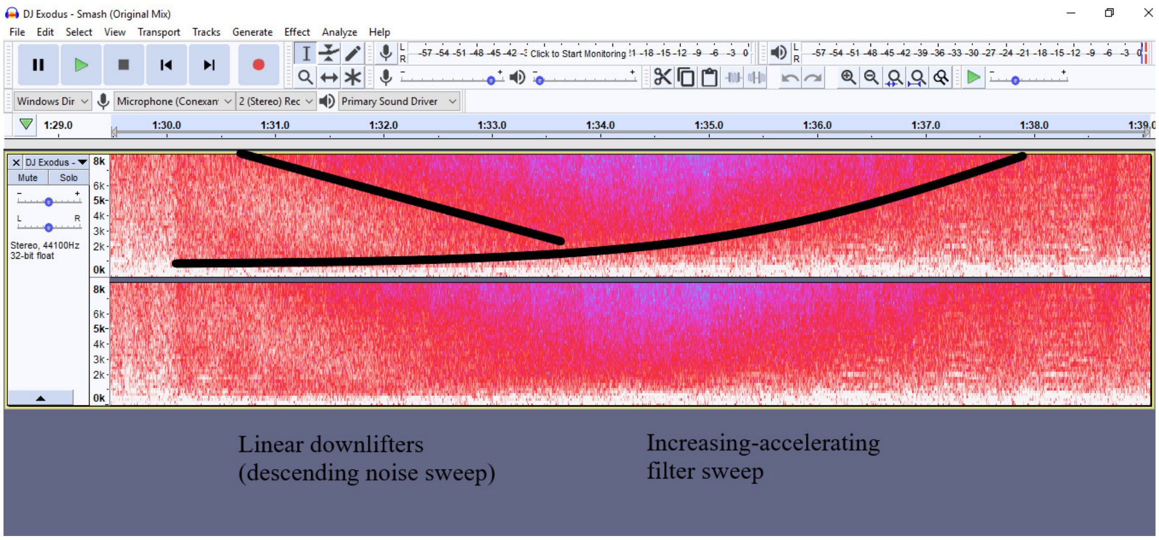

Figure 5-24: Shapes of filter sweeps for the first part of buildup 1 (1:29–1:36) in "Smash" by Exodus (2014).

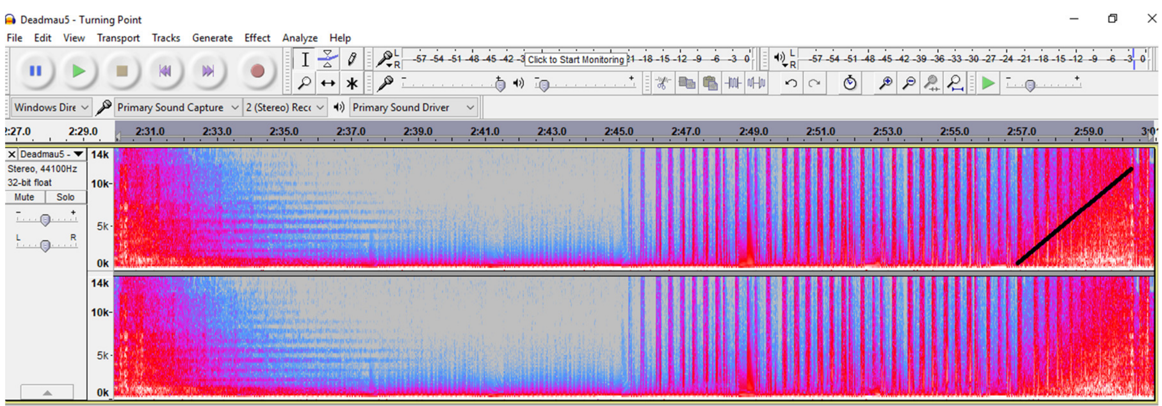

Figure 5-25: A linear ascending noise sweep at the end of the buildup (2:56–3:00) in "Turning Point" by Deadmau5 (2007).

Not all noise sweeps are linear however. In chapter 3 I discussed how many sections of "Star Guitar" by The Chemical Brothers begin with descending noise sweeps, and I showed a spectrogram of a section that also includes short crescendos and diminuendos. A close-up of one of the descending noise sweeps is shown in Figure 5-26. This reveals that the shape is one of exponential decay, with a decreasing-decelerating curve. Due to this shape, the beginning of the sweep sounds more salient than the ending, and the effect is one of a sudden and sharp descent that eventually flattens out.

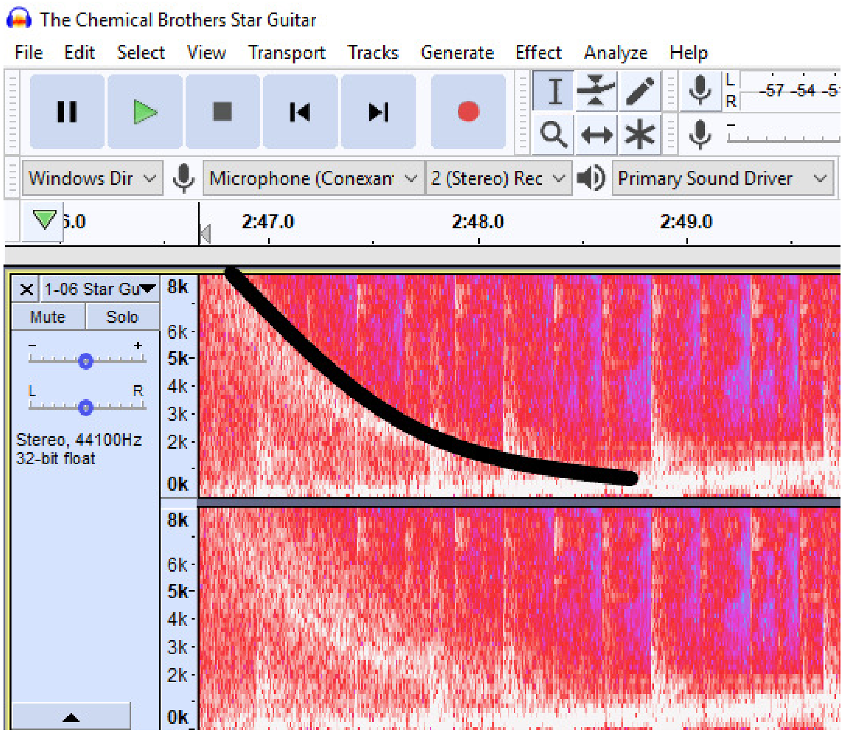

Figure 5-26: A descending-decelerating noise sweep from 2:47–2:49 in "Star Guitar" by The Chemical Brothers (2008).

In "First House" by Sebastian Davidson, linear filter sweeps are used to change the timbre of the voice. Throughout the track, the singing voice says "I've got a feeling woo" repeatedly, but sometimes it is much more subdued than others because of a dull timbre created by not allowing the higher frequencies of the voice to sound. Twice in the span of one minute a filter sweep is used to make the vocal timbre more pronounced and resonant, as shown in Figure 5-27. The first time (2:23–2:30) occurs in a buildup section, and notably it ends four measures before the next core section begins at 2:39. A crescendo takes place from 2:30 to 2:39, so that in the two four-measure spans preceding the drop at 2:39, different continuous processes are used to build the energy level of the track in different ways. The second filter sweep that changes the voice occurs in the core section, from 3:07 to 3:11. In this case, the timbre continuously changes for a shorter period of time, and at 3:11 it discretely (suddenly) becomes brighter. The white line that continues to ascend in the spectrogram but also becomes fainter accounts for the high-pitched noise that is also ascending during this time.

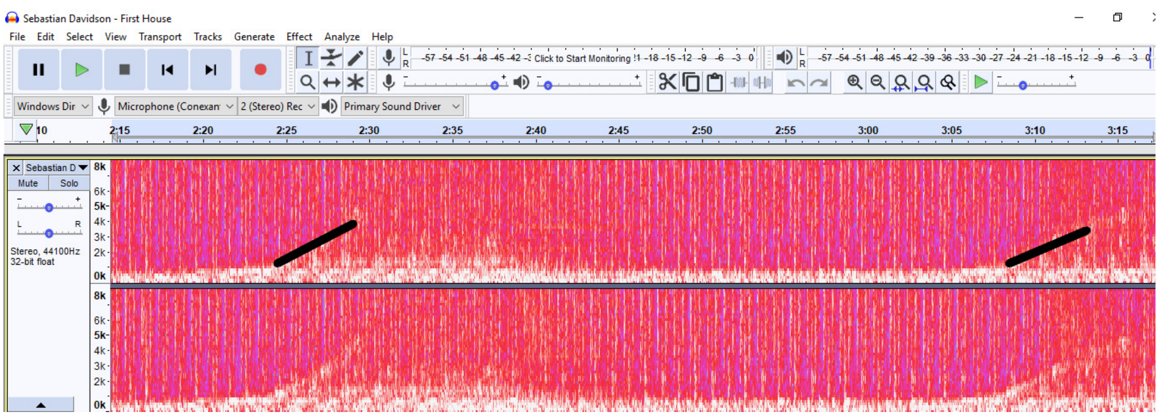

Figure 5-27: Linear ascending filter sweeps in "First House" by Sebastian Davidson (2016).

A final example for this section nicely shows three different continuous processes and their different shapes. The spectrogram for one of the buildup sections (from 3:01 to 3:16) in Redub's remix of "Summer Feeling" by Nafis is shown in Figure 5-28, and annotated to show different shapes of three continuous processes. This track was discussed in the section on filter sweeps in chapter 2, but now I will discuss it with respect to shapes. The section starts with a linear descending noise sweep, which makes the high frequencies fade out. This takes place over approximately three measures. In the fourth measure of the section, ascending pitch slides start continuously rising over two octaves. These pitch slides take the shape of an increasing-accelerating exponential curve, ascending faster and faster towards the end. Finally, two measures before the end of the section and the start of the next core, a low-cut (high-pass) filter continuously removes low frequencies from the texture. This happens for seven beats, and then on the last beat of the section, tension is released and the low frequencies are re-introduced, not suddenly, but quickly with a linear motion. The resulting shape of the two filter sweeps is a triangle, as shown in the annotated spectrogram.

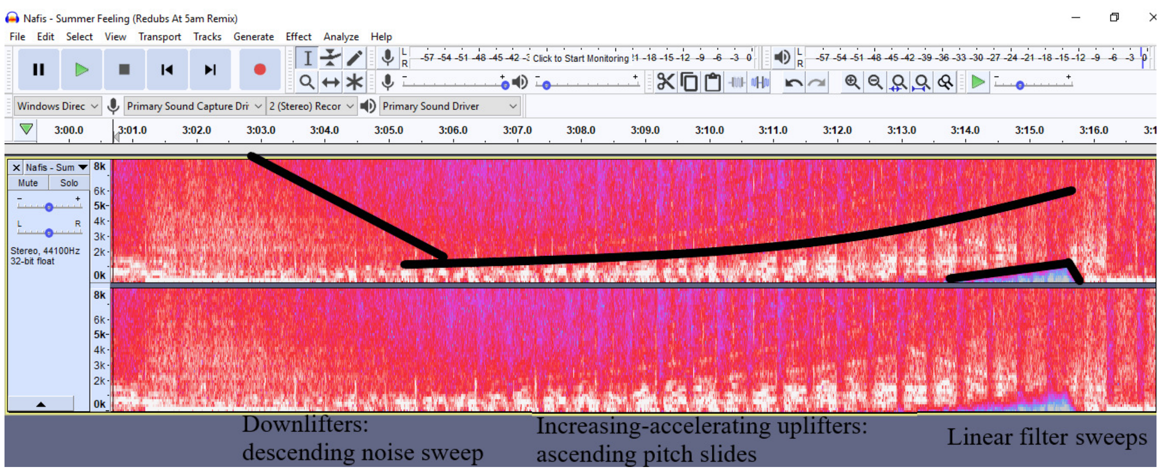

Figure 5-28: Linear and exponential shapes for filter sweeps and pitch slides in "Summer Feeling" (Redub's At 5am remix) by Nafis (2013).

Guidelines 6–8 for Comparing the Salience of Continuous Processes

In chapters 2 and 3, five analytical guidelines were developed for comparing the salience of continuous processes in contemporary EDM. Salience was defined as a multifaceted concept encompassing prominence, memorability, and significance. Chapter 1 defined a single continuous process as applying to only one perceived parameter and lasting until continuous change is no longer audible, or until the next musical marking point happens as determined by meter or phrase structure. Wave-shaped changes in any parameter are generally considered to be one continuous process that includes both an increasing and a decreasing part. The first two guidelines have to do with relative loudness and distinctiveness, and the next two concern groups of continuous processes that happen at the same time being more salient than individual ones. Guideline 5 was presented in chapter 3 and has to do with how frequently and consistently continuous processes are repeated. Guidelines 6–8 have to do with the shapes of continuous processes.

6) A continuous process that lasts a greater *length* of time is more salient than a continuous process that lasts a shorter length of time.
7) A continuous process that has greater *depth* of change in its parameter is more salient than a continuous process that changes its parameter less.
8) A continuous process that has a higher rate of change (in magnitude) is more salient than a continuous process with a lesser rate of change (in magnitude).

Guideline 6 simply says that longer continuous processes are more salient than shorter ones. This may seem counter-intuitive, given that short continuous processes can be quite salient as shown in chapter 3. Generally, however, longer ones are more memorable and often have more of a structural function in EDM tracks, as will be discussed in the next chapter. Continuous processes are inherently unstable, and this creates musical tension (which will also be discussed further in the next chapter). The longer a process lasts, the more tension is created, and thus the more salient the process becomes. Huron and Patty both write about "delaying" the resolution of something musically unstable as a method for increasing tension.[36] Huron says that "larger changes in physiological arousal require more preparation time," and "delay tends to magnify the tension response."[37] Speaking specifically of buildups in tension leading towards musical climaxes (which long continuous processes often participate in), he adds that the extended length of continuous processes allows listeners to "better recognize the clangorous, disorienting, and stressful character of the climactic build-up."[38]

In "Find a Way" by Wolfgang Gartner feat. Snow Tha Product, guideline 6 is highly useful for comparing the salience of different continuous processes. This track was discussed in both chapters 2 and 3, where it was noted that uplifters of different lengths occur. The final buildup utilizes uplifters throughout the entire section (2:30–2:45), leading to a climax at the start of the final core, whereas other uplifters (for example at 1:51 and 2:06) are short and are used to highlight less important hypermetric downbeats within a core section. Under guideline 6, the longer uplifters are more salient and in the foreground of perception than the others.

Guideline 7 says that a continuous process with greater *depth* of change in its parameter is more salient than a process with less depth. The term depth is being used here to indicate the *amount* of change in a musical parameter. For example, if a pitch scoop goes from C4 to C5 (an octave) it will be more salient than a scoop from C4 to C2. Similarly, the more a crescendo changes its volume, the more salient it will be, and the more an acceleration changes its speed, the more salient it will be. Continuous processes

[36] Huron (2006, 319–326); Patty (2009, 338–339).
[37] Huron (2006, 319, 325).
[38] Ibid. (326).

with greater depth have more instability than those with less depth because they contain more change. However, this guideline needs to be considered in conjunction with guideline 6 in order to evaluate the *rate of change*, which is the basis of guideline 8.

The rate of change represents how much a continuous process is changing its parameter over time. It can be visually represented by the slope of any line or curve, and the function for the rate of change of a curve is its first derivative. Guideline 8 combines the previous two, saying that a continuous process with a steeper slope is more salient than one with a less steep slope. In other words, a continuous process that changes its musical parameter significantly within a short amount of time is more salient than one with less parameter change over the same amount of time *or* one with an equal amount of parameter change taking a longer time. This may seem contradictory with guideline 6, but guideline 6 still holds as an individual assessment.[39] In general a pitch slide that takes place over eight measures will be more tense and salient than a pitch slide that takes place over four measures. However, the rate at which the metaphorical distance of parameter change is being traversed is an important indicator of how salient a continuous process will be. Guideline 6 (length) is especially useful for comparing processes with the same depth, and guideline 7 (depth) is highly useful for comparing processes with the same

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[39] Patty (2009) might argue that my guideline 8 validates the "pace-tension hypothesis" which he debunks. He says that acceleration does not necessarily correlate with increasing intensity (347, 366), but only because in situations where deceleration *combines* with intensification in other parameters (such as volume increasing, pitch heightening, or texture thickening) (329), the "struggle scenario" ensues and tension is increased (335). In his analyses of late nineteenth-century works he combines processes of intensification or abatement with acceleration or deceleration to create "pacing scenarios," whereas in most of this dissertation I separate these into different processes for clarity. In the next chapter on function I will discuss the combinations of continuous processes more. For now, it is sufficient to say that accelerations in sound layers with repeated continuous processes increase the rate of change and therefore increase the salience of the repeated continuous processes, so the pace-tension hypothesis holds when only applied to one long continuous process (an acceleration or deceleration) at a time.

length. Guideline 8 (rate of change) is relevant for comparing the salience of processes with neither the same length nor the same depth.

Note that guidelines 6–8 all have practical limits of applicability based on perception. The continuous process must contain enough change so as to be perceived as a change and as a continuous change, but it cannot have such a high rate of change that it becomes perceived as a discrete jump rather than a continuous slide. Processes that happen so quickly that they are almost instantaneous but can still be perceived as changes fall under the category of microrhythm as explained in chapter 3. This can also be explained geometrically as shown in Figure 3-12, since the rate of change can be represented by the steepness of the slope on a line or a curve. In general the more vertical a line is the higher the rate of change is, but it cannot be entirely vertical (infinite rate of change, like a discrete jump) or entirely horizontal (no rate of change, no continuous process). This is why there is a continuum between discrete processes and continuous ones.

The salience of a continuous process under each of these three guidelines can also be changed for repeated continuous processes within a track, and the rate of change can change *within* a single continuous process, so that the salience of a continuous process can be altered while it is still going on. For linear shapes, guideline 8 can easily be used to compare entire continuous processes, since lines have a constant rate of change. Continuous processes that can be represented by steeper lines are more salient than those that can be represented by less steep lines. Other curve types, however, change their salience as they go on according to guideline 8. Sinusoidal and sigmoidal curves, for example, are most salient when they are in between their highest and lowest points, since the rate of change is slow just before and after those points. Also according to this guideline, the two types of exponential curves that "accelerate" (that is, the magnitude of their rate of change increases) become more and more salient as the change to their parameter happens faster and faster. The two types of exponential curves that "decelerate" become less and less salient as the change to their parameter happens slower and slower. If a linear process and an increasing-accelerating process take place at the same time, the linear process may be more salient at first, if it has a steeper slope, but then the increasing-accelerating one could eventually become more salient as the steepness of the curve increases.

Earlier in this chapter, the shape of the pitch slide from 1:30 to 1:45 in Aback's remix of "Everything is Bright" was discussed. Due to the increasing-decelerating curve shape (shown in Figure 5-21), the rate of change slows down as the process goes on and therefore the pitch slide becomes less salient. However, just after the graph in Figure 5-21 ends, the long continuous pitch slide morphs into repeated short continuous pitch waves. These waves become taller and taller, with the highest and lowest pitches ascending and descending respectively, in a wedge progression. This means that the depth of each consecutive wave increases in a continuous process. The length of each wave only changes slightly, if at all, so it is useful to compare the salience of each wave with guideline 7 and notice that each consecutive wave is more salient than the previous one because of its greater depth. Therefore, despite the steepness of the long pitch slide decreasing, the overall salience level of this sound layer increases as the section goes on, leading anacrustically to the start of the next section.

The final example for this chapter comes from "James Brown is back (club mix)" by the German duo Spencer & Hill. This track contains many short continuous processes throughout, and their salience sometimes continuously changes. The first buildup can be thought of in three subsections, starting at 0:53, 1:08, and 1:23. Figure 5-29 shows the basic outline of the four-measure harmonic loop that happens twice in each of the first two subsections. In the first part (starting at 0:53), the length of each note is actually roughly a sixteenth note, and no pitch slides take place. In the second part (1:08), the length of each chord is now about equal to an eighth note, and each chord contains a short continuous pitch fall on every note. The third part (1:23) just repeats the C-sharp major chord, now with little to no rests between each chord, and pitch falls that have more depth. From 0:53 to 1:23, a discrete process has taken place, with the chords becoming suddenly longer and the pitch slides becoming deeper at each step of the process. According to guideline 7, the pitch slides at 1:23 are more salient than the pitch slides at 0:53.

Figure 5-29: The basic outline of the four-measure harmonic loop in the first and second parts of the buildup in "James Brown is Back (Club Mix)" by Spencer & Hill (2012).

From 1:23 to 1:38, an acceleration occurs in the final part of the buildup. It is difficult to tell if it is a discrete acceleration or a continuous one, but it is easily perceived as continuous, especially towards the end. During this time, the depth of the pitch falls continuously decreases, making each one less salient than the last under guideline 7. Furthermore, since each pitch fall is also becoming shorter and shorter in length, the rate of change is also decreasing so each one is less salient than the last under guideline 8. It is likely that the same sample of the chords is being used for all parts of this buildup, and that the varying depth of the pitch slides is a result of the varying lengths of the chords. Nonetheless, the effect created is one of not only lengthening and shortening the chords, but also increasing and decreasing the depth of the pitch falls. Even though the pitch falls are becoming less salient as the section draws to a close, the acceleration combined with an ascending pitch slide in the high-pitched layer that has a sci-fi "laser" effect, are more than enough to increase the energy level of the track in this buildup. The acceleration even makes the chords so fast that their rhythm turns into a low frequency at the end.

Conclusion: The Importance of Shapes in the Musical Experience

This chapter has shown how the various shapes of continuous processes contribute to their roles in contemporary EDM tracks. Music is experienced through the shapes of its gestures, and the shapes of continuous processes influence aspects such as their salience and how it evolves over time. They also influence categorizations of processes as either long or short, and clearly discrete, clearly continuous, or neither. The customizability of automation curves in DAWs and the realities of improvised live performances make the possibilities, and therefore the aesthetic effects of shapes, basically limitless. Furthermore, the shapes of continuous processes can be manually altered for virtually any parameter that you can think of.

However, there are some general correlations between the archetypal shape of a continuous process and its place in the categories discussed in chapters 2 and 3. Long volume changes are usually linear, although they are often perceived better in logarithmic shapes, especially for fade-ins and fade-outs. Short volume changes created with the tremolo effect are usually sinusoidal because the generating wave type from the LFO is most often a sine wave. Accelerations and decelerations are usually in the shape of one of the four prototypical exponential curves, for example the increasing-accelerating exponential growth curve or the decreasing-decelerating exponential decay curve. Pitch slides and filter sweeps take on a wide variety of shapes, including linear, sigmoidal, and exponential curves.

The types of curves discussed in this chapter are also generalizable and can be used to represent techniques other than continuous processes in EDM. Briefly examining some other uses of these shapes can help us better understand their aesthetic effects in EDM. Exponential acceleration can be seen in the prototypical Schoenbergian sentence, which divides a phrase into segments of 8, 8, 4, 4, 2, and 2 beats respectively. This can be thought of as exponential growth in terms of events per duration. The first part of the phrase has one segment and eight durations (beats) so it can be represented by the number 1/8, then the second part 1/4, then the third part 1/2. Framed this way it is easy to see that the numbers are growing exponentially larger.

The exponential acceleration that takes place in a Schoenbergian sentence also models a common strategy in joke-telling. In comedy, knowing how long to stay with a particular act of humor before moving to another one is important because the audience will get restless. Within one particular comedic scene or act, new actions or lines must be done or spoken before the audience gets bored, and they will get bored more quickly with each new variation of a particular scene.[40] An example of this occurs in the movie *Harry Potter and the Prisoner of Azkaban* (2004) when Harry accidentally inflates his aunt Marge, and the scene grows exponentially more absurd to generate the most humorous response.[41]

Sinusoidal functions are also used in other forms of entertainment outside of music. For example, roller coasters can often be best represented by a sinusoidal curve. On a roller coaster, the increase in height and the tension accompanying it before the climactic descent that creates an adrenaline rush correlate well with musical experiences of heightening pitch or increasing volume before a climactic moment such as a beat drop.[42] The experience of listening to sinusoidal or sigmoidal continuous processes in EDM is therefore similar to the experience of going on a roller coaster, and this is in fact what Deadmau5 describes in his masterclass.[43]

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[40] Reisz and Millar discuss the importance of timing in film editing for comedy, and specifically recommend that when variations on the same joke are repeated, they should become shorter and funnier each time. In one exemplary scene they also describe an acceleration in the rate of visual cuts. Reisz and Millar (2010, 81–85).

[41] This scene takes place from 2:30 to the end in this video. https://www.youtube.com/watch?v=nBtVptIIJOU. EvoClanDK (2011).

[42] Huron (2006, 325–326).

[43] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 13, 11:02–12:00). Deadmau5's thoughts on this will be explored more fully in the next chapter.

The shapes of continuous processes are important aspects of their utilization in contemporary EDM tracks. Understanding the general curvature of them helps us to understand when and why they are utilized, and how they shape our own listening and dancing experiences. Even if we do not know the intricate details of each continuous process, we hear the music *through* general shapes, and the ups and downs make the music exciting. The next chapter continues to build on this theme, focusing on the various formal functions of continuous processes in EDM tracks, especially during breakdown and buildup sections, which have general aesthetics of disorientation and tension respectively.

Chapter 6 – The Functions of Continuous Processes and the Aesthetics of Breakdown and Buildup Sections

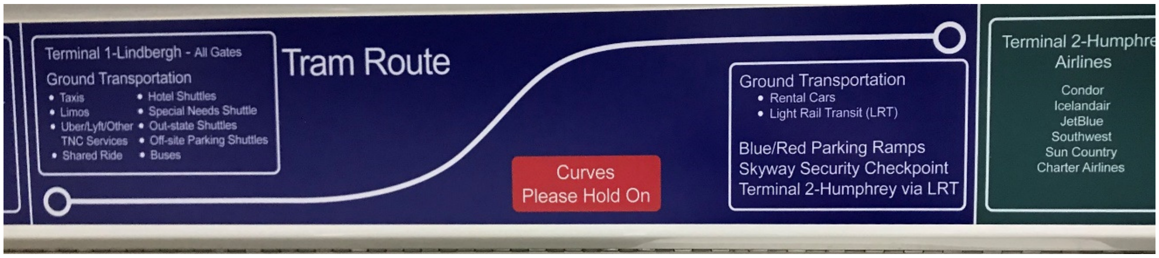

Figure 6-1: Map inside a tram at MSP airport.

Curves: please hold on. This instruction is apt for both riding the tram at MSP airport and for experiencing EDM. Listening to an EDM track is like going on a ride, and curves in the musical shapes create instability that is tense, but part of the pleasurable experience. Previous chapters have shown many examples of continuous processes in contemporary EDM, and focused on their categories, salience, and shapes. This chapter examines the functional roles of continuous processes in EDM tracks, and how they contribute to an overall aesthetic and prototype for this kind of music. Continuous processes generally take on more significant roles in “non-dancing” sections of tracks, such as breakdowns and buildups, rather than the main “core” sections. This is because they are associated with change, instability, and the buildup or release of tension, and the aesthetics of breakdown and buildup sections are of instability and tension. Therefore this chapter will focus mostly on the roles of continuous processes in breakdowns and buildups as markers of disorientation and transition.

The first part of the chapter will provide an overview of scholarship on form, climax, functionality, and aesthetics for EDM in general, showing how this literature has historical origins in the traditions of energetics and music psychology that theorize musical tension and expectation. Previous scholarship on EDM has shown the importance of breakdowns, buildups, and beat drops as formal markers and sonic instructions for dancers.[1] However, these have not previously been linked with continuous processes. It has been shown that filter sweeps and "upward" gestures are very common in buildups,[2] but in this chapter I want to argue further that a high level of continuousness, often due to multiple salient continuous changes in many sound layers at once, is common in breakdown and buildup sections, and that this continuousness contributes significantly to the aesthetics of disorientation in breakdowns and tension in buildups.

The second part of the chapter will outline all the different functions of continuous processes in EDM tracks, including less common and less obvious ones. Although continuous processes in general occur more frequently and with more salience in breakdowns and buildups, they can also be utilized in intros, outros, and cores. Short continuous processes (which last two measures or less) are more frequently used in cores than long ones. They often have an embellishing function that makes melodies and rhythms sound more slippery and less stable. They can also orient listeners to important points that reinforce the duple hypermeter of EDM at various levels. For example, soft noise sweeps in the background of the texture often precede and follow the midway point of cores.

The third section of the chapter will focus on the role of continuous processes in breakdowns. Breakdowns are defined by their thin texture due to the removal of many sound layers and often the removal of all drum parts that outline a clear beat. The

[1] Butler (2006, 206–254); Peres (2016, 19–20); Zeiner-Henriksen (2010b).
[2] Peres (2016, 17–19); Solberg (2014, 67, 70).

purposes of this sectional type are to provide dancers an opportunity to rest in between cores and to make the beats and melodic “hooks” more emotionally powerful when they return. Since there are relatively few sounds and often no drum parts, listeners often lose their place in the groove and cognitively or physically disengage with the music during this time.[3] Confusion and disorientation ensues, often due to metrical dissonance as shown by Butler,[4] but also often due to continuous processes creating instability that is highlighted due to the lack of discrete drum beats as reference points.

The fourth part of the chapter will focus on the aesthetics of buildups and show how continuous processes combine with discrete ones to create increasing tension in these sections. Buildup sections signal to dancers that there will be a new core section upcoming. They allow listeners time to get ready to dance with full energy again by mentally and physically reorienting themselves to the beat. The continuous processes in buildups lead to increased tension that is part of a prototypical three-step formula of a continuous build, then a sudden drop off and a cue, then an instantaneous climactic “drop” at the hypermetric downbeat and the start of a core section. The continuous build usually features ascending pitches and/or large crescendos, collectively known as a riser.

Since risers in buildups are psychologically linked with climactic drops, they are highly salient in the EDM experience. This is the basis for the final guideline for comparing the salience of continuous processes, guideline 9, which states that a continuous process is more salient if it immediately follows or precedes a structurally significant moment than if it does not. The final section of the chapter applies this

[3] Solberg and Jensenius (2016, 309).
[4] Butler (2006, 138–175).

guideline to some examples, and briefly discusses how all nine guidelines can be used together in analysis.

The General Form and Aesthetics of EDM: Energetics, Tension, and Expectation

Existing analytical scholarship on EDM has emphasized the importance of tension and release, heightened expectation leading towards climaxes, and a narrative of disorientation followed by clarification.[5] EDM tracks are based on the alternation of main dancing sections, which have high levels of energy and groove, with non-dancing sections that either buildup or release tension and often lack consistent or clearly-articulated beats. The former, dancing sections are cores, and the latter, non-dancing sections are intros, outros, buildups, and breakdowns.[6] The non-dancing sections can still usually be danced to because beats are often present, if not clearly articulated in multiple drum layers, but these sections are marked by *not* being cores. They are associated with instability and transition, and if dancing happens during these sections it is usually less energetic. Core sections, which usually start with climactic drops, are very energetic, and they are comfortable for listeners, as opposed to the uncomfortable (tense) buildup sections.[7]

The important moment of the drop releases the tension that has been mounting in the buildup section, which usually contains highly-salient continuous processes. Butler notes that dropping the beat is part of the important process of "disorientation followed

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[5] Butler (2006); Butler (2014); Eigenfeldt and Pasquier (2013); Hawkins (2003); Redfield and Thouin-Savard (2017); Solberg (2014).

[6] For a more detailed description of these terms and the typical form of an EDM track see chapter 1.

[7] In general in this chapter I use the terms "energy" or "energy level" as an alternative to "intensity," since the latter could be confused with tension. By tension I mean the uncomfortable sense felt in listeners during buildup sections and sometimes breakdown sections. The tension created in a buildup section is released at the start of the next core, which is filled with intensity, not tension.

by clarification" that listeners experience, and that the drop is "usually preceded by manipulation of the effects."[8] This is noteworthy because as discussed in chapter 3, "effects" is one of the terms that is often used to describe continuous processes in general. Drops are also highly anticipated and expected, because of the continuous processes (usually risers) that precede them, and because they are conventional in EDM. This makes them more climactic psychologically.[9]

Many EDM scholars and producers have discussed drops as emotional and psychological climaxes. Solberg has empirically studied the psychological and physical effects of drops in club experiences, showing that drops correlate with high amounts of pleasure and body movement.[10] Snoman also describes emotional responses in listeners, saying that the "main body" of the track provides the highest amount of pleasure.[11] As we saw in chapter 1, he describes the general aesthetics of EDM too, saying that all dance music "deals mostly in emotional waves, consisting of building and dropping the arrangement to generate an emotional state in the audience."[12] Similarly, the superstar producer Armin van Buuren discusses listening to EDM as like surfing on waves of energy. "You're waiting for the next wave and when the wave comes, that's the drop. It's the kick in the bass. You want to be on your board and the wave needs to take you to the beach."[13] Hawkins takes a more historical and cultural approach, describing drops as part of the rhetoric and narrative of house music.[14] Both Solberg and Hawkins incorporate

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[8] Butler (2006, 246–247).
[9] Huron (2006, 325).
[10] Solberg (2014); Solberg and Jensenius (2016).
[11] Snoman (2009, 224–228).
[12] Ibid. (269).
[13] "MasterClass | Armin van Buuren Teaches Dance Music" (2018, lesson 17, 0:00–0:30).
[14] Hawkins (2003).

spectrograms that highlight the continuous nature of the buildup (particularly the gradual increase in high frequencies) and the discrete, instantaneous nature of the drop, but neither specifically address it in these terms. Beat drops are inherently linked to the breakdowns and buildups that precede them; the power of the drop cannot exist without the increase in tension that happens before it.

Similar phenomena have also been discussed in pop music in general, outside the world of EDM. Peres discusses beat drops and climaxes in recent "top 40" music, noting how the continuous processes of filter sweeps are used in buildup sections.[15] His dissertation focuses on how timbre and tone quality (collectively called "the sonic dimension") are the main sources of musical functionality and energetic motion in today's popular songs, rather than melody and harmony. Attas also explores the importance of buildups, specifically in the introductions of popular songs.[16] However, she outlines this in terms of adding new layers one by one, in the same manner as what Spicer calls (ac)cumulative form in rock music.[17] The sudden addition of new layers one at a time is indeed a common and important part of popular music aesthetics, but the continuous processes of fade-ins and fade-outs are also quite common. Osborn also discusses climax in recent rock songs, showing instances of "terminally climactic form."[18] In songs exhibiting this shape, the choruses provide only local maximum points of energy, whereas a new section is added at the end that provides the true climax of the song.

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[15] Peres (2016).
[16] Attas (2015).
[17] Spicer (2004).
[18] Osborn (2013).

This research by Attas, Osborn, Peres, and Spicer is part of a large amount of scholarship on form in pop music written in the twenty-first century.[19] More broadly, however, this strand of research, which will inform my analysis of the functions of continuous processes in EDM, can be traced back to the form-centered theories of musical energetics. There is a long history of describing music as energetic and dynamistic, containing forces that push and pull the music in certain ways,[20] but in the early twentieth century a specific school of thought developed that discussed music with terms from physics such as force, energy, and power in a more thorough way than past scholarship. This is known as musical energetics.

Two of the first to articulate these ideas so strongly were August Halm (1869–1929) and Heinrich Schenker (1868–1935).[21] Halm believed that music contains forces creating a tonal ebb and flow. For example, the interval of a major third is the "impelling force (*Trieb*) and germ of movement."[22] Similarly, Schenker regarded music in terms of forces such as the "biological urges" of the tones.[23] In *Free Composition* (1935), Schenker says that musical form is "in an almost physical-mechanical sense… an energy transformation – a transformation of the forces which flow from the background to the foreground through the structural levels."[24]

Another important theorist of musical energetics was Ernst Kurth (1886–1946). He wrote three analytical monographs, each talking about the energy and forces in music,

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[19] Examples include Biamonte (2014); Endrinal (2011); Neal (2007); Nobile (2011); Summach (2011).
[20] The historian of music theory Lee Rotharb provides a useful overview of this in Rothfarb (2002).
[21] Halm first wrote about it in his *Harmonielehre* (1900), and Schenker in his *Harmonielehre* (1906). Ibid. (937–939).
[22] Ibid. (937).
[23] Ibid.
[24] Ibid. (939).

but the last of these is most relevant to the discussion here. In *Bruckner* (1925) he says "The conflict between becoming and being is the never-ceasing primordial tension of the concept of musical form."[25] His main concept that he poses related to musical form is the "force wave," which has "escalatory and de-escalatory undulations that shape the musical flow."[26] Similarly, Arnold Schering (1877–1941) and Hans Mersmann (1891–1971) frame all musical activity, not just harmony and melody, in terms of alternations between tension and release. These theories work very well for describing musical form in EDM and our experiences of it, even though the techniques causing the undulations are different than those in the music analyzed by these early energeticist scholars.

Later in the twentieth century music theorists began to classify *tension* more systematically. Hindemith (1937) created a system for evaluating tension in chords and defined "harmonic fluctuation" as the "shift of harmonic gravity."[27] Berry (1976) says that the intent of his book is "exploring a mode of musical meaning expressed in relations in contextually shaped processes of *mounting and receding intensity*, processes and relations involving the entire spectrum of elements."[28] He describes this varying intensity through "intensity curves," and outlines what increasing intensity sounds like for different musical parameters: ascent in pitch, dissonance and modulation in harmony, acceleration in rhythm and tempo, thickening in texture, and sharpening in timbre.[29] He further says that "The capacity of related musical events to convey the sense of intensity

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[25] Ibid. (943).
[26] Ibid.
[27] Hindemith (1941, 99–108, 115–121).
[28] Berry (1976, 26). Emphasis mine.
[29] Ibid. (4, 11).

(dissonance, complexity, instability) and release (resolution, stability) is of fundamental importance in the musical experience."[30]

Lerdahl (1996) came up with a method of calculating tonal tension, and Krumhansl (1996) corroborated his system by showing that listeners in an experiment thought similarly about Mozart's piano sonata K. 282.[31] The two authors also co-wrote a paper titled "Modeling Tonal Tension" in 2007.[32] In this article they state that tension is correlated with instability and relaxation with stability.[33]

Instability and tension have also long been associated with musical passages of transition. Riepel (1754) and A.B. Marx (1841) both describe *Gang* passages as athematic, syntactically-weak sections that transition between *Satz* sections with stable main themes.[34] The *Gang* sections are also defined by intense *motion* and quick, rushing passages. The lack of melodic themes with coherent syntax makes these sections less memorable, and therefore they function to not only transition between main themes (*Sätze*) but also to highlight them, making them more memorable and emotionally significant.[35]

Similarly, the German scholar Werbeck (2003) has written about passages of intensification (*Steigerung*) in the tone poems of Richard Strauss. He contrasts these passages with "static" ones, and says that the difference in functions of these sections is important to the formal structure of pieces such as *Don Juan* (1888).[36] It is important in

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[30] Ibid. (26). Note how Berry conflates the concepts of musical intensity/energy with tension.
[31] Lerdahl (1996); Krumhansl (1996).
[32] Lerdahl and Krumhansl (2007).
[33] Ibid. (329).
[34] Monelle (2000, 100–110).
[35] Ibid. (110).
[36] Werbeck (2003, 129–130).

the context of this dissertation on continuous processes that Werbeck specifically highlights "the significance of passages of intensification for musical continuity."[37] In the introduction of *Don Juan* for example, "The rhythm changes continuously, and the meter is uncertain, as is the harmonic center."[38] There is a connection between continuous changes and the functions of transition and intensification in buildup sections of EDM tracks too.

Other scholars have developed theories of *expectation* in music that are derived from energetics and relevant to the aesthetics of EDM. Zuckerkandl (1956) says that the "directional tendencies" we hear in musical tones "result in a continuous state of expectancy."[39] Meyer (1956 and 1973) thoroughly discusses feelings of expectation and suspense in music-listening experiences, using principles of Gestalt psychology to explain patterns of perception.[40] He talks about the aesthetic importance of "weak" shapes, caused through exaggerated differentiation, which generate intense desires for clarification and uniformity.[41] Narmour (1990 and 1992) took these ideas and created the implication-realization model of melodic expectation.[42] Huron (2006) has shown the importance of psychological expectations in music with his ITPRA theory representing the five responsive stages of imagination, tension, prediction, reaction, and appraisal during the expectation cycle.[43] He cites "upwards pitch glides," the use of vibrato,

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[37] Ibid. (129).
[38] Ibid.
[39] Rothfarb (2002, 949).
[40] Meyer (1956); Meyer (1973).
[41] Meyer (1956, 160–163).
[42] Narmour (1990); Narmour (1992).
[43] Huron (2006, 8–18).

crescendos, timbral changes, and accelerations as common techniques for building up tension in sections prior to climaxes.[44]

Patty (2009) lists pitch heightening, crescendos, and increasing textural density as methods of creating intensification, however he notes that tension can also be created before climaxes with *deceleration* in what he calls the "struggle scenario."[45] Larson (2012) theorizes metaphorical musical forces such as gravity, magnetism, and inertia in his book on melodic expectation.[46] Finally, another strand of musical analysis that relates to energetics and the aesthetics of EDM focuses on narrative and dramatic archetypes. Maus and Karl both explore narrative, drama, and plot in eighteenth- and nineteenth-century instrumental music, and Schmalfeldt incorporates musical narratives of processual becoming into her analysis of early-nineteenth-century musical form.[47]

The scholars described above that analyze "classical" Western music attempt to model our experiences of listening to music through a narrative that we empathize with; the empathic aural experience is a fundamental premise of energetics. Musical details suggest the narrative, but it is ultimately generated by us as listeners and analysts. The above scholars also describe our tension and being uncomfortable in a state of expectation when listening to music. As discussed above, the main narratives in EDM tracks are ones of oscillation between dancing and non-dancing sections, alternation of tension and release, fluctuations in energy levels, and buildups leading to climaxes. What

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[44] Ibid. (326).
[45] Patty (2009, 329–339).
[46] Larson (2012).
[47] Maus (1988); Maus (1991); Karl (1997); Schmalfeldt (2017).

musical components suggest these narratives and create different degrees of tension in EDM?

Some techniques that increase or decrease tension and/or energy in EDM are discrete. Specifically, Butler states that listeners correlate tension and energy levels with texture changes.[48] Tension is highly linked with the withholding of the beat and specifically the kick drum. The presence or absence of the kick drum is highly important in determining the amount of tension and the structural function of different sections in EDM tracks.[49] Another way tension is generated in EDM is through metric irregularity and metrical dissonance.[50] A third common discrete technique that increases tension in buildups is the snare-drum "roll" or "fill."[51] This was already discussed as an example of discrete acceleration in chapter 2, since the speeding up takes place in various stages such that the rhythmic values become twice as fast in each new stage.

As the examples in this dissertation show, however, continuous processes also contribute significantly to the increasing and decreasing of energy levels and tension in EDM tracks. Solberg highlights the importance of continuously-rising pitch slides as an extremely common aspect of buildup sections. Peres talks about "gradual ascending gestures" (filter sweeps and pitch slides) in buildup sections of pop songs,[52] noting that the sonic syntax of "setup-buildup-peak" he describes has its origins in EDM.[53] On filter sweeps in buildup sections, Snoman says "It is these filter movements that are typically

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[48] Butler (2006, 221).
[49] Ibid. (91, 247).
[50] Ibid. (138–175); Hawkins (2003, 92–94).
[51] Snoman (2009, 252, 266–268); Solberg (2014, 70).
[52] Peres (2016, 75–84).
[53] Ibid. (2–3, 73).

used to create tension and movement in all forms of dance music and have formed the basis of the most well-respected dance records."[54] These scholars do not discuss these processes in terms of continuousness though, as I do. The rest of this chapter will demonstrate how continuous processes function in EDM tracks, and how they fit within the established narrative described above.

An Overview of the Functions of Continuous Processes in EDM

Continuous processes represent the uncomfortable notions of change and instability. This is why they are used to symbolize fear, volatility, mental illness, and the like in music for films and video games.[55] It is also why they are used most often in EDM during breakdown sections and buildup sections, when disorientation and tension are the primary aesthetic traits. This will be discussed in much more detail in parts three and four of this chapter. Continuous processes can also be an important part of intros, outros, and cores, although this is less common and they are often less salient in these sections.

Broadly speaking, continuous processes add variety and complexity to music that is otherwise very discrete and repetitious; in EDM, melodies and harmonies are relatively simple, if they exist at all, and rhythms, while complex and groovy, repeat in short loops incessantly.[56] As discussed in chapter 3, continuous processes are often understood as "effects" that are not fundamental to the identity of a "work," but only to the identity of a particular text or performance (a particular version of the work).[57] In contemporary

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[54] Snoman (2009, 226).
[55] Brownrigg associates pitch slides and pitch destabilization with the horror genre of films. Brownrigg (2003, 118–121).
[56] The prominence of clear melodies and harmonies is one of the important markers of distinction between various EDM genres. Trance and house are much more melodic, whereas techno and "drum and bass" are more focused on rhythms and drum parts.
[57] Butler (2014, chap. 1).

culture where remixes are copious, continuous processes are not often part of the original "stems" of a track, but instead are added near the end of the production process or improvised during live performance.[58] This does not mean that continuous processes are not salient or not important to the musical structure of tracks though, as the examples in this dissertation show.

More specifically, continuous processes often provide a function of ornamentation or embellishment. Therefore, short continuous processes in EDM are similar to ornamentation in Western classical music. In that tradition and especially during the Baroque period, trills, vibrato and the like are often added to performances in repetitions of melodic figures, so that the second time a section is heard it is more interesting.[59] In EDM, short ornamental processes are generally used as part of musematic repetition in loops.[60] Depending on their salience, short continuous processes used in this way can either embellish and highlight the discrete melodies and rhythms, or destabilize them, altering their perception and encouraging the ambiguity and multiplicity of interpretations that are characteristic of EDM and all loop-based music.[61]

This can happen in any section of a track, not just breakdowns or buildups. There is, however, a significant difference between various *genres* of EDM in terms of which sections more often employ short continuous processes such as pitch slides. In genres that purposely highlight the digital nature of their creation such as techno, jungle, drum and

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[58] See chapter 3 and Butler (2006); Butler (2014); "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016).
[59] Neumann (1983, 572–573).
[60] Middleton (1990, 69).
[61] Butler (2006) repeatedly points to this as a theme of his book, saying that ambiguity and interpretive multiplicity of rhythm is a defining feature of EDM. However, it is also important to note that this is true for minimalism and other cyclic music as well.

bass, dubstep, breakbeat, electro house, and acid house, they are used more frequently and often featured in cores. Contrastingly, in genres that are more melodic and incorporate acoustic elements or vocals such as trance, big room, progressive house, and deep house, short continuous processes would be seen as too disruptive during core sections and are often used during breakdown sections to add instability in and of themselves.

Briefly revisiting some examples from previous chapters will be useful in discussing the role of short continuous processes as ornamentation that can create instability and ambiguity of interpretation. In both the core and the breakdown sections of "Space Junk" by Wolfgang Gartner, many short pitch slides make the discrete notes of the melody sound slippery and unstable, so it is hard to sing along with.[62] In "Musique" by Daft Punk, short timbre changes accomplished with filtering embellish the melody, which is very repetitive, in different ways throughout the track. The core melody in "Diamonds" by Popeska is based solely on a continuous two-measure pitch slide spanning a small melodic interval.[63] In this case it is difficult to discern any sense of a traditional melody at all.

Repetitive short continuous processes can also interrupt longer ones, creating brief discontinuities in them. For example, an ascending pitch slide that takes place over eight measures can be interrupted with low pitch scoops at time intervals that get shorter and shorter in stages, as heard in the buildup sections of "Tissot" by Bolivaro (first

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[62] To listen to these techniques, play the first core which starts at 0:59 and the first breakdown which starts at 1:29.

[63] The cores in this track begin at 1:30 and 3:00.

discussed in chapter 2).[64] This technique combines long and short continuous processes with discrete acceleration.

All of the short continuous processes described above are salient and affect the main melodic lines in tracks. They also create instability and ambiguity in varying degrees. However, short continuous processes can also be a part of the background, with less salience, and contribute to stability by orienting the listener toward important boundary points in the music. This is most commonly heard in the form of ascending or descending filter sweeps or pitch slides that start or end near hypermetric downbeats, signaling the arrival or mid-point of a new section or subsection. Peres shows numerous examples of this with ascending filter sweeps just before the mid-point of the chorus in contemporary pop songs.[65] He says this is much more common with white-noise filter sweeps that do not have a clear pitch, but an example to the contrary is "Find a Way" by Wolfgang Gartner feat. Snow Tha Product, which has short ascending pitch slides in the first half of the fourth and eighth measures of each core section (for example at 1:51 and 2:06 in the track), and descending pitch slides at the beginning of many different sections (for example at the start of the breakdown (2:15) and the outro (3:15)).

As already said, these short continuous processes that orient the listener towards sectional boundaries are usually not very salient for the listener, but one exception is what I called "pitch slide type B" in "Tissot."[66] In this case, the usual short process that

[64] The buildup sections in "Tissot" begin at 0:30, 1:19, 1:49, 2:56, and 3:26.
[65] Peres (2016, 79–82). About these he says "the pitch bend's function, like the filter sweep in its various forms, is to guide the listener toward a goal in a sweeping, ascending motion." Ibid. (84).
[66] This technique is heard in "Tissot" at 2:14, 2:30, 2:49, 3:20, 3:52, and 4:07.

serves to highlight the mid-point of the core is expanded into four measures, and it alters its salience through volume changes, being loudest in the middle.

In general, long continuous processes (which last four measures or longer) are most commonly used in buildup sections, as will be discussed in part four of this chapter. However, they are also regularly used in intros and outros, especially in the form of crescendos and diminuendos, as well as ascending and descending noise sweeps. In intro sections, sound layers that are rhythmic and repetitive often fade in to the texture, becoming gradually audible as the track is seemingly taking shape. At the end of many tracks, the outro section begins with a long descending noise sweep while most or all of the discrete repetitive elements of the core continue to play. The descending sweeps are used to calm the energy of the music down, and this translates to the psychological and physical states of dancers.[67]

Rarely, long continuous processes can also be used in core sections. In "Cthulhu Sleeps" (first discussed in chapter 2) the "pitched synth" slowly but continuously accelerates and ascends in the first core starting at 4:30, and in "Zero-Day" (discussed in multiple previous chapters) the deep pitch slides continue throughout most of the track, including cores. However, when long continuous processes are utilized in cores they are usually subtler and less salient, often in the background of the texture, so as not to disturb the stability and repetitive nature of the core. Overall, the functions of continuous processes in contemporary EDM can be summarized in four categories: orientation, disorientation, ornamentation, and intensification.

[67] Huron (2006, 326); Solberg and Jensenius (2016).

The Importance of Continuous Processes in the Disorientation of Breakdowns

The "breakdown" sections in EDM tracks are very important, because they allow dancers the chance to take a break so that they can dance again with renewed energy at the next core. These are the sections in which there are the fewest number of elements in the track, and the energy level is at its lowest. In order for dancers to be encouraged to rest their bodies, breakdown sections often have an aesthetic of confusion and disorientation. Multiple factors contribute to this.

First, most breakdown sections contain little to no drum parts.[68] The removal of drums and especially the kick drum that directly signals "the beat" makes listeners feel less grounded. Particularly in live performance, withholding the beat is a crucial part of EDM aesthetics and it is an important part of the interaction between performers and audiences.[69] Second, a main melodic motive (or sometimes more than one) from the core usually holds over and keeps repeating in the breakdown.[70] Since these motives are often syncopated or metrically dissonant with the drum parts, this creates confusion when they are heard by themselves. A common technique is for the melodic parts to be in some level of triple meter (with three-beat repetitions) instead of duple meter, so when a loop in triple meter sounds by itself, the duple meter outlined by the drums easily gets lost.[71]

[68] An exception to this is "This is the Hook" by Deadmau5, which comically explains the various sections of the track through a robotic narrator voice. As the first breakdown section begins at 2:00 the voice says "Now it is time for the breakdown. The breakdown allows the track to breathe and breaks the repetition. Let's filter the hi-hat. Let's filter the chords. Let's filter the bass." One of the only parts not to get filtered out of the texture in this example is the kick drum.
[69] Allen (2009); Butler (2006, 91).
[70] Butler (2006, 221); Snoman (2009, 226).
[71] By triple meter "at some level" I mean it could be at the quarter-note, eighth-note, or sixteenth-note level. Different levels of base units can each be "metrical" at the same time. Krebs (1999, 29–30).

Third, and most importantly in the current context, breakdown sections often feature continuous processes that contribute to the aesthetics of confusion. This is the aspect of breakdown sections that has been least studied in analytical scholarship. Butler only mentions it briefly in his research, saying that timbral manipulation and “tweaking” are common in breakdown sections.[72] By tweaking, he means using effects like pitch slides and reverb, or distorting the timbre of sounds (for example by increasing the amount of echo/delay to create the chorusing, flanging, or phasing effects).[73]

The first example I would like to show of continuous processes contributing to the disorienting aesthetics of breakdown sections is from “Superliminal,” the first track on Deadmau5’s 2012 album > *album title goes here* <. This piece can best be thought of in compound meter, with a time signature of 12/8, as shown in the transcription (Figure 6-2a). In the breakdown section (2:03–2:59), the main synth line of the piece which articulates eighth notes (what would be triplet eighth notes in 4/4 time) and its accompanying chords both hold over from the core, but the drums (on dotted quarter notes) and the bass (which provides a triple-meter feel with quarter notes in 12/8, creating metrical dissonance) are notably absent. Continuous processes contribute to the disorientation caused by this breakdown section in multiple ways.

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[72] Butler (2006, 92, 222–224).

[73] Ibid. (54, 225). For more information about chorusing, flanging, and phasing see page 132.

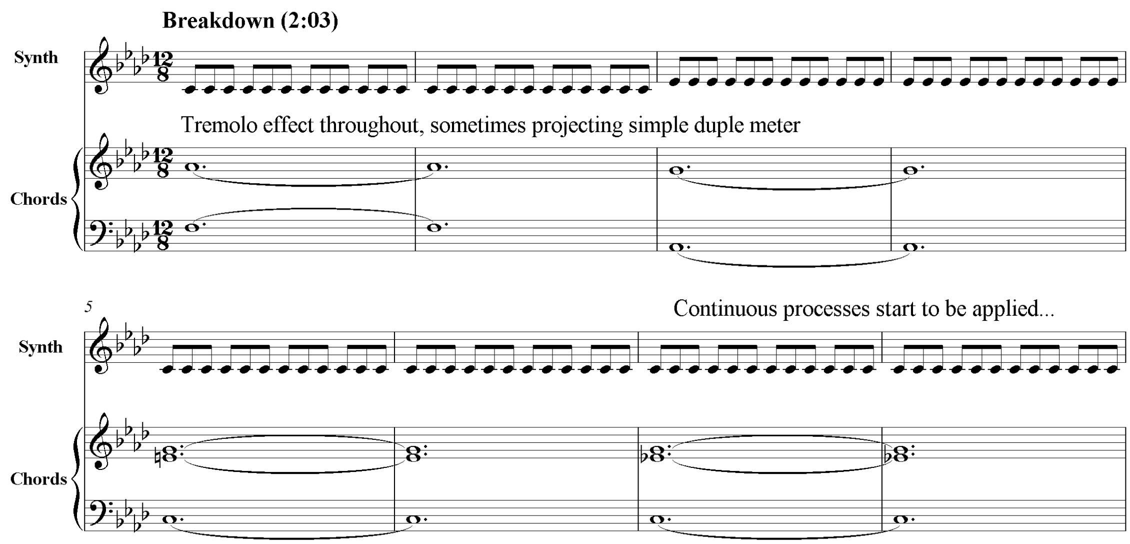

Figure 6-2a: Transcription of the beginning of the breakdown (2:03) in "Superliminal" by Deadmau5 (2012).

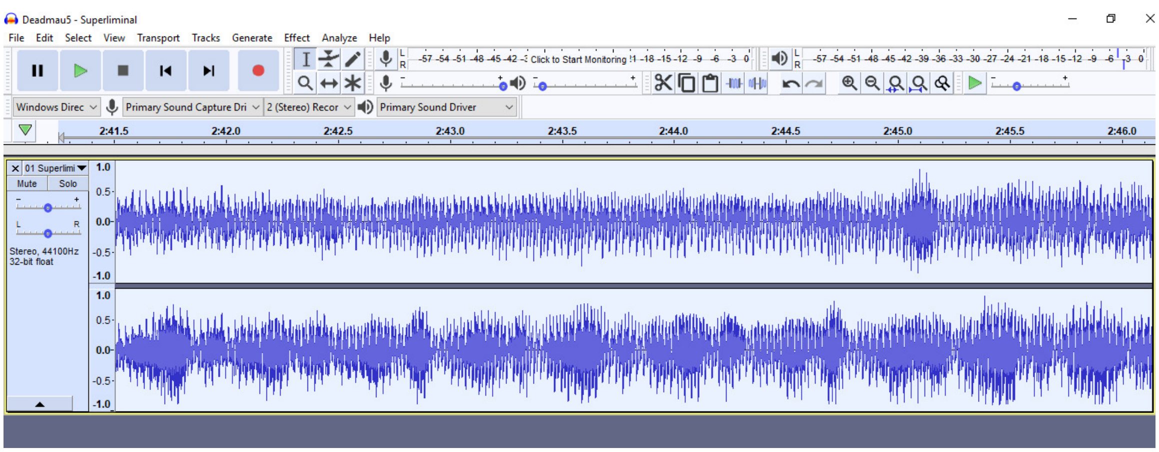

Figure 6-2b: Amplitude graph for 2:41–2:46, showing panning in "Superliminal" by Deadmau5 (2012).

The accompanying chords feature the tremolo effect throughout. In other words, even though it sounds like they have sustained notes changing every two measures on the downbeats (which helps provide some consistency and a sense of hypermeter), each chord swells continuously up and down in volume, creating rhythmic effects without re-articulation. The rhythm created by the tremolo effect is also not very clear. Sometimes it seems to be emphasizing each beat of the measure with its peak volume, and other times it seems to emphasize what would be “off beats” in simple meter (as in 4/4 time). Other times it is not clear at all what rhythm the tremolo effect is supposed to create with its pulsations. Figure 6-2b (the amplitude graph from near the end of the section, when the chords are featured alone without the accompanying rhythmic synth) shows that panning is also utilized significantly and seemingly randomly, which could be why the rhythms generated by the tremolo effect sound so unclear.[74] The continuous swells of the tremolo effect and the panning therefore create rhythmic confusion in this breakdown section.

Additionally, and more saliently, the main rhythmic synth line that articulates eighth notes undergoes a variety of changes in this section. Its utilization takes place in three stages. Stage one is the first six measures of the section (2:03–2:15), when it is used with a regular timbre, clear pitch, and clear rhythm, as it was used in the previous sections of the track. Over the next ten measures (stage two, 2:15–2:33) numerous continuous processes are used to alter this sound layer. Its timbre is changed, becoming filled with more frequencies so that no single pitch is clearly defined. Another sound also fades in and articulates a rhythm of displaced eighth notes, halfway in between the others, creating a resultant rhythm of sixteenth notes. This is a technique I described in chapter 2 as the “illusion of acceleration,” since it seems as if the rhythm is speeding up but it is actually caused by a crescendo in a different rhythmic layer. Then it seems as if delay and echo effects are used to complicate the rhythm even further, so that not only is the pitch unclear but also the rhythm is muddled. Volume changes are also used on this sound

[74] As discussed in previous chapters, panning is the change in volume between left and right speakers in stereo audio.

layer at the same time. The result is that in the middle of this breakdown section numerous continuous processes are being used as effects to create confusion on the part of the listener. Stage three (2:33–2:49) is just a fade-out, gradually removing the main synth line from the texture so that the tremolo effect in the chords is highlighted and the return of the eighth notes in the synth in the next section is made more powerful.

After this fade out, the listener can entrain a sense of meter again because the chords are still repeating every two measures and the tremolo effect is emphasizing pulses on every "off beat." However, this is a simple meter phenomenon, sounding like 4/4 time, and the start of the next section clearly returns to 12/8, so part of the function of the breakdown here is to lull the listener into a metric group of pulses that will soon be contradicted. They are being disoriented from the true prevailing meter of the piece. Therefore, even with the discrete and repetitive chord changes providing some stability, the lack of drum parts combined with the continuous changes applied to the synth sound and the tremolo effect in the chords successfully create an aesthetic of disorientation in this breakdown section.

A second example is from "Everything Before," the final track on Deadmau5's 2010 album *4x4=12*. In this breakdown section, from 3:30 to 4:00, the main techniques that generate disorientation are crescendos and panning. The section starts with a relatively simple texture and simple rhythms, shown in Figure 6-3. There is only some basic syncopation and metrical dissonance at first. Then with each two-measure repetition, more and more different rhythms are introduced using the upper two notes of the synth (F-sharp and C). The composite rhythm soon becomes constant sixteenth notes, alternating between two different parts. Then more layers are added, fading in and crescendoing to create more metric dissonance and more confusion.

Figure 6-3: Transcription of the start of the breakdown (3:30) in "Everything Before" by Deadmau5 (2010).

The usage of the right and left speakers differently is also used to great effect here, as is evidenced by listening to the section with only one speaker or the other. The right speaker repeats the same rhythm from the start over and over, although the timbre seems to change so that the attack gets more muddled. In the left speaker more complicated cross-rhythms are introduced, in addition to the initial rhythm.

By the end of the section, it is immensely difficult to mentally retain which one of the many sound layers is articulating the initial pattern, and therefore it is very easy to lose the beat. This is also partially because the other bass line (called "bass 1" in the transcription, Figure 6-3), which had helped retain some sense of hypermeter and where the downbeats are by repeating its motive every two measures, does *not* repeat for the last two measures in the section. This means that at the end of the section (3:52–4:00) four measures of extremely metrically dissonant sounds in the "synth" layer predominate and overwhelm the texture. A continuous noise sweep at the end provides a sense of anacrusis to the next section, but this cue is hard to interpret without clear rhythmic pulses. When the next section starts, the re-introduction of the drums to the texture engenders a sense of relief. This is part of the important EDM aesthetic of disorientation followed by clarification. There is also another continuous process that helps create an overall aesthetic of continuousness throughout this section, and that is a pitch wave that takes place in "bass 2" on beats three and four of every fourth measure.

Another example of continuous processes contributing to disorientation in a breakdown section occurs in "Interferance" by Chunda Munki. This track was studied extensively in chapter 2, as an example of one sound layer decelerating even though the global tempo stays the same. The transcription for this breakdown section was shown in chapter 2 and is reproduced in Figure 6-4. Note how the deceleration is not technically continuous in the way I defined continuous rhythm or tempo changes in chapter 2, because the length of time between adjacent notes is usually constant for at least two notes in a row, so the deceleration occurs in a step-by-step process. However, because of the lack of drums in this breakdown section (as is typical), the slowing down of the cell-phone "interference" sound effect can easily cause the listener to lose where the beat is and stop dancing.

Even though three other layers are sounding at the same time, the cell-phone interference sound has the most distinctive and harsh timbre, so it stands out. It is also new to the texture at this point, whereas the other three layers continue on from the previous core. Therefore it is easier to pay attention to this sound layer and its rhythms, which are confusing when there are no drum parts providing metrical reference points. In chapter 2 I argued that this deceleration serves to musically communicate "breaking up," since it sounds like the rhythmic pulse is disintegrating. At first, this serves as a metaphor only for a phone call "breaking up" because of the lack of a clear signal. The narrative of the song later clarifies, however, that a couple is also breaking up, giving the title of the song and the effect of the deceleration more meaning. It is noteworthy that this deceleration representing a phone call "breaking up" only occurs once in the song, in the first breakdown section, and that the parallel moment in the narrative where the second "breaking up" occurs also serves the musical function of a breakdown section, from 3:56 to 4:27. In that section the speaking voice, with its own complicated rhythms, takes the place of the decelerating line in the first breakdown.

Figure 6-4: Deceleration in the first breakdown (1:03–1:18) of "Interferance" by Chunda Munki (2017).

As shown in the transcription, the other three layers in the first breakdown (1:03–1:18) do provide at least some degree of metrical stability, if not much. The stability of two of them (synth 3 and synth 2) is also counteracted by the use of continuous changes to some aspect of their sounds. First, the "synth 3" part utilizes a pitch wave that contributes to the aesthetic of continuousness and instability, but it is also consistent and lands at its high point on beat three and its low point on beat one each time. Second, the "synth 2" part also utilizes a continuous process, the tremolo effect. Interestingly, this usage of quick repeated volume swells actually helps articulate each beat and maintains some of the energy from the core. However, the beat is not clearly re-articulated with a new attack on each beat, which would have been an even clearer counterpoint to the deceleration in the “interference” sound.

The only rhythmic layer that sounds completely discrete is synth 1, which is the main melodic hook that is present throughout the entire track. It does contain a significant amount of rest in its four-measure pattern, and some syncopation, but it also clearly articulates beat one of the first measure and beat three of the second measure, outlining these as points of stability for the listener to hold on to. Overall the first breakdown section in “Interferance” utilizes continuous processes in conjunction with discrete ones in similar ways to breakdown sections in other tracks: to generate instability, especially metrical instability, and create a space of time when dancers can rest.

The final example for this section of the chapter comes from “Be Strong” (The Loops of Fury Mix) by Elite Force, which was first discussed in chapter 3 and will also be analyzed for the first example of the next section on the importance of continuous processes in buildups. It contains a multitude of short continuous processes throughout the track, including in the intro and cores. The breakdown section (2:45–3:15) is sixteen measures long, broken up into two eight-measure parts. It is preceded with an ascending noise sweep and starts with a descending noise sweep. These are uplifters and downlifters that highlight the sectional boundary. In the first part of the breakdown (2:45–3:00) only two rhythmic layers are present. As in all the previous examples, one melodic motive from the core holds over, and here again it is the “hook” of the song. The vocals saying “be strong” come in during the first of every four measures and fade out continuously over the next three. This in and of itself contributes to the instability valued in breakdown sections.

The second rhythmic layer in the section is much more salient though. It utilizes repeated filter sweeps that add or remove high frequencies in continuous waves. The shape of the waves seems to include exponential growth for the ascending part and exponential decay for the descending part, as shown in the spectrogram (Figure 6-5a). The filter sweeps continuously change the timbre and the volume of the sounds, making up-and-down swells, with the peak of each wave generating a rhythmic pulsation. This creates rhythms that are metrically dissonant with the non-sounding but still-internalized beat.[75] Since the drums are not present for eight whole measures though (2:45–3:00), the beat is easy to lose. When the drums come back in at 3:00 for the second half of the breakdown, the meter of the track is re-clarified. However, the continuous filter sweeps are still salient and now create explicit metrical dissonance with the sounding reference points of the drums.

Breakdown sections do not always contain a large number of continuous processes, but continuous processes often take on a more significant role in them than they do in cores. Along with the typical removal of drums and metrical dissonance created by syncopated layers, continuous processes contribute to the aesthetics of low energy, instability, and disorientation that define breakdown sections.

[75] In a situation like this, the beat from the rest of the track is maintained internally as a "virtual reference structure." Danielsen (2010, 4).

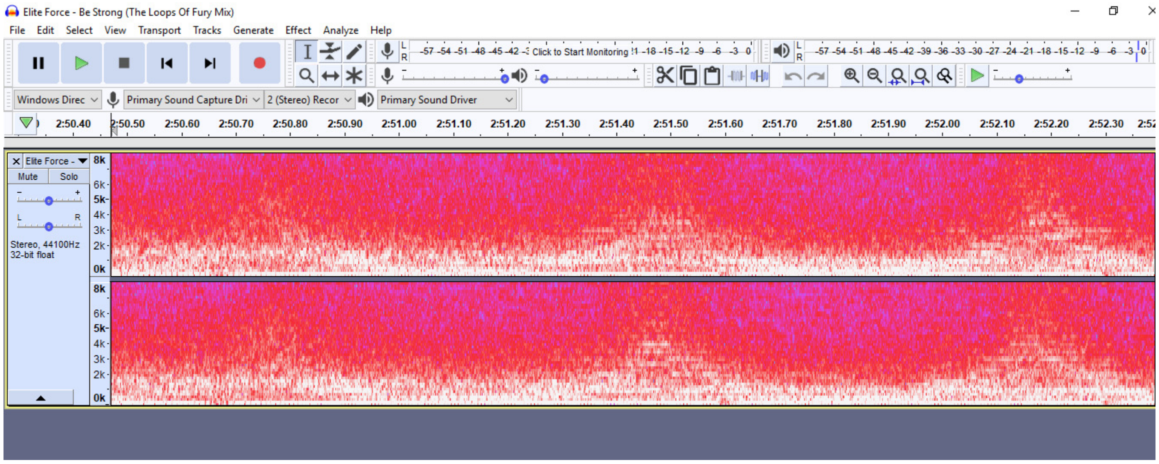

Figure 6-5a: Spectrogram showing waves created by filter sweeps in the breakdown of "Be Strong" (The Loops of Fury Mix) (2:50–2:52).

The Importance of Continuous Processes in the Increasing Tension of Buildups

The main aesthetic of breakdown sections is disorientation, and the main aesthetic of buildup sections is tension. The primary goal of this chapter is to show the importance of continuous processes in generating these aesthetics. In breakdown sections continuous processes can help create a sense of instability by making melodies or rhythms unclear or obscured. This can happen in buildup sections too, but in buildups continuous processes also work towards a specific goal point. They participate in the teleological push to the beat drop. This is because the most common and salient types of continuous processes in buildups are ascending pitch slides or noise sweeps (uplifters), and crescendos through increased volume or increased number of sounds in the texture. These collectively form what I defined in chapter 1 as a "riser." Both ascending gestures and crescendos are metaphorically associated with growth and increasing tension, so they contribute to the sense that buildup sections are tense and moving towards a clear goal point.[76]

[76] Brownrigg (2003, 118–121); Huron (2006, 326); Patty (2009, 329).

Another important difference between breakdowns and buildups is that buildup sections usually include drum parts that articulate metrical beats strongly and consistently. Sometimes the low drums are included, but often it is just the high percussion sounds of the snare drum and hi-hat or claps on backbeats that are used, to provide metrical stability without the fully-firm grounding that is saved for the upcoming core. Regardless, it is the combination of ascending gestures and crescendos with clear and consistent beats that creates tension without disorientation. This also makes buildup sections have a sense of renewed energy and excitement that engenders a sense of expectation in dancers, and allows them to prepare for the upcoming beat drop by re-entraining themselves to the beat. Snoman recognizes the importance of the return of the drums at the beginning of the buildup section, saying that "the drum rhythm picks up again…signifying that the track is about to come back." [77]

In general, buildups are more salient, more tense, and more often used than in previous decades, especially in genres like trance, progressive, and big room house.[78] They are almost ubiquitous in not only contemporary EDM but contemporary pop music in general, as Peres shows in his dissertation.[79] Buildup sections are also often formulaic. The first part of the formula features a general increase in energy through techniques such as crescendos, ascending pitch slides, filter sweeps, and rhythmic diminution culminating in the "snare roll." Three out of these four trademark signifiers for buildups involve

[77] Snoman (2009, 226–227).
[78] Butler (2006, 226); Solberg (2014, 65).
[79] Peres (2016, 73–125).

continuous processes. However, the fourth is based on clear, easily followed discrete rhythms that are in the drum parts.

This general increase in energy usually lasts for about seven measures (sometimes more, sometimes less), and it is followed by the second part of the formula, a sudden drop off in energy, sometimes called a "break."[80] Not all buildups utilize this feature, but many do. Often most of the sounds are completely cut out of the texture except for one or two that serve a special function I call the "cue."[81] This is a short anacrustic motive that is usually a vocal line, a speech sample, a melodic hook, or even just a single snare drum hit. It can last one beat, two beats, a whole bar (four beats), or rarely three beats. Cues are often self-referential and humorous, making fun of their obviousness, as in the spoken line "we came to smash this club" during the track "Smash" by Exodus (discussed in previous chapters). After the sudden drop off and the cue comes the instantaneous drop, the climactic moment when all of the elements, including the drums and the bass, return to the texture at the start of the core. The intensity and thrill of this moment is for many listeners the most pleasurable part of the EDM experience, as has already been discussed above.

DJs and producers are aware of the formulaic nature of some buildups. Deadmau5 describes it and his opinion of it in his masterclass.

> It's like a roller coaster ride. You're going up and then you go down, and that's the kind of feeling it would invoke out of a listener. So you have this thing and then just this little snippet of "oh, hey, we're going over the hump," and then it's up here [visually illustrates with his hands], because that's right after this drop[-off], this *lull in that crescendo*, and that really does do a thing.

[80] Ibid. (93).
[81] Peres hints towards this feature, saying that sometimes the vocals are left by themselves during the break, but he does not give it a name. Ibid.

> But in my mind, and this is just solely my opinion…there are other ways to invoke moments of intrigue or hype or mystery without having to *blatantly* illustrate it.[82]

I will now show several examples of how continuous processes significantly contribute to the increasing of tension in buildups, some of which are formulaic, and some of which are more unusual. First, "Be Strong," the last track discussed in the previous section on breakdowns, features a fairly formulaic final buildup (3:15–3:45). In this sixteen-measure section, the drums follow the rhythmic diminution/discrete acceleration pattern by lasting for 1/2 of a bar (half notes) in the first eight measures, then 1/4 of a bar (quarter notes) in the next four measures, then 1/8 of a bar (eighth notes) for two measures, then 1/16 of a bar (sixteenth notes) for the last seven beats before the cue. This is the standard way of accomplishing a snare roll at the standard pace, although here it is accomplished with a kick-drum sound.

Another way in which the tension increases in this formulaic buildup section is through the very loud and salient pitch slide that occurs for almost the entire sixteen-measure section. This pitch slide is even more salient than usual ones because the glissando is applied to a chord, not just an individual pitch. Towards the end of the process, a noise sweep joins it, creating an even stronger drive towards the goal point. This can be seen in the spectrogram (Figure 6-5b).

A different sound layer in this buildup section features short continuous processes, specifically three pitch slides in every measure. This layer is relatively quiet at this point in the track, but it was one of the primary stimulants of tension in the first

[82] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 13, 11:02–12:00). Emphasis mine.

buildup section (0:45–1:00), when it articulated pitch waves that got faster and faster and ascended in terms of their peak and valley points (this was discussed in chapter 3).

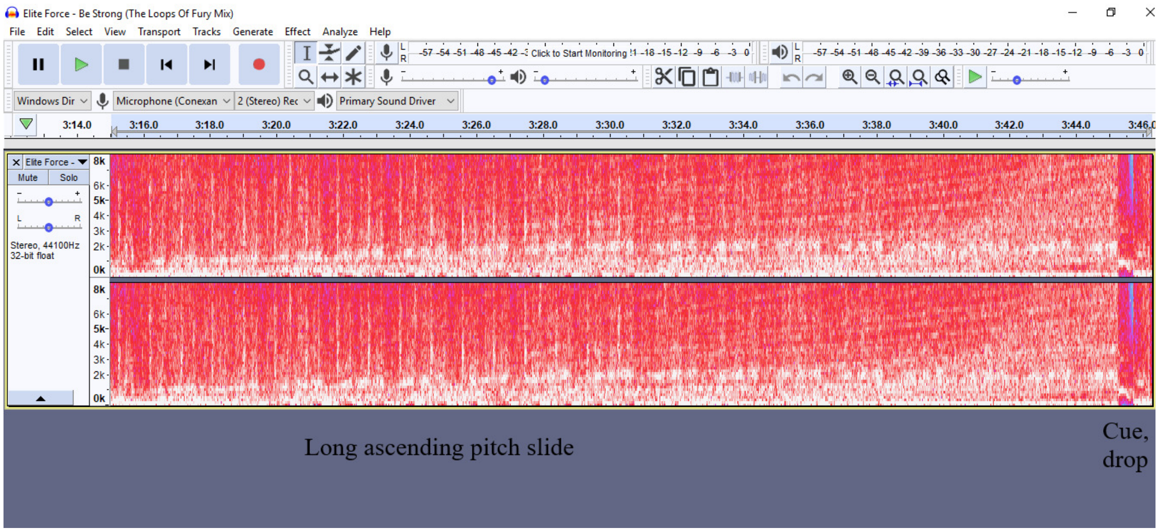

Figure 6-5b: Spectrogram for 3:15–3:46 showing continuous processes in the buildup of "Be Strong" (The Loops of Fury Mix) by Elite Force (2011).

Also during the final buildup section (3:15–3:45), the vocal hook "be strong" that was discussed in the breakdown section is still present, but now not fading out and only looping every two measures instead of four. It cuts out of the texture four measures before the beat drop, so that the continuous processes of growth can be focused on even more and more tension can be created. After fifteen measures and three beats of salient continuous processes in this buildup section, there is a one-beat break that features the vocal cue of just an excited "woo," signaling the upcoming beat drop and the start of the final core in the track, when tension is released.

The most salient continuous process in the final buildup of "Be Strong" is arguably the ascending *pitch* slide, but other times it is a crescendo in *volume* that is the most important contributor to increased tension. In "Be Strong" the buildup contains little if any crescendo, but in "One More Time" by Daft Punk, the buildup contains a huge crescendo and no pitch slides. As shown in the transcription (Figure 6-6), the crescendo mostly results from many different layers fading in, and one layer (the tambourine) abruptly being added. The gradual thickening of the texture through continuous volume processes is what increases the energy and tension of the buildup section, leading to a measure-long break at 4:16 and a two-beat cue right before the climactic beat drop at 4:18.

This climax at the beginning of the second and final core has an especially strong effect because it is the only real drop in the entire track; the first core was differentiated from its preceding buildup by hypermetric emphasis and the addition of other high-pitched percussion sounds like backbeat claps and the tambourine sound, rather than the addition of low-pitched layers like the kick drum or bass line. The breakdown and buildup sections before the final core are also quite extended, even containing a "false buildup" where the tambourine sound enters at 3:00 and then exits, leaving the same thin texture of the breakdown section, at 3:24. It is not until 3:47 that the texture starts thickening up in a way that lasts and the true buildup is accomplished, primarily through continuous processes. This buildup through crescendos in multiple parts is very effective in a track from the year 2000, even though it does not have the formulaic pitch slides, filter sweeps, and snare drum rolls that are so commonplace today.

Figure 6-6: Transcription of the first part of the final buildup (starting at 3:40) in "One More Time" by Daft Punk (2000).

Another track from even earlier in Daft Punk's career is "Rollin' and Scratchin'" (1995). This track prominently features sounds that many would consider noise. The scratching sound effect in particular has no clear melodic pitches. It appears to generate unpredictable and uncontrollable frequencies, but ones that still move up and down continuously. In the final buildup section (5:34–6:07), two other sounds fade in (first a rhythmic synth part at 5:34, then a percussive cymbal part at 5:52), which contribute to the building up of energy. Just as in "One More Time," Daft Punk use continuous processes of volume as the primary element of the buildup for most of the section.

However, what really increases the tension even more significantly before the final core is the continuous pitch ascent of the scratching noise. This happens relatively quickly and with exponential growth, as can be seen in the spectrogram (Figure 6-7). For the breakdown section and most of the buildup section, the scratching noise has been relatively low, featuring frequencies no higher than around 3,000 hz. But in the last four measures of the section, and especially in the last measure, it ascends to frequencies around 5,000 hz. The quick ascent engenders high feelings of tension, because it has a high rate of change. In the following core section, the intensity comes not only from the loud drum beats, but also from this scratching sound being loud, harsh, and at its highest frequencies in the entire piece. This is an example of the high point of a pitch ascent being reached just *after* the start of the core and *stayed* at during the core. It is more common for an ascending pitch slide or filter sweep to reach its peak just *before* the core, and then for its sound to either cut out at the core (as in the example from "Be Strong" above) or descend. This more normative pattern occurs in many examples from previous chapters, such as "Zero-Day" by Judah.

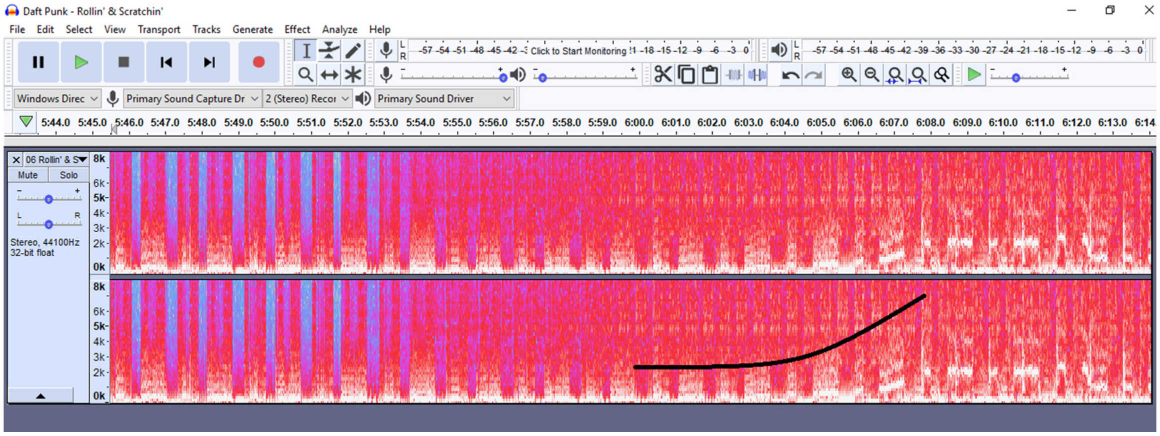

Figure 6-7: Spectrogram showing the exponential ascent of the scratching sound in the end of the buildup (5:45–6:14) in "Rollin' and Scratchin'" by Daft Punk (1995).

The final example in this section deviates the most from the formula described above. It comes from "Electronic Battle Weapon 1" by The Chemical Brothers (1996). The final buildup does not have a clear starting point, blurring the boundaries with the breakdown. Butler notes that this is common, and that in these cases it is best to think of the buildup as more of a technique rather than a distinct sectional type.[83] In fact in this track, even the starting point of the breakdown is unclear. This is unusual, as the breakdown is usually signaled by many sounds suddenly cutting out. Instead, the second core of the track starts at 3:03 and at around 3:30 several parts begin decrescendoing and fading out. From about 3:40 to 3:47 the texture is very sparse, so this section could be labeled as a breakdown, but then at around 3:47 uplifters are introduced, continuously rising in pitch and signaling a buildup as shown in the spectrogram (Figure 6-8). Soon afterward one of the layers that faded out (which itself utilizes short continuous pitch slides on every beat) now fades back in and crescendos, contributing to the aesthetic of

[83] Butler (2006, 224).

the buildup. The uplifters reach their peak at around 4:05, but continue to move slightly up and down in the high frequency range.

At 4:14 an unexpected beat drop occurs, with both the drum and bass parts suddenly re-entering the texture without any distinctive break or cue. The uplifters continue to sound in their high range until 4:21 when they quickly drop out, meaning that they reach their peak nine seconds before the start of the core, and stay there until seven seconds after. This does not follow the typical three-step formula of contemporary buildups, but is also quite different than the previous example from "Rollin' and Scratchin'." Nevertheless, in this part of "Electronic Battle Weapon 1" it is the continuous processes of an ascending pitch slide and a fade-in that make it a buildup section, increasing the tension with continuous change.

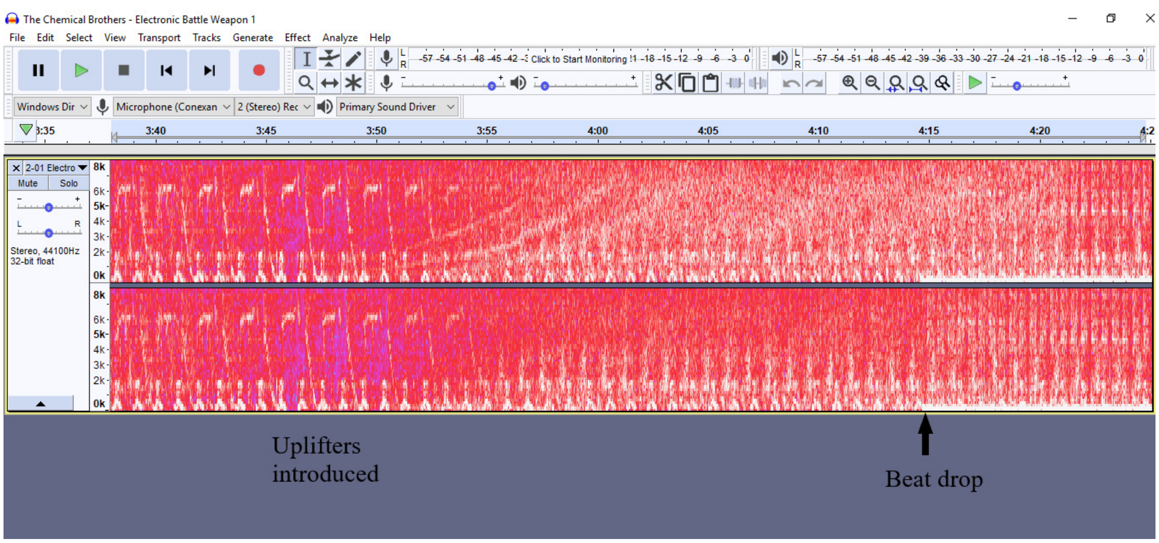

Figure 6-8: Spectrogram of the end of the buildup and start of the final core (3:38–4:24) in "Electronic Battle Weapon 1" by The Chemical Brothers (1996).

The Final Guideline for Comparing the Salience of Continuous Processes

The groups of continuous processes discussed in the previous section are all highly salient. This is in part because they occur right before beat drops, which are climactic marking points in EDM pieces. Other continuous processes embellish melodies in core sections or highlight midway sections of cores, but risers in buildups play a structural role in the form of tracks. They *create* the buildup section and distinguish it from other formal sections. It is their link with climaxes and their structural significance that makes them especially salient, and this is explained in guideline 9.

9) Continuous processes that highlight more important structural marking points and hypermetric downbeats are more salient than those that highlight less important marking points or do not play a structurally significant role.

By "more important structural marking points" I mean those that start formal sections, rather than midway points of sections. These usually occur at hypermetric downbeats at the sixteen-, thirty-two-, or sixty-four-measure levels.[84] By "highlight" I mean occur close in time to, whether preceding or following the significant moment. Guideline 9 partially explains why risers in buildups are so memorable and why they generate so much tension. It also accounts for the fact that risers in buildup sections are the kinds of continuous processes that have been most explored in analytical scholarship of EDM to date.

According to guideline 9, the ascending pitch slide in the buildup section of "Be Strong" (3:15–3:45) is more salient than the ascending pitch slides in the middle of the core sections in "Find a Way" (for example at 1:51 and 2:06). Similarly, the increasing amount of reverb used just before the final chorus (3:24–3:32) in the extended mix of

[84] Butler talks about the important of duple hypermeter nested in multiple levels in EDM. Ibid. (185–194).

“Who’s That Chick?” by David Guetta is more salient than the increasing and decreasing volume of echoes in the intro (0:00–1:13) to “Right This Second” by Deadmau5 (both of these tracks were discussed in the same section in chapter 2). Using the same guideline, the filter sweeps used just before core 2 (starting at 3:12) in “Summer Feeling” (Redub’s at 5am mix) by Nafis (discussed in chapter 6) are more salient than the short filter sweeps heard throughout “Musique” by Daft Punk.

In total, nine analytical guidelines have been outlined in this dissertation for comparing the salience of continuous processes in EDM tracks. These account for the relative loudness, distinctiveness, grouping, repetition, length, depth, rate of change, and structural significance of continuous processes. Which of these guidelines is the most important? How can they all be used to create informed musical analyses?

Arguably, guideline 1 (relative loudness and prominence in the mix) is the most important for determining salience in a track. Patty heavily implies this when saying that “if a melodic descent is accompanied by a crescendo, the melodic descent does not detract from intensification due to the crescendo. Instead, the melodic descent participates in the intensification.”[85] However, there are certain situations when each guideline is more relevant or less relevant. For example, when comparing the salience of two processes that do not repeat frequently in a track, guideline 5 (repetition) is not relevant. When comparing how a crescendo and a pitch slide both contribute to a riser, guideline 9 (structural significance) is irrelevant because they both occur at the same

[85] Patty (2009, n. 9).

time, but one may contribute more than the other to the increasing tension in the section and be more salient according to guidelines 1, 2, 6, 7, or 8 (volume, distinctiveness, length, depth, and rate of change). Analyzing both the crescendo and the pitch slide in the riser as a group, however, explains why they are salient as a collective under guidelines 3 and 4 (grouping multiple parameter changes and multiple sound layers) and guideline 9 (they are a riser in a buildup section and are structurally significant). The guidelines are useful for analysis generally because they make the foreground-background parsing involved in listening explicit, and help explain how we hear and contextualize continuous processes in multiple levels throughout EDM tracks. They also add a necessary third dimension to the analysis of continuous processes, since a process can have the same shape and same function, but different salience level than another one. All of the guidelines for comparing salience of continuous processes will be used in my extensive hermeneutic analyses of two seminal tracks in the next chapter.

Conclusion

Continuous processes move between two discrete points with constant change. They are by definition unstable. Listening to them is potentially uncomfortable because our brains and bodies do not know when the change is going to stop. We can make predictions based on previous patterns and our expectations, but it is not until the change stops and our predictions are fulfilled at the moment we expect (or slightly *after* we expect) that a climactic moment of release happens.[86] This explains why even though continuous processes can have many different musical functions in EDM tracks, they

[86] Huron (2006, 322–326).

play their most significant roles in sections that are marked by transition and change, such as intros, outros, and especially breakdown and buildup sections, since those sections have the aesthetic functions of creating disorientation and tension respectively. Continuous processes such as crescendos, pitch slides, filter sweeps, and timbre changes shape the structure of the music and how it is experienced in these sections of EDM tracks, and they contribute to the alternation of tension and release that music theorists have been writing about for centuries.

Dancers in a club or at an EDM festival often speak about moments of ecstasy when they are intimately connected with strangers, experiencing "communion" together.[87] In both club settings and workout sessions, people talk about the music *moving* them "up and down" and giving them a boost of energy at specific points.[88] These situations happen when listening to EDM because of the intense climaxes experienced and continuous processes that precede them. The joys of stability, of being firmly grounded, of being mentally and physically synchronized with the beat and with other bodies around you, can only be fully appreciated after moments of disorientation, tension, and instability.

Different genres, artists, and tracks use the instability of continuous processes in different ways, utilizing various shapes and varying degrees of salience. The functions, shapes, and saliences of continuous processes are each significant in their employment in the EDM repertoire, as shown in chapters 2, 3, 5, and the current chapter. All of these components can also be studied with different analytical techniques from different lenses,

[87] Garcia (2011, 167–174); Redfield and Thouin-Savard (2017).
[88] DeNora (2000, 89–102).

as these chapters have shown. Now that I have shown many short examples from a variety of EDM tracks, I will put my analytical techniques into practice in the last chapter of this dissertation, focusing on the intersection of salience, shapes, and functionality in two seminal works by The Chemical Brothers and Deadmau5.

Chapter 7 – Continuous Processes Representing Paranormal and Science-Fictional Phenomena in Two Tracks by Deadmau5 and The Chemical Brothers

This final chapter will investigate the roles of continuous processes in two exemplary tracks: "Phantoms Can't Hang" by Deadmau5 (2014) and "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998). These tracks will serve as case studies for showing various saliences, shapes, and functions of continuous processes and how they interact with each other and discrete processes. The analytical tools developed in the rest of the dissertation will be combined with a hermeneutic approach to showcase how continuous processes can represent paranormal and science-fictional phenomena.

The hermeneutic analyses in this chapter are based on the methods of Lawrence Kramer and others in that tradition.[1] In other words, this chapter provides an "open interpretation" of two tracks, such that "The meaning produced by interpretation is inextricable from the interpretive activity."[2] As Cook puts it, "it is through the interaction of music and interpreter, text and context, that meaning is constructed…it is wrong to speak of music *having* particular meanings; rather it has potential for specific meanings to emerge under specific circumstances."[3] Interpretation in this sense is a kind of performance that tries to tell us something about the world.[4] Through "historically aware hermeneutics" that takes into account historical and cultural context along with "the purely musical dimension," the analyses in this chapter present a "reading (not a solution

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[1] Kramer (2002); Kramer (2011).
[2] Kramer (2011, 2–3, 9).
[3] Cook (2001, 180).
[4] Kramer (2011, 9–10, 147–152).

once and for all)" of continuous processes representing paranormal or science-fictional phenomena in two EDM tracks.[5]

There is some precedence for close reading of EDM tracks in this way. Hawkins uses "French Kiss" by Lil' Louis (1989) as a case study for discussing the rhetoric and aesthetics of house music as articulated through common metric and hypermetric patterns.[6] Butler analyzes different live performances of "The Bells" by Jeff Mills (1997), showing how the synthesized bell sound, which "thematizes repetition" and "reflexively indicates its content" by echoing itself, signifies the work in different performances.[7] Solberg proposes a "hypothesized phenomenology" for "Body" by Cinnamon Chasers (2013) and "Icarus (Extended Version)" by Madeon (2012).[8] She discusses tension and the "emotional impact" of musical features such as risers and drops, showing her interpretation through schematic models and graphs of perceived intensity.[9] In this chapter I will focus in detail on the musical form and aesthetics of "Phantoms Can't Hang" and "Electronic Battle Weapon 4 (Freak of the Week)," showing how discrete and continuous processes interact and how the salience, shapes, and functions of continuous processes play key roles in signifying the meaning of the music in cultural context and in representing paranormal or science-fictional phenomena.

Something that is paranormal is "beyond the scope of normal scientific understanding."[10] It is unexplainable and "out of this world." A very similar term is

[5] Hepokoski (2014, 75–79).
[6] Hawkins (2003).
[7] Butler (2014, 154, 152–169).
[8] Solberg (2014, 68–78).
[9] Ibid.
[10] "Definition of Paranormal in English by Oxford Dictionaries" (n.d.).

"supernatural." Paranormal and supernatural beings such as gods, angels, demons, wizards, magical creatures, and ghosts are often represented in fantasy stories. Scholarship on representations of the paranormal and supernatural in music has primarily focused on opera and the music of the classical Western canon.[11] McClelland has written two books on musical topics of the supernatural, the *ombra* and *tempesta* topics.[12] *Ombra* music is unsettling and eerie, creating a sense of "awe and fear," but not "terror and panic" like stormy *tempesta* music does.[13] In both cases a sense of the supernatural is invoked by tonal instability, harmonic dissonance, and angular (disjunct) melodic lines.[14]

A different but related concept to the paranormal is the science-fictional. Science-fiction books, films, and television shows display spaces, technologies, and beings such as extra-terrestrials that are not part of our everyday experience but *could* possibly exist in the real world or a future version of it.[15] Studies of music representing science-fictional phenomena have concentrated on soundtracks for films and video games.[16] In these soundtracks, continuous processes on electronic instruments often represent the alien or the futuristic.[17] Both paranormal and science-fictional themes fit well under the umbrella of horror. In horror films, music is a crucial part of how fear is generated in viewers, and continuous processes such as crescendos and pitch slides are particularly effective for creating tension.[18]

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[11] Buch (2009); McClelland (2012); McClelland (2017).
[12] McClelland (2012); McClelland (2017).
[13] McClelland (2017, viii).
[14] McClelland (2012, chaps. 2–3); McClelland (2017, chaps. 2–3).
[15] Hayward (2004, 3).
[16] Barham (2008); Hayward (2004); Whalen (2007); Wierzbicki (2002).
[17] Two classic examples of this are *The Day the Earth Stood Still* (1951) and *Forbidden Planet* (1956). Barham (2008, 248); Hayward (2004, chaps. 1, 3); Wierzbicki (2002).
[18] Brownrigg (2003, 118–121); Larson (1996, 65).

In “Phantoms Can’t Hang” by Deadmau5, paranormal phenomena are represented by ghostly voices. The intro and outro of the track contain a “phantom choir” that sings dissonant and unstable pitches. The breakdown utilizes a solo phantom voice with a haunting melody that leaves in the following buildup but eventually returns to join the rest of the melodic and rhythmic elements in the second half of the final core. Phantom voices in this track are signified by bright timbres, high and unstable pitches, a lack of clear articulations, and continuous panning. Continuous processes also play important structural roles in the breakdown and buildups, functioning in the typical way that was outlined in the previous chapter. The two buildups contain huge risers with sigmoidal shapes that seem to plateau near the end, creating suspense before the climactic drops. The breakdown section uses continuous motion between the notes of the solo ghost melody, harmonic accompaniment that gradually evolves from white noise, and a continuously growing echo in the bass that creates “the illusion of acceleration.”

In “Electronic Battle Weapon 4 (Freak of the Week)” by The Chemical Brothers, science-fictional phenomena are represented musically in different ways. Throughout the track, many short and long continuous processes contribute to portraying the sense of a dystopia, for example with high pitch slides that sound like warning sirens. The second core of the track contains a group of long continuous processes that are highly salient and sound “otherworldly,” [19] like a UFO coming down to earth for an abduction. These continuous processes seem to take over the track and try to interrupt the dancing at this point, which is unusual in core sections of EDM tracks. The use of continuous processes

[19] “The Chem Base Forum: N00b Corner! Introduce Yourself Here! [Reply #99 by Enjoyed]” (2018).

as signs for unusual, unstable, or unexplainable phenomena, however, fits with The Chemical Brothers' usual psychedelic style,[20] and with the use of continuous processes as signs for instability and fear more generally.[21]

"Phantoms Can't Hang" by Deadmau5 (2014)

Deadmau5 (pronounced "dead mouse") is a Canadian producer whose real name is Joel Zimmerman. He rose to fame in the late 2000s and early 2010s and is currently one of the most popular EDM producers in the industry, running the record label Mau5trap. He became known as an artist in the "progressive house" genre, but in recent years he has branched out and his work has become more multifaceted and more experimental. For example, many tracks on his recent albums do not utilize drums and do not have the standard rhythmic groove of EDM. The 2018 album *Where's the Drop?* features slow orchestral arrangements of his previously released music. In the last few years he has also taken on more of a public persona. He created a comprehensive masterclass on electronic-music production, composed the score for the 2019 film *Polar*, and he has regularly live streamed on Twitch.[22]

Many tracks by Deadmau5 have been studied throughout this dissertation, but "Phantoms Can't Hang" deserves considerable discussion because it is exemplary of many of the techniques explored in previous chapters. It utilizes salient continuous processes that mostly function in typical ways, and contribute to the paranormal theme of

[20] The Chemical Brothers are known for incorporating psychedelic imagery into their live performances and music videos. One of their most popular tracks is "The Private Psychedelic Reel" (1997).
[21] Brownrigg (2003, 118–21); Huron (2006, 326).
[22] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016); "Mau5ville" (n.d.); "Twitch: Deadmau5" (n.d.).

the track. It is also one of several of his tracks that references paranormal phenomena, including the platinum hit “Ghosts ‘n’ Stuff” (2008), “Cthulhu Sleeps” (2010, discussed in previous chapters) and “Closer” (2012), which uses a five-note motive from the film *Close Encounters of the Third Kind*.[23]

“Phantoms Can’t Hang” is the ninth track on the first disc of Deadmau5’s seventh studio album, *While (1<2)* (2014). The album contains two discs with original “unmixed” material composed by Deadmau5 and marks the beginning of a turn towards a more experimental, less dance-focused style in Deadmau5’s career. “Phantoms Can’t Hang” is actually one of the less experimental tracks on the album; it utilizes the tempo, drum beats, and standard form of a typical track in the progressive house genre, which Deadmau5 is still most known for.

This track was released as the fourth single on the album, but it was originally combined with what would later become the first single on the album, “Avaritia.” Before the pieces became separated, the combined track was released unofficially on SoundCloud as “Where Phantoms Sleep 04.”[24] This version uses the same melodic hook and the same dissonant “phantom choir” chords as the final version of “Phantoms Can’t Hang,” but for most of the track the chords of “Avaritia” are used. In the cores, the main melodies of what would later become two separate tracks are combined in counterpoint. Notably, the main “phantom solo” melody that is introduced in the breakdown of

[23] The five-note motive comes from the track “Wild Signals” by John Williams, which was part of the original soundtrack for *Close Encounters of the Third Kind* (1977). Deadmau5 also frequently invokes the science-fictional by using “robot voices” in his tracks. Tallchief (2018, 14:15–14:58).
[24] *Deadmau5 - Where Phantoms Sleep 04* (n.d.). https://www.youtube.com/watch?v=yYPD6ZQMI8g.

“Phantoms Can’t Hang” is absent in “Where Phantoms Sleep 04,” meaning that it was added to the album version and is associated with “phantoms” but not “Avaritia.”

The meanings of the words in the title are ambiguous. A phantom can be thought of as a ghost, or a visible spirit of someone that was once living. It can also mean anything that is an illusion or a figment of the imagination though. Similarly, to hang something can mean simply for it to be suspended in air, floating or swaying (as phantoms do), or it can mean to kill someone via hanging. In more informal terms, to hang or hang out with someone is a social activity, and if someone is able to maintain a certain level of social status or skill level necessary to be associated with or compete with someone else, it is said that “they can hang with” the other person.

These ambiguous words raise multiple possible interpretations of the meanings in this track. Perhaps the title refers to phantoms as ghosts not being able to hang themselves or not being able to be executed by hanging, even though they can hang over living people metaphysically. If the phantoms being referred to are negative thoughts or imaginations inside a person’s mind, then them not being able to hang can refer to them not being able to die and fully go away, but also the saying “Phantoms Can’t Hang” could be spoken in a positive light by the person who has negative thoughts or doubts, meaning “my phantoms can’t hang over me,” or “my phantoms can’t hang out with me.” In the context of Deadmau5’s music and EDM, the qualifying phrase might be added, “on the dancefloor.” This interpretation works well for Deadmau5’s track “Phantoms Can’t Hang” because of the implementation of the phantom voice parts, as will be discussed below. It also complements the meaning of the older track, “Ghosts ‘n’ Stuff,” since the music video for that song shows Deadmau5 having an out-of-body experience as a ghost and finding social acceptance on the dancefloor after doubting himself.[25]

Continuous processes are used in "Phantoms Can't Hang" primarily to change and control the amount of tension and stability in non-core sections, fitting well with the functions described in chapter 6. The continuous motions of sigmoidal pitch slides and linear filter sweeps, as well as fade-ins, crescendos, and timbre changes, contrast with the very repetitious and discrete melodic hook. Both the "phantom choir" chords that use panning and the "phantom solo" melody that uses continuous pitch motion with no articulations combine with the minor tonality of the piece to create a dramatic and eerie feel.

A form chart of the track is shown in Figure 7-1. The piece can be interpreted narratively regarding the phantoms' presence and how it interacts with other elements of the standard EDM track. Phantom voices are present in the intro and breakdown, but in the following buildup sections they go away. This suggests that they "can't hang around" for the most important, "main" parts of the track that represent happy, energetic experiences on the dancefloor. It is only in the second half of the last core that the phantom solo part returns, creating an apotheosis for the track. I will now discuss the piece chronologically, focusing on the non-core sections where the phantom sounds and continuous processes in general are the most salient.

[25] Ultra Music (2009). https://www.youtube.com/watch?v=h7ArUgxtlJs. This interpretation of "Ghosts 'n' Stuff" is articulated by fans in the discussion thread on SongMeanings (n.d.). https://songmeanings.com/songs/view/3530822107858790580/.

Formal Section	Time Started	Phantom Sounds
Intro	0:00	Choir at 0:15
Buildup 1	0:45	Faded out by 0:50
Core 1	1:15	Not present
Breakdown	3:15	Solo throughout
Buildup 2	4:30	Faded out by 5:45
Core 2	6:00	Solo in at 7:00
Outro	8:00	Solo faded out by 8:15. Choir present from 8:30 to end

Figure 7-1: Form chart of "Phantoms Can't Hang" by Deadmau5 (2014).

Intro (0:00–0:45)

The track starts with two repetitions of the four-measure melodic hook, as shown in the transcription of the intro (Figure 7-2). This melodic line is truly the "hook" in the sense that it is incessant for most of the track, has recurring rhythm and pitch patterns within it, and is the most distinctive and memorable aspect of the piece.[26] It also grounds the piece tonally in F minor, despite some soft A naturals that sometimes occur in the underlying harmony. It uses only notes of the F minor pentatonic scale, emphasizing F, A-flat, and C, the tonic triad in F minor.[27] Rhythmically, the hook is based on a three-sixteenth-note cycle, creating metrical dissonance with the duple meter of the track.[28] The dissonance is briefly resolved at the end of each four-measure cycle with two consecutive eighth notes that provide a rhythmic and tonal anacrusis to the beginning of the next

[26] These are the main elements of a hook as discussed in Traut (2005).
[27] The tonality of the piece (rather than modality) is more firmly established starting in the breakdown section, when harmonic progressions involving all the notes of the F harmonic minor scale are used.
[28] Specifically, G4/3 (sixteenth note = 1) metrical dissonance is used in the system of Krebs (1999, 31). G4/3 metrical dissonance is very common in EDM. Butler (2006, chap. 4); Smith (2015).

cycle. The goal-directed nature of the loop itself demonstrates what Butler calls "autoteleology" and Fink calls "recombinant teleology."[29]

At 0:15 the first continuous processes begin to take place. New elements suddenly enter the texture, namely the bass pitch F and some eerie, uncanny voices that I will call the "phantom choir," but these layers also utilize continuous changes. The sound quality of the voices is unclear and unstable, as is the pitch they sing, which flutters around in continuous change.[30] The bass pitch gradually becomes a sustained pitch after first having many re-articulations, like a repeated note. It is as if the voices are chattering quickly or chanting, perhaps summoning other spirits while they hang over the scene. When the phantom choir returns in the outro, continuous panning is also used to rotate around stereo space and create a sense of the voices moving around the listener.

At 0:19, some white noise fades into the texture, along with a hi-hat sound articulating every quarter-note beat, while the phantom voices and bass decrescendo into the background.[31] It is interesting that these fade-ins begin in the middle of a four-measure phrase, and (to my ears at least) begin to sound in the middle of a measure. This means that the first metric clarity in the piece (due to the clear quarter notes in the hi-hat) begins in a place that is hypermetrically *unclear*. At this point a listener may have an idea of where the pulses are for dancing, but not which pulses are most important or where they are in the phrase.[32]

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[29] Butler (2014, 209–211); Fink (2005, 43–47). These terms were also discussed in chapter 3.
[30] The voices sing a chord that seems to contain the notes of the F minor triad but also emphasizes B-flat.
[31] Technically, this may not be "white" noise but could be "pink" or "blue" noise. Holmes (2012, 214–215). For simplicity, I will refer to it and other similar sounds as white noise.
[32] This is the kind of ambiguity Butler describes as "underdetermination." Butler (2006, 123).

By 0:28, the white noise has had a descending filter sweep applied to it and faded out, but the hi-hat layer remains strong. At this point it is clear that the rhythm of the hi-hat layer is repeated eighth notes, alternating between strong and weak articulations. Since the off-beats are quieter, they are not heard at all until after the quarter-note pulse established by the on-beats has already been established. It seems as if first quarter notes fade in, then eighth notes, in two separate continuous processes (even though it was probably accomplished with one automation curve on the whole sample). Continuous processes relating to volume directly change the perception of rhythm and meter in this section.

After the high percussion parts have been firmly established, the kick drum enters abruptly at 0:30, providing further metric and hypermetric clarity. The phantom choir is still present though, providing a constant background sound.

Figure 7-2: Transcription of the intro (0:00–0:45) in "Phantoms Can't Hang" by Deadmau5 (2014).

Buildup 1 (0:45–1:15)

At the end of the intro, three beats before the start of the buildup section and the next eight-measure hypermetric downbeat, some "downlifters" suddenly and obviously enter the texture. They descend in pitch until the downbeat at the start of buildup 1 at 0:45, which is also a hypermetric downbeat as the start of the fourth eight-measure section of the piece. At this point white noise is also re-introduced to the texture, and it holds over for the first two measures of the buildup, before gradually getting much softer starting at 0:47. The downlifters and the decrescendo of white noise create two descending lines that can be seen in the annotated spectrogram (Figure 7-3). The first is generated by the continuous change of pitch from high to low, and the second is generated by the continuous softening of high frequencies through volume changes. Both of these continuous processes function as signals to the listener that the energy of the track is temporarily decreasing and that the buildup, when energy and tension will grow significantly, is beginning. By the time that these processes are finished, the phantom choir is no longer in the texture. It disappears just as the buildup is starting.

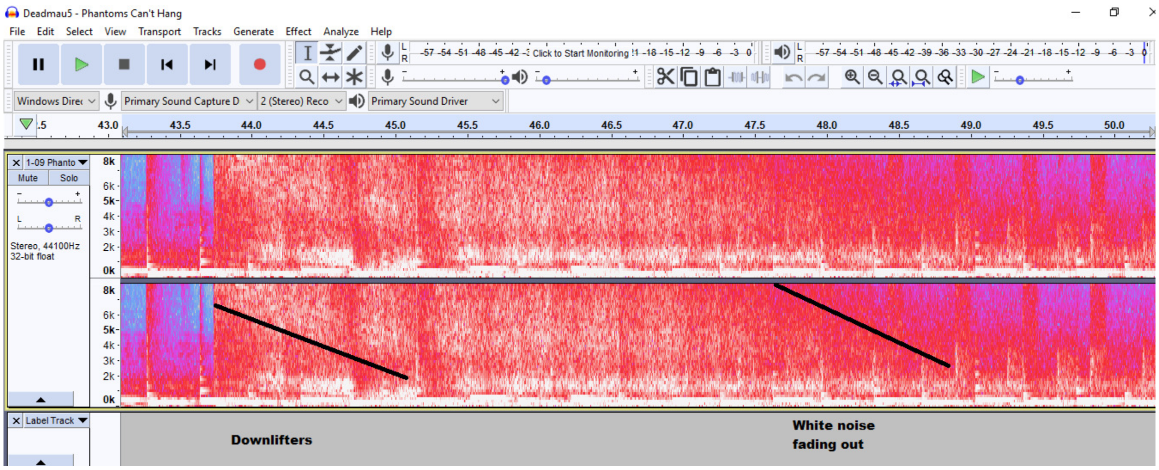

Figure 7-3: Spectrogram for the end of the intro and start of the buildup (0:43–0:50) in "Phantoms Can't Hang" by Deadmau5 (2014).

Buildup 1 can be divided into three subsections, based on different stages of the uplifters, which can be modeled using a sigmoidal curve as shown in Figure 7-4. During the first subsection (0:45–0:58) the long continuous pitch ascent is "slow to get going," as a sigmoidal curve is, and it sounds in the bass register starting around 0:54. The ascending pitch slide also begins to crescendo significantly during this subsection. The second subsection (0:58–1:08) contains the fastest rate of change as the highest pitch heard (pitch 3 in the graph) slides up to approximately G5, the supertonic in F minor. In this subsection the uplifters also seem to add another voice that gets "left behind," not going as high as the G5 (this is pitch 1 in the graph). Another layer fades in on D5 starting around 1:06 (pitch 2 in the graph). The effect of this is of one pitch slide splitting into multiple parts. During the third subsection (1:08–1:15) the high G5 plateaus while the lower voice (pitch 1) continues to rise and the D5 (pitch 2) crescendos. Then the whole track seems to go through a band-pass filter to remove both the lowest and highest frequencies in the mix. The effect of this technique is a perceptual merging of the rising pitches into one note again, coalescing and focusing the pitch on D5. The only sound layers that are not affected by the band-pass filter focusing on D5 are the hook, which becomes the only rhythmic element, and the bass, which holds a sustained F that is quiet and hard to hear. Just before the beat drop at the start of the first core, a single drum hit on the last beat of the measure acts as a cue.

There is definitely a feeling of a plateau (actually multiple plateaus, first the G then the D) reached *before* the beat drop at the start of the first core (1:15), and this is significant mathematically and aesthetically. The shape of the uplifters is clearly sigmoidal (S-shaped), with the highest amount of change and the largest variety of frequencies in the middle, and the coalescing pitches at the beginning and ending. It is as if "this thing has gone as much as it can go, reached its climax, [so] let's go on to the next thing. It's suspense."[33]

The high amount of tension achieved in this buildup section can also be explained with the analytical guidelines for comparing the salience of continuous processes. In this section, the continuous processes of the uplifters combine with a crescendo to collectively form a riser. Overall the riser is loud and distinctive in the texture, so it is salient under guidelines 1 and 2. The only other layer that is similar in prominence is the melodic hook, which continues its incessant repetitions. Guidelines 3 and 4 point out that another reason why the riser is highly salient is because it uses continuous changes in multiple parameters (pitch, volume, and timbre due to the filtering techniques), and in

[33] Miller (2018b).

multiple sound layers. Under guideline 6, the riser is salient because it lasts about twenty seconds, which is longer than other short processes such as the fade-in of the hi-hat in the intro. The riser also utilizes significant depth (guideline 7) in its continuous changes, particularly in pitch, since the pitches move more than three octaves. Finally, under guideline 9, the riser is salient because it is structurally significant, preceding and highlighting an important hypermetric downbeat at the start of a new formal section.

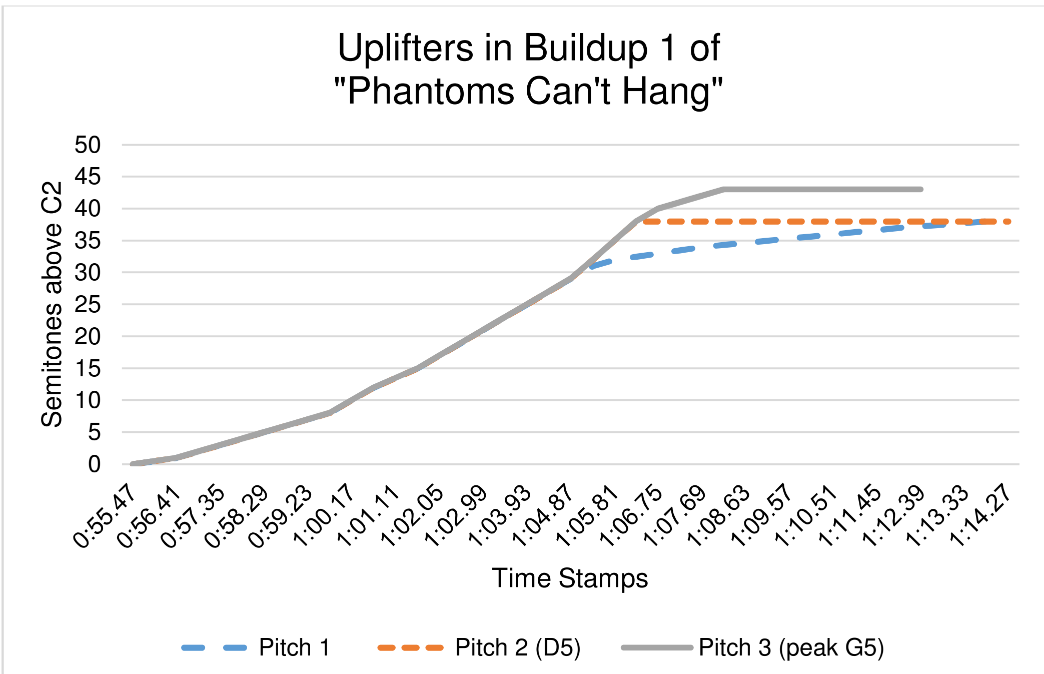

Figure 7-4: Graph of the uplifters in buildup 1 in "Phantoms Can't Hang" by Deadmau5 (2014).

Core 1 (1:15–3:15)

The first core of the track is very clear, consistent, and repetitive. It has many discrete elements such as the melodic hook (which now has a harsher timbre) and loud drum beats, and very few continuous processes. It is also clearly divided into sixteen-measure sections that last thirty seconds each. The beginning of each of these sections is highlighted with the short continuous process of the “backwards reverb” effect, when reverb is continuously added to a snare drum clip that has been reversed in a DAW.[34] This accomplishes a very common function of short continuous processes that was discussed in chapter 6.

Two other continuous processes that are more subtle and less salient are still important contributors to the aesthetics of this core section. Firstly, before the midway point of the core (2:15) the bass crescendos and changes its timbre to become harsher, making it stand out more. Secondly, the background melodic line transcribed in Figure 7-5, which uses the highest pitches of the melodic hook, seems to gradually add more echoes of itself during the second half of the core (2:15–3:15), adding more articulations after the main attack points. Both of these continuous processes help the core avoid becoming stagnant and overly repetitive.

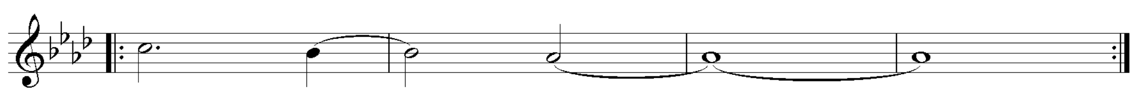

Figure 7-5: Transcription of the background melodic line in core 1 (1:15–3:15) of “Phantoms Can’t Hang” by Deadmau5 (2014).

Breakdown (3:15–4:30)

The breakdown section in “Phantoms Can’t Hang” introduces and highlights the solo phantom voice, and utilizes many discrete and continuous processes. As is typical in breakdowns of contemporary EDM tracks, the continuous processes sound more salient and create more instability here than in previous core sections because there are no drum

[34] Ibid.

beats present. This allows dancers to take a break and re-energize before the next core. Another signal that this is the breakdown section is the removal of the hook for the first time in the entire track.

A transcription of the breakdown is shown in Figure 7-6. There are three layers in this transcription, and each contributes to the slippery, changing aesthetic of the section in its own way. First, the vocal line (the "phantom solo") introduces a new melody that is the most prominent feature of the section.[35] It is a melody quite different than the hook which it replaces, because its vocal delivery is much more imbued with indexes of humanness. The timbre of a human voice is quite different than the electronic synth sound of the hook. It is also different from the timbre of the "phantom choir" though, which was less stable. If the voices of the choir summoned another spirit, then by the time it arrives the new spirit has a stronger, clearer voice.

The rhythm of the voice part is much less consistent and predictable than the hook; it does not fall into a pattern in the way that the hook clearly does. Furthermore, the voice part moves between pitches continuously, with no articulation points for each new note. It is as if the entire part has a slur marking over it. There are no words or consonants that are used, only vowels, and this vocalise style allows for continuous connection between each of the melodic pitches. Whether there are actual pitch slides between each note is debatable, and becomes an issue related to microrhythm (discussed in chapter 3), but this vocal line still creates an aesthetic of continuousness and instability due to its

[35] Part of the voice melody used here was first heard in Deadmau5's earlier track "Blue File" from the album *Project 56* (2008). In that track, only one four-measure phrase of the full melody in "Phantoms Can't Hang" is used. "R/Deadmau5 - The 'Oooh's in Phantoms Can't Hang Are from Another Song." (n.d.).

lack of articulation on each note and its gradual dynamic changes (such as the crescendo and decrescendo from 4:05 to 4:15).

When this vocal part is interpreted as a phantom (a departed human soul that is returning to the world of the living), it explains why the melody lasts for several measures at a time without breathing, and sings the high-pitched "ooo" vowel that is stereotypically associated with ghosts in film and television. It adds a sense of the paranormal to the track. Furthermore, as will be explained in the analysis of the next sections, it is removed from the track between 5:40 and 7:00, as if it "can't hang" around for a while, but then intrudes into the final part of the last core.

The second layer shown in the transcription undergoes a more obvious continuous process. It is a gradual change in the frequencies of the synth layer so that white noise continuously morphs into clearly defined pitches. This could be discussed as a change in terms of timbre, or just of pitch clarity. Over the course of the section this layer keeps growing, containing sustained harmonies that expand to include more and more notes. Eventually it turns into one of Deadmau5's famous synth chorales. These chords change on downbeats and tonally project the key of F minor complete with the leading tone E. The volume of this synth sound also increases a great deal as the breakdown section goes on, while the pitch becomes clearer and the harmonies expand. As the white noise dissipates and chords emerge, the music settles into a kind of meditative space, when dancers can take a physical break to focus on more mental phenomena, including things that may be illusions or phantoms within one's own mind.

Figure 7-6: Transcription of the first part of the breakdown (starting at 3:15) in "Phantoms Can't Hang" by Deadmau5 (2014).

The third layer in the transcription is the bass. This layer undergoes a continuous process with a technique that I discussed in chapter 2 called the "illusion of acceleration." Rhythmically, the bass starts out with clear repeated eighth notes, but gradually the rhythm becomes clear repeated sixteenth notes. This effect is accomplished by the fading in of the notes halfway in between each adjacent pair of eighth notes, starting around 3:24. In this case however, the fade-in only happens in the left speaker. This means that starting around 3:24, the left speaker has a rhythm of sixteenth notes but the right speaker has a rhythm of eighth notes. The usage of two speakers projecting the eighth-note pulse makes that pulse stronger than the sixteenth-note one, enforcing traditional notions of duple metric hierarchies and making the metric construct of the piece clearer.

Breakdown sections very often have an aesthetic of confusion. In the beginning of this breakdown section, musical confusion is caused by the introduction of the new "phantom solo" element, the white noise transitioning to chords, and the "illusion of acceleration" only occurring in one speaker. As the section proceeds, the pitches and rhythms become clearer, the volume grows louder, and the music gradually transitions into the next section, the buildup. The continuous processes in this section are salient because they are long (guideline 6), and because the texture is sparse so each layer is relatively distinctive (guideline 2). They are salient in a different way than the riser in buildup 1 though, because the continuous processes in the riser are more clearly coordinated and work towards a clear climactic goal. In both instances there is a sense that the listener is taken along for a teleological ride (or, in the breakdown, at least the ride begins), but the ride in the buildup section is more intense.

Buildup 2 (4:30–6:00)

The second and final buildup in the track is signaled by the sudden re-entrance of the hook, but it is also marked by the other layers that were introduced in the breakdown section continuing to get louder and move towards the long-term goal of the next beat drop. The harmonic synth part also reaches a new melodic high point of A-flat (scale degree 3) and has a double-neighbor motive around that. Interestingly, the bass part that gradually changed rhythm from eighth notes to sixteenth notes now gradually changes back to eighth notes in the first part of this section. By 4:52 the rhythm is clearly eighth notes again, and that rhythm continues in the bass for the rest of the section.

The second part of buildup 2 occurs from 5:00–5:30. During this time many of the same techniques used in the intro reoccur. The hi-hat fades in at 5:08 and the kick drum enters suddenly at 5:15, recalling 0:19 and 0:30 respectively.[36] Three beats before the hypermetric downbeat at 5:30, downlifters are used again to signal the start of the third and most intense part of the buildup. In this next subsection, just when the tension is ramping up and the riser is starting, the "phantom solo" fades out (starting around 5:40). It had just done a crescendo, bringing it to further prominence in the track (according to guideline 1), but at this point it "can't hang" with the dancers who are getting ready to

[36] This raises the question of whether 0:15–0:45 should also be included as part of a two-part buildup 1 rather than the intro. That would be a possible reading, since the energy increases and sounds are added to the texture in that section. However, the sections that build up energy the most in the track are 0:45–1:15 and 5:30–6:00. These sections are definitely worthy of the title buildup, but are the sections immediately preceding them also? One reason I have decided to label one of them as part of a buildup section and the other as not is because 4:30–5:00 does not sound like the continuation of a breakdown and so that section should be counted as some part of a buildup section, as well as the part from 5:00–5:30. At 4:30 the hook comes back and there are many elements in the texture, whereas breakdowns are defined as having thin textures with minimal elements. This means that my analysis is a three-part buildup 2. There are obvious parallels between 0:15–0:45 and 5:00–5:30, so calling them two different names is not ideal for analysis, but the former is still setting the scene for the track as a whole so it is subsumed under the label of intro, whereas the latter is part of a longer building up process.

experience an intense climax. It is only strong enough to sound in non-core spaces. Perhaps the fading out of the phantom voice here represents how being on the dancefloor can help us escape from things that haunt us off the dancefloor. However, the phantom does come back and contribute significantly to the second half of the final core.

The riser used in this last part (5:30–6:00) of buildup 2 is similar to the one used in buildup 1, but not quite the same. The long continuous pitch ascent has less depth here (it ascends less distance) because in buildup 1 it clearly started with a glissando in the bass that seemingly faded in from nothing in that low register. This time, there is a pre-existing bass line from the harmonic progression in the breakdown that becomes an ostinato F (tonic) from 5:30–6:00. In buildup 2 there are also pre-existing *clear* harmonies in the synth part, as opposed to the *unclear* "phantom choir" heard before buildup 1. The long pitch ascent in buildup 2 reaches the same high points as buildup 1, but seems to start from a point that is less low. So there is less change in pitch in buildup 2, meaning that the pitch ascent is less salient than its predecessor in buildup 1 according to guidelines 7 and 8 (depth and rate of change, as discussed in chapter 5).

Another difference is that the filtering out of low frequencies happens much less in this buildup than the previous one. The percussion (snare and toms) gets softer but does not fully fade out as it did before, and the bass also gets softer but is not as quiet as it was before. The bass also maintains its clear eighth-note pulse throughout as opposed to its sustained note that it had in buildup 1. What this means is that the pitch ascents are less salient in the texture in buildup 2 than the pitch ascents in buildup 1 because the other layers are louder and more rhythmic than they were before.

Why then, is it easy to perceive buildup 2 and its following climax as more salient overall than buildup 1 and its following climax? It is because even if the pitch ascents in the later section are less salient than those in the former, there are other factors at play, and again the guidelines can help us explain our perception. In both instances, these risers are highly salient compared with other continuous processes in the piece according to guideline 9 because they are used to highlight climactic moments. The riser in buildup 2 though, is only the end of something much longer. The second buildup section contains three sixteen-measure (thirty-second) subsections and a long increase in tension over one-and-a-half minutes. There is an overall crescendo that takes place from 4:30 to 6:00, and according to guideline 6 (length), this is more salient than the crescendo from 0:15 to 1:15 that took place in the intro and buildup 1. The longer time taken to build up the energy before a climactic drop makes the tension in buildup 2 stronger, and the release of tension at the start of core 2 emotionally stronger as well.[37]

Furthermore, the cue at the end of buildup 2 is more salient than the cue at the end of buildup 1. In buildup 2, the pitch ascent gets cut off earlier and more clearly than in buildup 1, where the pitches clearly coalesce on D5 and hold that right until the last beat of the section, which contains a drum hit acting as a one-beat cue. The stoppage of the pitch ascent does not sound very clear at 1:14 though, because in addition to the drum hit there is white noise, just like in the anacruses to each subsection generated with the "backwards reverb" effect within core 1. In buildup 2, however, there is an entire measure of cue space, when nothing but the cue is heard. From 5:58 to 5:59 a very clear

[37] Huron (2006, 314–318); Patty (2009, 330–339).

cue is presented, with the last measure of the hook sounding suddenly much louder and sharper in timbre. All the other sounds (including any white noise) immediately drop off, leaving the hook to act as a very strong cue due to the large drop off in intensity. After all of the continuous processes, this sudden, discrete process is very noticeable, and it is one of the most salient moments in the track. On the last beat of the cue measure the drum hit sounds once again, with the white noise as before, but the extra beats preceding it without the plateau point of the long pitch ascent make the cue more salient. The whole riser in buildup 2 is an excellent example of the roller-coaster aesthetics of buildup sections that Deadmau5 described in his masterclass.[38]

Core 2 and Outro (6:00–9:15)

The final core starts much the same way as the first one (which started at 1:15). For the first minute (6:00–7:00), the same sound layers are used, including the anacrustic backwards reverb effect highlighting each sixteen-measure section.[39] As is characteristic of the progressive house genre though, the final core does not finish without adding an extra element that was not utilized in the first core. In this case, that extra sound is not introduced at 7:00, and it is the phantom solo voice originally heard in the breakdown section. This is significant because the phantom voice that was associated with continuousness and instability in the breakdown is returning here for the first time since 5:40 when it faded out during the buildup. When it faded out at just before the climactic point of the piece, this could be interpreted as the phantom not being able to "hang

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[38] "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lesson 13, 11:02–12:00). For a full quotation see the last chapter.

[39] One notable difference however, is that the eighth-note ostinato layer in the bass sound is made richer and has clearly present overtones such as A-naturals, which suggest an F major tonality that conflicts with the minor tonality outlined by the persistent hook and presented in the rest of the piece.

[around],” but it comes back here at a time when progressive house tracks are expected to add a final element that puts the energy of the track over the top. This moment represents the track’s completion and culmination, and in this case the phantom voice must be included. It is one of the central components that generates the identity of the track. If the phantom being swept under the rug during the intense buildup and core sections first suggested that dancing with energy can help us forget about things that haunt us, then the phantom’s return here suggests that we have to learn to live with the difficulties of life and dance with joy nonetheless, even with our phantoms right beside us.

The outro of the track (starting at 8:00) contains mostly discrete processes, including the instantaneous peeling away of many layers. The phantom solo voice sings one more phrase and then fades away on an unresolved B-flat (scale degree four). However, the phantom choir returns in this section, first at 8:30 with the melodic hook still providing clear articulations and rhythms, and then at 9:00 the choir is all alone. Since this is the only time in the piece that the phantom choir is alone in the texture, the amplitude graph or this section provides a good indication of how it works. Specifically, looking at Figure 7-7, it is clear that continuous panning is used to create a rotating effect around stereo space. Even though the overall volume level of the sounds is soft and they are fading away to end the track, the panning can still be heard, and it contributes to the sense of otherworldliness in the phantom choir parts, along with the unstable pitches.

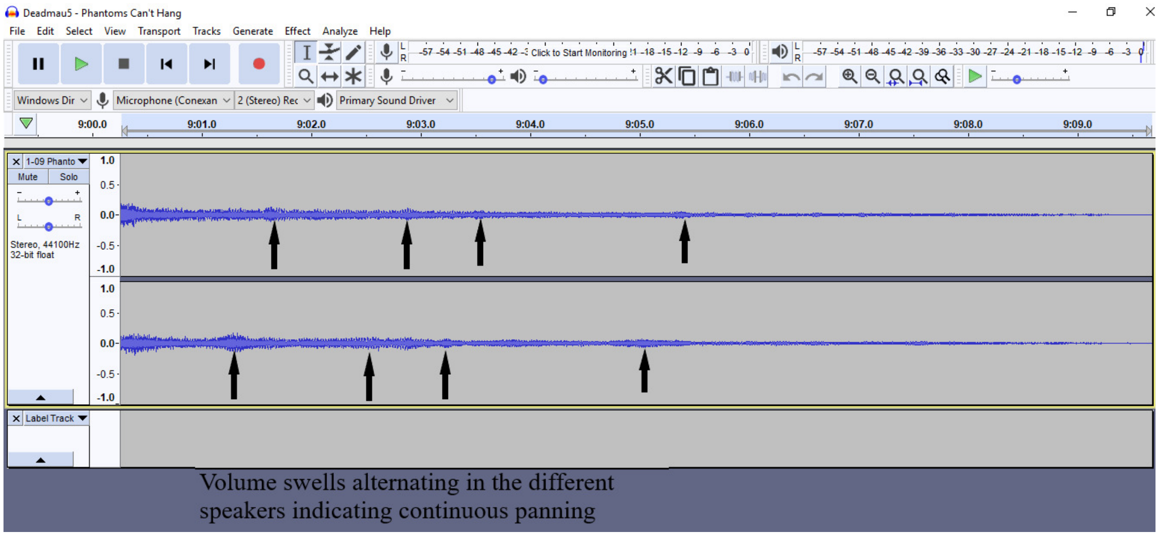

Figure 7-7: Amplitude graph showing continuous panning in the last part of the outro (9:00–9:10) of "Phantoms Can't Hang" by Deadmau5 (2014).

In "Phantoms Can't Hang," continuous processes interact with discrete ones to create a sense of the paranormal. The highly-salient risers in the buildups add significant tension before climactic drops, and the melodies and rhythms gradually become more stable in the breakdown through the "illusion of acceleration" and the turning of white noise into clear tonal chords. The instability of the "phantom choir" in the intro and outro sections creates a dramatic feel to the piece, and the "phantom solo" part in the second half of the track uses continuous volume changes and a lack of articulation to signify the paranormal. Even though the track follows the standard structural norms of contemporary progressive house, the aural representations of the paranormal create a unique, potentially uncomfortable aesthetic to the music, and their usage suggests a narrative of phantoms being with us, even during the moments when we try to escape them.

"Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998)

The Chemical Brothers are a British EDM duo whose members are Tom Rowlands and Ed Simons. They have been an integral part of the EDM community from the mid-1990s to the present. (Their ninth studio album *No Geography* was just released on April 12, 2019.) Their music is eclectic but is often psychedelic, and usually fits within the genres of techno, electro and acid house, electronica, or big beat. This last genre reached its height in popularity in the late 1990s, and it is strongly associated with three English artists: Prodigy, Fatboy Slim, and The Chemical Brothers. It relies heavily on sampling from funk, soul, jazz, and rock songs, turning the percussion sounds into sped-up breakbeats and distorting the bass lines electronically.[40] In the case of "Electronic Battle Weapon 4 (Freak of the Week)," percussion parts from the funk song "Freak of the Week" by Funkadelic are used.[41] The breakbeat style contrasts with the more common "four-on-the-floor" style (simple drum patterns with a kick drum on every beat) that is most commonly used in EDM today and is associated with house genres.

In previous chapters I have examined several tracks by The Chemical Brothers, specifically "Star Guitar" and Electronic Battle Weapons 1, 3, 9, and 10. The Electronic Battle Weapons (hereafter abbreviated to EBWs) are a series of tracks that are designed specifically for DJs to use in clubs, because they are usually extended or altered versions (a.k.a. "club" versions) of shorter album tracks that have regular names. They are generally more experimental versions than the singles, trying newer and more innovative

[40] For a more in-depth explanation of breakbeats, see Butler (2006, 78).
[41] This is most obvious when comparing 4:45 in The Chemical Brothers' version with 3:45 in Funkadelic's version. *Funkadelic - Freak of the Week* (n.d.). https://www.youtube.com/watch?v=0qXuMdQLwkQ.

musical techniques. Until the release of the compilation album *Brotherhood* in 2008, the EBWs were only sold as a series in vinyl format to select DJs of the duo's own choosing.[42] Their title and their circulation among DJs leads one to wonder if they can be or were intended to be sampled and used as weapons in DJ battles. In total there are twelve EBWs released to date, spanning the years 1996–2019.

"Electronic Battle Weapon 4" was first released on June 1, 1998, and later re-released with the title "Freak of the Week" on the EP *Music: Response* (2000). It is a rare instance of an EBW being unaltered from its original version to its album/single version. As previously mentioned, it uses percussion samples from the 1979 funk song "Freak of the Week" by Funkadelic. This is significant because EBW4 utilizes continuous processes throughout the track to create the sense of a paranormal dystopia where an alien abduction occurs, and the Parliament-Funkadelic collective led by James Clinton is known for incorporating science-fictional, outer-space themes in their music.[43] During the time period of EBW4's release, science-fiction was an important part of mainstream culture in the U.S. and the U.K due to the popularity of television shows such as *Star Trek: Voyager* and *The X-Files*. This was also the time period when afrofuturist scholarship began to flourish, exploring how African-diasporic arts and culture intersect with contemporary technology and science-fiction.[44]

In EBW 4, there are many high sounds with unstable pitch that behave like sirens or warning signals, and in core 2, a group of continuous processes with wave shapes

[42] Parks (2008).
[43] Corbett (1994, 7–24).
[44] Dery (1994); Eshun (1998).

sound like the descent and ascent of a UFO interrupting the dancing in the main part of the track. In this piece, The Chemical Brothers have taken the phrase "freak of the week," which was used in the lyrics of the funk song to refer to a licentious woman who enjoys partying, and repurposed it to represent something more literally "freaky" in the sense of something creepy and unusual. Perhaps the dystopian setting was created by a freak accident, or the aliens that come are thought of as freaks by humans (or vice versa). Even though the track feels energetic and driving because of its fast tempo and use of drum beats almost throughout, continuous processes are layered on top of the nearly-constant drums to generate feelings of tension (especially in the cores), without complete disorientation.

An overview of the form of the track is shown in Figure 7-8. There are three cores, which is a high number for a track that is only six minutes long. The first and third core are similar, but the second core stands out as the central and most unique part of the track. The fact that continuous processes are most salient in the cores means that this track is an interesting counter-example to the norms described in the last chapter of continuous processes being most salient in breakdowns and buildups. Another interesting feature of this piece is that the intro and outro stand out as being significantly different from the rest of the track. There are elements that tie these sections to the rest of the track, but the intro is in a different key, and the outro utilizes mostly only drums. This strong differentiation of the outer sections may be because of the track's original intended purpose of being used by DJs in live performance, so the intro and outro may be designed to mix well with other preceding and following tracks.[45] However, this is an unusual amount of differentiation from other sections when compared with other tracks. When looking at the form chart, it is also noteworthy that there is a section before the first breakdown that stands apart by itself. I call this section the "interlude" for lack of a better term, and discuss its usage of continuous processes in the chronological overview of the piece.

In some ways EBW 4 is symmetrical, because core 1 and core 3 are similar but core 2 is different and in the middle. There are multiple salient elements present in both core 1 and core 3 that connect them, but core 2 has the most salient continuous processes in the entire track, which are the long multi-part waves featuring changes in many parameters that could be interpreted as the descent and ascent of a UFO. In other ways though, the piece is not symmetrical. For example, the intro is highly different from the outro (although they are both similar in that they stand out from the rest of the track). The beginning of the piece also clearly poses E-flat major as the key and the rest of the piece presents D minor as the key, with E-flat as a prominent pitch class "fighting" against it. Furthermore, core 3, in addition to having multiple sound layers from core 1 (making it symmetrical in some way) also brings back sound layers from other sections such as buildup 1, and newer sounds that were only introduced after core 2.

Core 3 is in some ways a synthesis and culmination of the elements in the track, because it contains techniques from many previous sections such as extended pitch waves

[45] Butler's studies of live performance discuss this extensively. He notes that "The portion of a DJ set in which two different records overlap is called 'the mix,'" and the goal of doing this is to create a perceptual hybrid "third record." Butler (2006, 94).

(which were used in core 2), both scoops and falls on E-flat, and a clear bass line in D minor. This reading of the piece suggests a teleological narrative. Perhaps the E-flat-major section at the beginning represents a happy time in the world of the track, before troubled times begin (represented by the high warning sirens, the dissonant battle between D and E-flat, and then the alien abduction). By the end of the piece, only the drums have survived, with there being no clear winner between the two pitch classes. I will now discuss the piece chronologically, showing how the narrative unfolds in more detail and focusing on the use of continuous processes in the middle sections of the piece, (particularly the cores), when continuous processes are most salient.

Time Stamp	**Section**	**Continuous Processes**
0:00	Intro	
0:27	Buildup 1	Short pitch falls, E-flat layers 1, 2, 3.
1:01	Core 1	Short and long pitch scoops and down-up waves (including “squeaking” sounds). Reverb increased. Local accelerations and decelerations. Volume changes.
1:56	Interlude	Up-down “squealing” pitch waves. Short pitch falls in E-flat layer 2.
2:09	Breakdown 1	
2:30	Buildup 2	Short pitch falls in E-flat layers 1 and 2. Ascending noise sweep.
2:43	Core 2	Three-phase sigmoidal pitch wave that also has volume and timbre changes. “Alien abduction.”
3:38	Breakdown 2	Down-up pitch wave with reverb, speed, and volume changes. Ascending noise sweep. Phase 1 of “hollow tube” sinusoidal wave.
3:44	Buildup 3	Phase 1 of “hollow tube” wave continues.
3:51	Core 3	End of phase 1, phases 2–4 of “hollow tube” wave. Volume swells in other layers. Short pitch falls *and* scoops on E-flat at the same time.
4:32	Outro	Reverse cymbal effect.

Figure 7-8: Form chart and summary of continuous processes used in “Electronic Battle Weapon 4 (Freak of the Week)” by The Chemical Brothers (1998).

Intro and Buildup 1 (0:00–1:01)

The piece starts very discretely, as shown in the transcription of the intro (Figure 7-9). There are only slight differences between the first eight measures of the track (loop 1 in the transcription) and the second eight measures, notably more percussion and more rhythm being added in general. The ostinato bass line and one-measure melodic motive (which I will call the “intro motive”) are sampled from the piece “Ictus: Primordial Pulse” by progressive electronic musician Roger Powell, who worked with Robert Moog.[46] The intro motive presents an E-flat major-minor seventh chord, and its emphasis through repetition makes the chord seem like a stable tonic.[47] Although the harmony is not a pure major triad, the dissonance of the chordal seventh is mitigated by the fact that the highly-consonant pitch G is the only note in the motive that sounds on the beat. All the others are syncopated, on the off beats, and the G is on beat 3, metrically emphasized. The dissonance of the seventh also implies the presence of overtones in the chord (if in a mechanized, digital way), which is a trope representing nature and innocence. At this point in the hermeneutic narrative, there is peace in the world.

[46] “The Chemical Brothers’s ‘Freak of the Week’ - Discover the Sample Source” (n.d.); *Roger Powell - Cosmic Furnace - “Ictus / Lumia / Fourneau Cosmique”* (n.d.). https://www.youtube.com/watch?v=pvp04HXpdTQ.

[47] Some listeners with classical ears may be inclined to hear the opening harmony as a dominant seventh in the key of A-flat major, expecting an “auxiliary cadence” because of an off-tonic opening. However, in this contemporary piece, the major-minor seventh sonority is not interpreted as being in need of resolution.

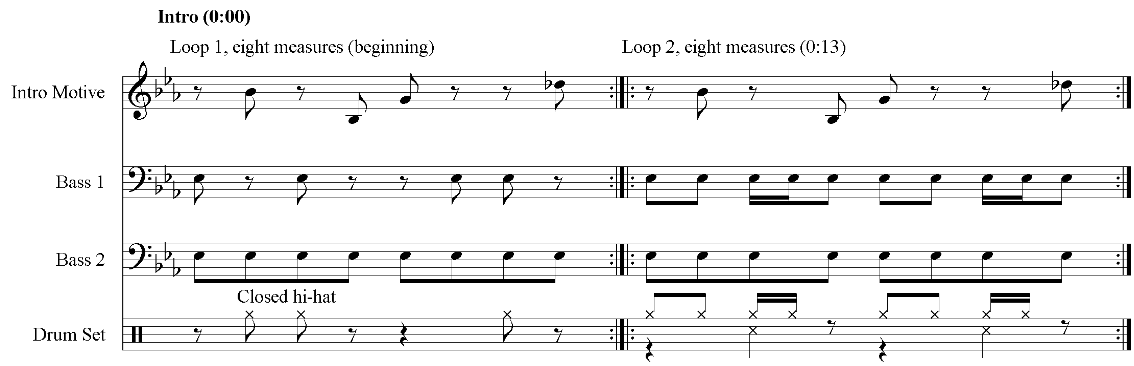

Figure 7-9: Transcription of the loops in the intro (0:00–0:27) in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

At 0:27 the first buildup section starts and the first continuous processes (short pitch falls) are introduced. Although they are weak in terms of salience and short in length, they make the piece seem unstable and/or unpredictable. A transcription for this section is shown in Figure 7-10. Three new pitched layers enter the texture, each coming in suddenly, and each centered on E-flat4. I will call these E-flat layers 1, 2, and 3. Together with the bass ostinato, they surround the "intro motive" both above and below with tonic pedal points of repeated eighth notes. E-flat layer 1 enters at 0:27 and contains very slight pitch falls on every note. This layer also alternates between two different starting pitches, the first being a little flatter in tuning and the second being sharper.

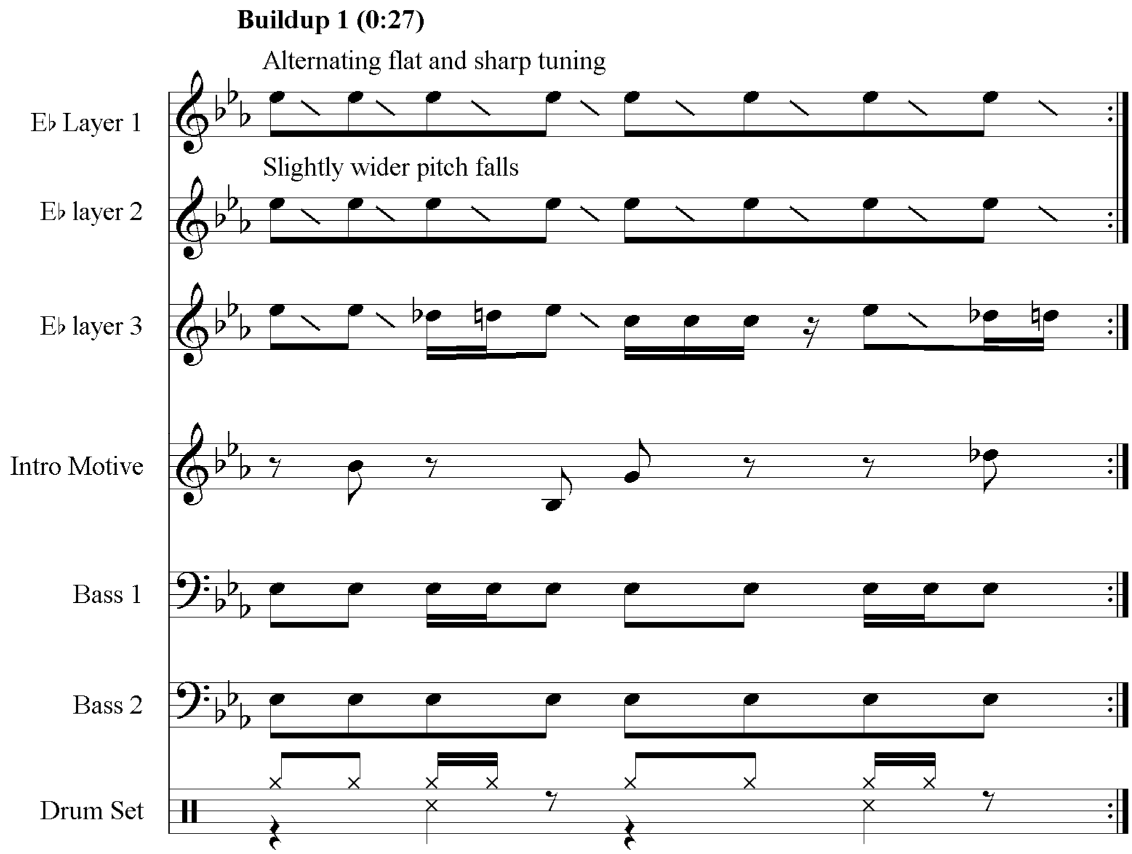

Figure 7-10: Transcription of the loop in buildup 1 (starting at 0:27) of "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

E-flat layer 2 comes in at 0:34, and has slightly more rangy pitch falls, meaning that they are slightly more salient than the pitch falls in E-flat layer 1 according to guideline 7 (depth). This layer has the same tuning for every starting pitch, unlike the first layer. It also sounds like both of these layers have the same timbre (which is reminiscent of the sounds of lasers in science-fiction movies), but the second is slightly louder; the new part is highlighted rather than the old in order to create excitement and a sense of growth.

The third layer centered on E-flat is significantly different than the first two. Its pitch and overall sound quality is less clear and definite, so it sounds as if it is fleeting and unstable.[48] It also descends further below E-flat than the previous two, so it has the most depth of the three. This means that as the buildup section progresses, the salience of the pitch descents grows with each new layer, increasing tension, as is the function of buildup sections. However, it is not the depth of the short continuous pitch slides that increases in E-flat layer 3, but the overall depth (pitch range) of the layer. The amount below the tonic that each eighth note descends does not drastically increase, but rather the change within each part of the loop, before it returns to the high tonic each time, is significantly bigger than the change in the eighth-note pitch slides in previous layers. This is reflected in the usage of different notes in the transcription. The first and last parts of the loop also contain both descents and ascents in terms of pitch, creating a down-up shape that will be more important later in the track. Overall the use of many repeated continuous pitch slides in this buildup section helps create a sense of instability and uncomfortableness; this is the first taste of the science-fictional dystopia to come.

As mentioned in the previous chapter, it is common for the ends of buildup sections to have a short "break," where the energy drops and the texture thins out dramatically. In contemporary EDM and pop music this section is usually at most one measure long and contains a "cue," but in "Electronic Battle Weapon 4" this "break" lasts for four measures. At 0:54, the only sounds left are E-flat layers 2 and 3. The focus is on

[48] The unstable qualities result from the manipulation of the sound with the software program Traktor, which emulates tape machines and allows for a very precise amount of control over effects. Miller (2018b).

layer 3, which flutters around in a way that is hard to follow, corresponding with its unclear timbre. Generally it goes down in shape for the first two measures, then alternates going up and down for the following two measures, ending the section lower in pitch. This contrasts the typical ends of buildup sections in contemporary EDM, which feature very high sounds before lower frequencies come back in at the beat drop. There is also no distinct cue here, so the start of the next core section is unexpected. The pitches heard during the start of the next core are also surprising, because they indicate a sudden key change from E-flat major to D minor.

Core 1 and Interlude (1:01–2:09)

The first minute of the track sets up a very clear key of E-flat major, with repeated tonic ostinatos and the "intro motive" outlining the pitches of an E-flat major-minor seventh chord, emphasizing G (the third). At 1:01, the first core of the track starts and suddenly the bass presents a motive clearly in D minor, as shown in the transcription (Figure 7-12). Core 1 contains four subsections of eight measures, as shown in the more detailed form chart for the section (Figure 7-11). The many pitch falls that slightly drop below E-flat in the previous buildup section could be interpreted as foreshadowing for this modulation down a half step. E-flat layer 3, however, stays in the texture for the first eight measures of this core, providing a dissonant and unstable conflict with the other pitched layers that are clear and stable in D minor.[49] At around 1:14 E-flat layer 3 fades out, so the new key is allowed to take over more fully, at least for the moment.

[49] Even though E-flat layer 3 is here used as a one-measure loop that could be viewed as stable through its repetition, the smaller components *within* the loop are still unstable and unclear.

Time Stamp	Section	Continuous Processes
1:01	Subsection 1	Pitch falls in E-flat layer 3.
1:13	Subsection 2	Down-up pitch wave with reverb, volume, and speed changes.
1:28	Subsection 3	E-flat pitch scoops in "beeping" sound. Reverb, volume, and speed changes.
1:43	Subsection 4	Short pitch scoop and "squeaking" down-up pitch wave.

Figure 7-11: Form chart for core 1 (1:01–1:56) in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

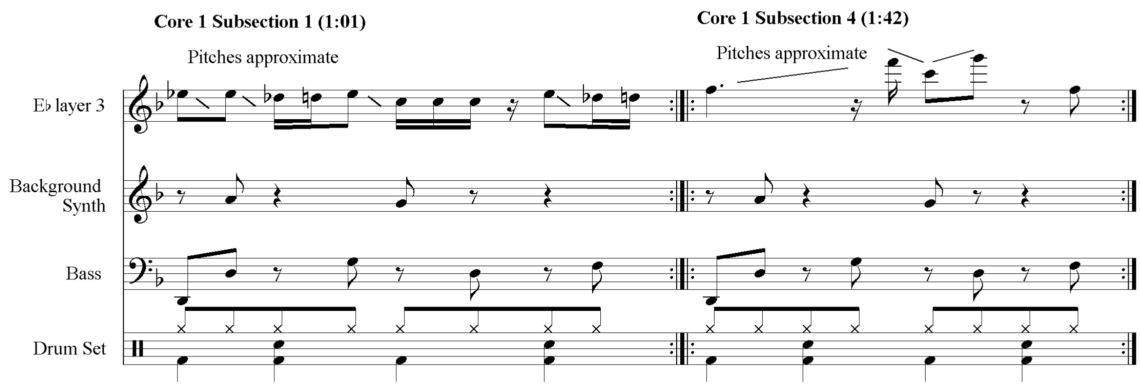

Figure 7-12: Transcription of two loops in core 1 (1:01–1:56) in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

Instead of descending pitch *falls*, which were used heavily in the intro and buildup 1 sections, core 1 and the interlude utilize pitch *waves* with various shapes and saliences. The first example of this occurs in subsection 2, from 1:13 to 1:24, in a new layer that fades in at 1:13, while E-flat layer 3 fades out. The new layer becomes highly salient and has many interesting components to it, including adjustments in the amounts of reverb and the tremolo effect, as well as continuous changes to pitch, volume, and rhythmic speed. It lasts for about six measures, and graphs of it are shown in Figure 7-13.

In terms of pitch, it slowly descends to A5 (the dominant in the new key of D minor), settles there or just below it, and then ascends. This means that it is a pitch wave that goes first down, then up, but it is difficult to identify starting and ending points for the pitch wave because of the volume changes. The sound layer fades in and crescendos, stays relatively loud at its midpoint (about three measures in) and then fades out again around 1:20. The rhythm of the passage is roughly sixteenth notes, but as the pitch gets lower, the speed of this layer gets slightly slower, and as the pitch gets higher the speed gets faster.[50] Once this salient layer with multiple continuous processes fades out, the texture is left with only very discrete patterns from 1:24 to 1:28.

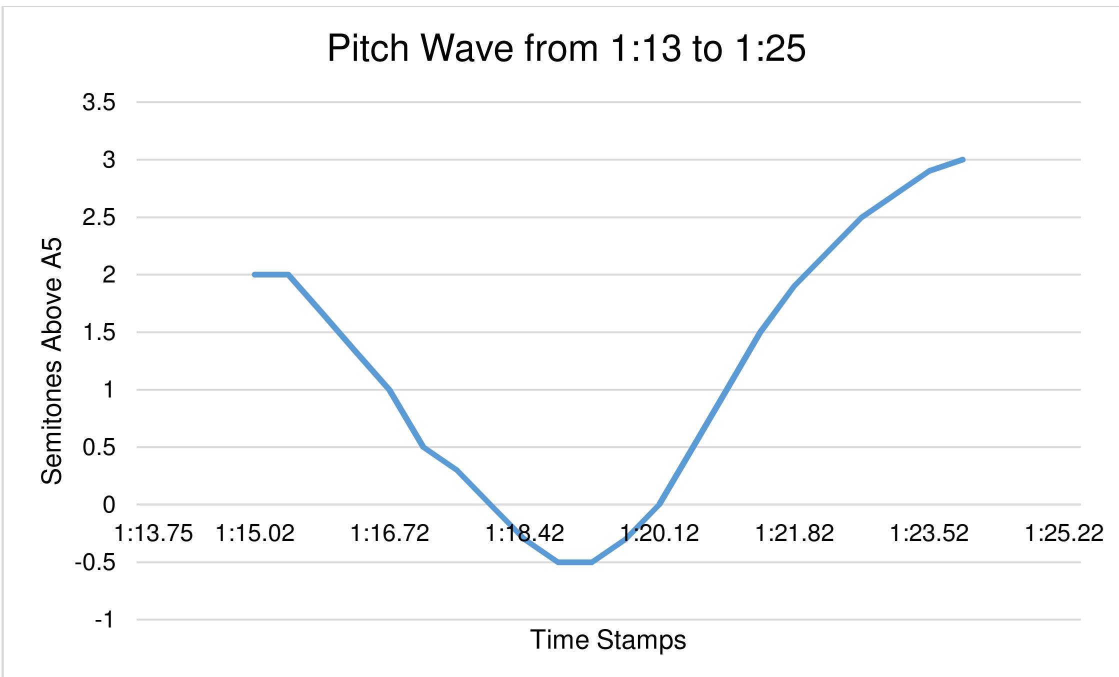

Figure 7-13a: Pitch wave for 1:13–1:25 in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

[50] All three of these continuous processes have wave shapes, as shown in Figure 7-13, but to interpret this connection as analytically meaningful is dubious since the shapes mean different things for different parameters, and volume shapes are almost always up-down because of fade-outs and fade-ins.

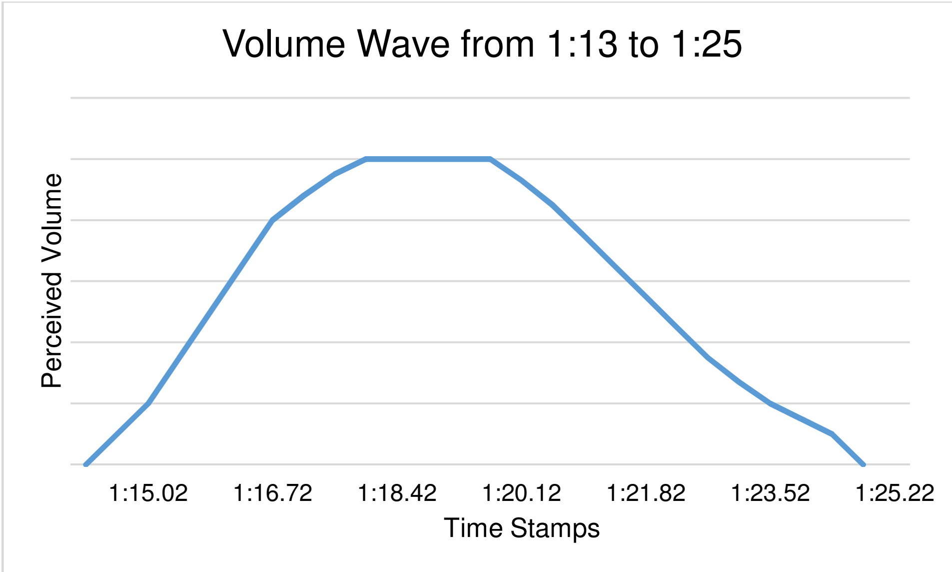

Figure 7-13b: Volume wave for 1:13–1:25 in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

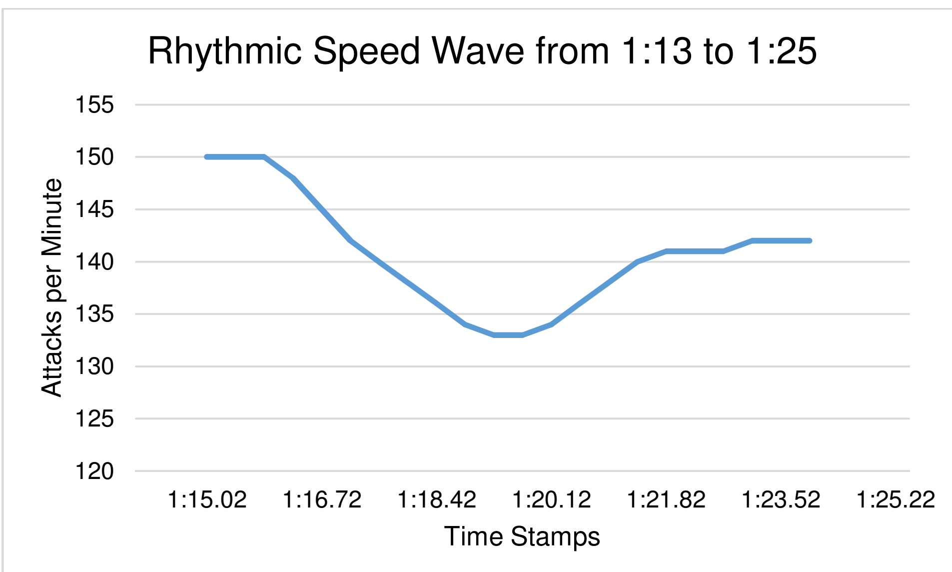

Figure 7-13c: Rhythmic speed wave for 1:13–1:25 in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

At 1:28 subsection 3 begins and E-flat comes back, continuing to battle against D and provide dissonance in the key of D minor. There are E-flats in two different octaves used, first a lower one at 1:28, then a higher one at 1:30, and they overlap a bit. More continuous processes in many different parameters are used on these high E-flat pitches from 1:28 to 1:42. In general the pitch comes in and out of focus, but there are also slight ascending pitch scoops used to make the notes unstable. There are also reverb, volume, and speed changes, similar to the preceding part (1:13–1:24). The high frequency and sharp timbre make the E-flat sounds piercing and uncomfortable to listen to, like a warning sound that is beeping.[51]

At 1:43 subsection 4 begins and a new high-pitched line enters the texture, repeating in a one-measure loop, as shown in the transcription (Figure 7-12). The depth of the first pitch scoop is small and it takes place over a relatively long time, so this first continuous process in the loop is not very salient. The second one, however, is much more salient, because it has a large range and occurs within a shorter span of time so the rate of change is higher (guideline 8). This is the second down-up pitch wave in the first core, with the previous one occurring in subsection 2. The one in subsection 4 is a lot shorter and stands out much more, having a "squeaky" sound quality. It is also clearly visible on the spectrogram (Figure 7-14).

[51] The unique sound of this layer was likely created with self-oscillation, an effect where the filter resonance has been turned up so high (the frequencies around the filter cutoff are so emphasized) that it creates its own sound. Miller (2018b).

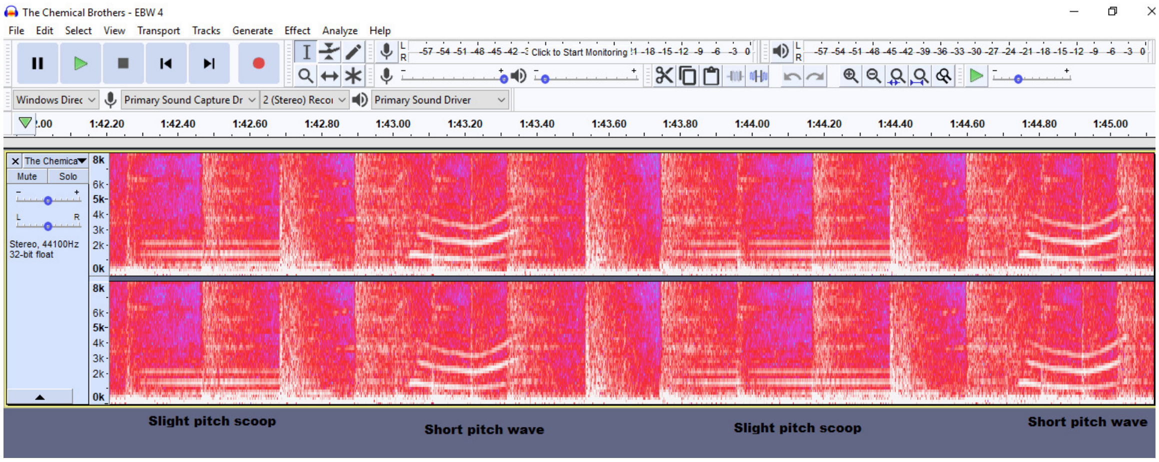

Figure 7-14: Spectrogram showing short pitch slides in part of core 1 subsection 4 (1:42–1:45) in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

The next section begins at 1:56. There are some new things that get introduced here, like the new simplified bass line emphasizing B-flat and F instead of G and D, and the choral voices on A-flat, B-flat, and C. These are both discrete things that make the key temporarily shift to F minor, but the most salient aspect of this "interlude" is the continuous pitch wave around beat three in the second measure of each two-measure loop. These pitch waves are similar to the short ones in the last subsection of the core because their rate of change makes them highly salient. However, they have different shapes than the ones in the core because they are ascending then descending (they are up-down waves). The rhythm is also slightly different, with the former starting clearly before the beat and the latter starting basically on the beat. Another important difference is that there are more frequencies involved in the interlude wave, as shown in the spectrogram (Figure 7-15). This makes it difficult to define specific pitches involved in this process. Instead it just sounds as if there are many high-pitched voices squealing. Another short continuous process also occurs in the second half of this interlude section, since E-flat layer 2 comes back with its repeated pitch falls, and the pitch E-flat is again re-contextualized in a different key (F minor).

Overall core 1 and the interlude use many short continuous processes (mostly with wave shapes) that act as effects. They all use high frequencies, and this combined with their continuous shapes make them like warning sounds that are beeping, squeaking, or squealing. The clear, discrete drum and bass parts maintain a steady groove, but the high effects add a sense of foreboding instability to the music.

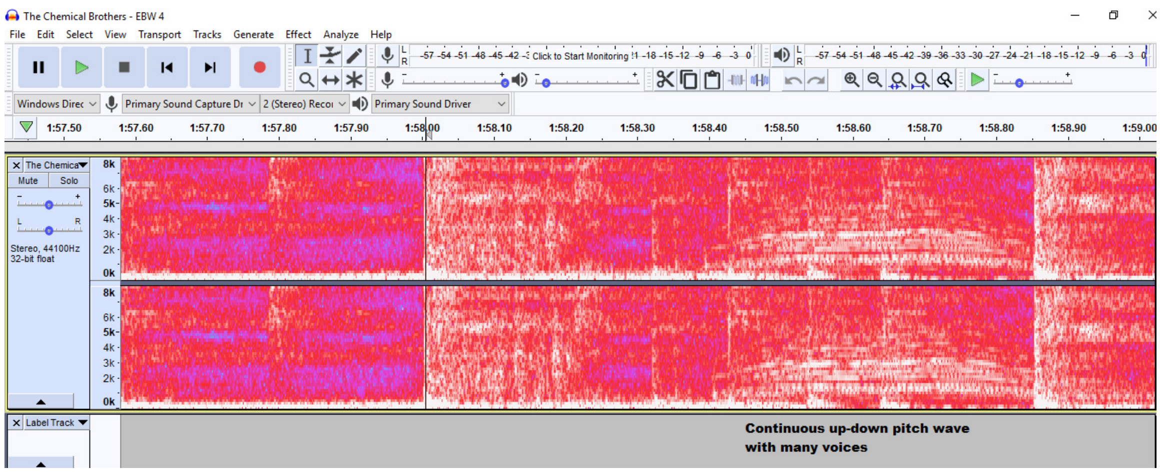

Figure 7-15: Spectrogram of part of the interlude (1:57–1:59) in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

Breakdown 1 and Buildup 2 (2:09–2:43)

These sections contain unusually few continuous processes for breakdowns and buildups, and they precede the second core, which has the most salient continuous processes in the piece. This is a reversal of the typical mode of operation in contemporary EDM tracks. In breakdown 1 (starting at 2:09), the thin texture of only drums and bass is used and they are both clearly discrete. In buildup 2 (starting at 2:30), there are some continuous processes that add tension but they are not very salient. Just like in buildup 1

(0:27–0:54), E-flat layer 1 enters (2:30) followed by E-flat layer 2 joining it (2:37). As mentioned previously, both of these have repeated pitch falls, but layer 1 also alternates between a flatter starting pitch and a sharper one, and layer 2 has greater depth in its falls from the starting pitch. The combination of fast pitch movements and different tunings in these sounds creates tension and instability.

Unlike in buildup 1 however, the E-flat layers are here competing with many other things, and they sound dissonant as the flattened ninth in D minor instead of sounding like tonic in E-flat major. This dissonance itself adds tension in a different way than continuous processes during this buildup section, whose purpose it is to increase tension. Also, in the second half of this buildup, after a one-measure ascending noise sweep, the E-flat layers get buried in the background behind the loud and salient percussion sounds. The sudden addition of these new drum sounds with a loud and fast rhythmic pattern adds tension because they are unfamiliar and brash. They act as a distinctive cue that is extended beyond the usual length. Buildup 2 is unlike most buildups in contemporary EDM, since there are no long continuous processes like risers leading directly into the second core, and the cue is longer than normal.

Core 2 (2:43–3:38)

Core 2 is the center of the track, both in time (it occurs in the middle) and in importance. It is a good example of the unique and expressive middle spaces in musical compositions generally.[52] This section also explains why Butler chose the term "core" for his formal prototype, and brings to mind his descriptions of DJs and producers referring

[52] Beckerman (2011).

to cores *as* the song itself.[53] Deadmau5 uses this kind of language in describing his compositional process, saying that the core (what he calls the main "hook") *is* the track and that it is what he works on first and the most.[54] After he has this main part down he goes back and creates the other sections based on variations of the core. The example of EBW 4 also brings to mind Snoman's term of the "body" as the main part of a track.[55] All of these descriptions work well for core 2 in EBW 4 because it is the main part of the track and the center of the hermeneutic narrative, when the abduction by aliens takes place.

The first twelve measures of core 2 (2:43–3:03) are very discrete, and sound like a typical core from a techno or breakbeat track. Several stratified layers are used (including the African drum sounds from the cue in the buildup) with complex syncopated rhythms, but there are no clear melodies or harmonies (which would be featured in the house and trance genres). At this point there is an abundance of energy and a clear groove; the listener is comfortable with clear and discrete loops and the music would be well-suited for any club or party situation.

At 3:04 (measure 13 of the section), some weird creepy sounds come in and act as effects to start disrupting the atmosphere. This is a new sound fading in, with a quasi-sixteenth-note rhythm. When it is still quiet the first noticeable pitch is E-flat5 (notable as the opposing pitch to D in the narrative). Then the beginning of the pitch wave from 1:13 is heard again, continuously sliding down to A and getting louder as it does so. These

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53 Butler (2006, 221–224).

54 "MasterClass | Deadmau5 Teaches Electronic Music Production" (2016, lessons 2, 13).

55 Snoman (2009, 224–228).

continuous processes and their unstable sound quality already make the core much more discomforting.

The next sixteen measures (measures 17–32 of the section, the second half of core 2, from 3:10 to 3:38) deserve extensive discussion because they feature the main group of long continuous processes in the entire track, which have multiple phases and utilize many continuous techniques. Before the ascending part of the pitch wave starting at 3:06 can happen, it is interrupted by a highly salient group of continuous processes that represent a UFO coming down to the dystopian environment and abducting humans on earth. One fan described this section as follows: "The synth sweeps in the section from 3:11 to 3:38 are still so mesmerising to me. I can speculate about some of the filter sweeping and pitch bending, but I think it's the combination of so many effects/techniques that results in a sound that I could only ever describe as otherworldly."[56]

In general these continuous processes can be grouped into one perceptual wave with three phases of six, six, and four measures where the pitch goes down, up, and down respectively. This can be seen in the graph of the pitch movement (Figure 7-16). The entrance at the beginning (3:10) seems to have multiple parts staggering in, one coming in at each of the first three eighth notes of the bar, all with the same stereotypically science-fictional sound, on E-flat. Each of these three entrances turn into one of the notes

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[56] "The Chem Base Forum: N00b Corner! Introduce Yourself Here! [Reply #99 by Enjoyed]" (2018).

of a triad, which slides up and down continuously throughout the section.[57] What makes this process more complicated though, is that each of the notes of the triad undergo continuous volume changes so that sometimes they are equally as loud as each other or in different levels of balance. Some parts also have the pitches obscured by an abundance of high frequencies.

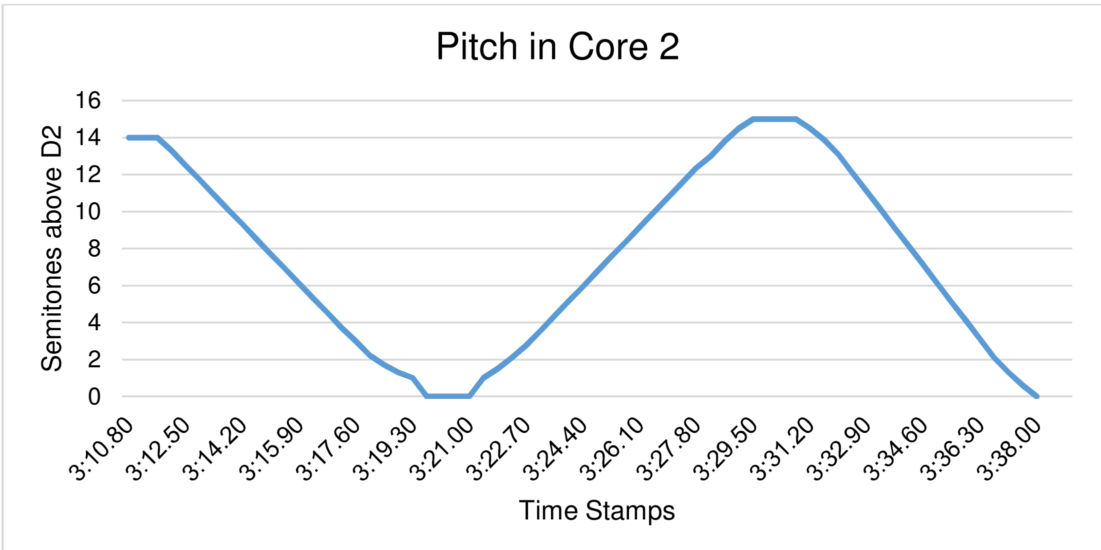

Figure 7-16: Graph of the main (root) pitches in the "alien abduction" (3:10–3:38) in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

In phase 1 (3:10–3:20) the pitches are most clearly defined at the start and the end. The high point is E-flat and the low point is a slightly-flat D (these are the two contradictory pitches in the track).[58] The shape of this segment is like a flipped sigmoidal curve (one of the shapes discussed in chapter 5), because the rate of change is highest in

[57] It seems to be a minor triad for phases 1 and 2, and a major triad for phase 3, although it is difficult to tell. There are also other sounds added and the usage of pitch is not quite as simple as a triad sliding up and down, but this is a good mental representation and approximation for it.
[58] It actually dips slightly below a perfectly-in-tune D, going about a quarter-tone flat at one point.

the middle and the pitch settles in a trough at the end. In phase 2 (3:20–3:30) the pitches continuously ascend, undergo more volume changes as well as timbre changes, and culminate in a salient E major triad with all three pitches prominent and clear. The shape of this segment in terms of pitch is a regular sigmoidal curve (S-curve) that mirrors the shape of phase 1, with the pitches going back up to the starting point of phase 1 (E-flat) and this time *exceeding* that point. Interestingly, the E major triad is slightly flat in tuning, corresponding with the slightly-flat D at the bottom point of phase 1. In the valley at the end of phase 1 and the peak at the end of phase 2, the D and E-flat markers that are important throughout the piece are slightly undershot and overshot respectively, furthering the aspects of symmetry in this large continuous process and the piece as a whole.

The major triad sonority continues to sound during the plateau at the end of phase 2 and into phase 3 (3:30–3:38). This is the easiest phase of the long continuous process to describe, because the major triad clearly slides down in pitch and fades out, marking the end of core 2. One could imagine this being a third in a series of three sigmoidal curves for pitch that have an overall periodic shape, but now the fade-out makes it difficult to assign a specific pitch as the bottom point.

Even though three sigmoidal curves with an overall periodic shape work well for modeling this process in terms of pitch (which is easiest to pay attention to), other parameters have peaks and valleys in their continuous movement that contradict the peaks and valleys of the pitch shape. The overall volume seems to remain constant for phase 1, not matching what the pitch does. In phase 2 it decrescendos first, and then crescendos toward the pitch peak, only partially corresponding with the pitch movement. The only phase of the single perceived wave in which the direction of the volume changes match that of the pitch changes is phase 3, when the volume fades out and the pitch descends.

In terms of timbre and spatiality, the triadic pitches involved in the long continuous process generally have the same timbre throughout, but occasionally continuous filter sweeps are used to add different levels of “sheen” or “glisten” to the texture. These are clearly visible on the spectrogram, and they have their own wave shape that does not correspond with the peaks and valleys of the pitch movement, as can be seen in Figure 7-17. The pitch peaks occur at 3:10 (the E-flat staggered entrances) and at 3:30 (the E major triad), whereas the “glisten” effects (the peaks of the filter sweeps) are added most notably at 3:14 and 3:28.

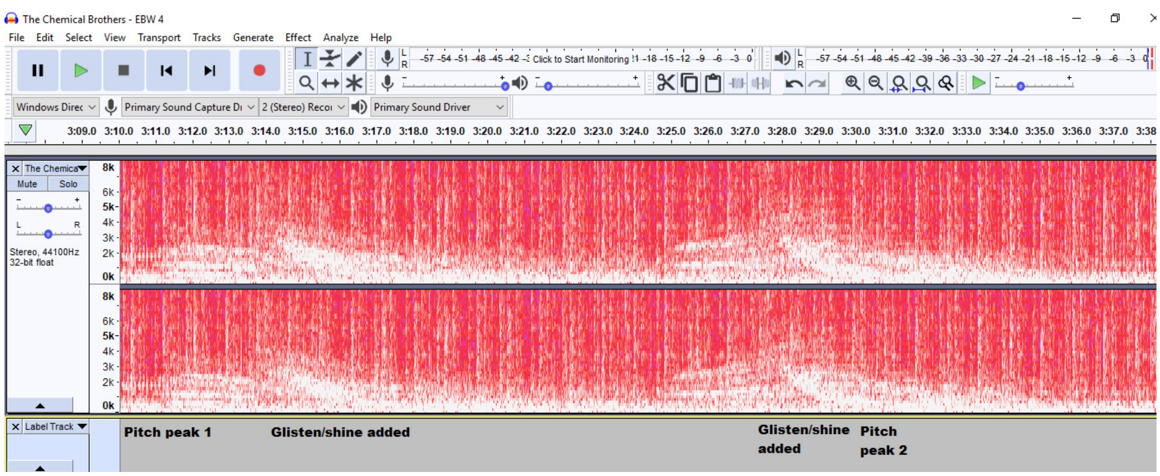

Figure 7-17: Spectrogram of the “alien abduction” (3:10–3:38) in “Electronic Battle Weapon 4 (Freak of the Week)” by The Chemical Brothers (1998).

The E major triad at 3:30 also seems to arise because of a timbre change, as if the triad coalesces into one sound in a very unique and salient way. This moment to me is the most memorable part of the track. It is reminiscent of the famous “deep note” THX sound effect heard at the beginning of many films, where a narrow band of frequencies gradually becomes a wide band through continuous pitch processes.[59] At the beginning of this sound effect it is difficult to identify any particular sonority, but at the end a very clear major triad is heard as the culmination of continuous changes in pitch and volume. In EBW 4 I think this effect is also created only by changes to the sound layer’s pitch and volume, with all three notes of the major triad becoming clear and equally loud for the first time, rather than a distinct change in the “timbre” of the sound itself. This is another example of how sometimes a continuous process is *perceived* to take place in one parameter but is actually caused by continuous processes in *other* parameters.

Overall the three-phase wave in this section sounds muddy and unclear in the middle parts between the peaks and valleys, but clear at the peaks and valleys. In the hermeneutic interpretation of the song, the initial descent represents the spaceship hovering down to earth, and the following ascent represents the flight back into outer space. The third phase sounds like a tornado siren signaling distress back on earth. Yet even though the alien abduction has tried to disrupt the main energetic part of the track, the drum and bass patterns that were established in the first part of the core maintain their groove steadfastly. There is some unusual use of hypermeter, because within this sixteen-

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[59] *THX Deep Note - Original Uncompressed Audio* (n.d.). https://www.youtube.com/watch?v=uYMpMcmpfkI.

measure section there are no two-, four-, or eight-measure patterns, but at the *metrical* level, the drums and bass are constantly looping to allow listeners to dance with high energy. In this core section, the use of clear and consistent discrete rhythmic patterns combined with highly-salient continuous processes allows for tension to be created without complete disorientation.

Breakdown 2 and Buildup 3 (3:38–3:51)

As with breakdown 1 and buildup 2, these sections contain relatively little continuous processes compared to what one would expect in breakdowns and buildups of more recent EDM tracks. Breakdown 2 (3:38) and buildup 3 (3:44) are also the shortest sections in the track, lasting only four measures each. The first notable continuous process that occurs here is the down-up pitch wave that first sounded from 1:13 to 1:24 and partially re-sounded at 3:06. It still has all the same features as before, including continuous changes in pitch, volume, and speed, but now it is re-contextualized in a breakdown instead of in a core. This means that it is not given any tonal or harmonic context because the texture is thinner and no bass line is present. It also interacts with the hypermeter differently because in core 1 there are only eight-measure sections whereas here there are clearly-marked four-measure sections, so this continuous process continues past the clear sectional boundary at the start of buildup 3. The sectional boundary at 3:44 is partially made clear and emphasized through the use of another continuous process, a short ascending noise sweep just before it.

Breakdown 2 also contains the entrance of a new sound layer in the track, a kind of “hollow tube” sound that will remain in the texture all the way through core 3 and until the beginning of the outro section. This sound layer is the result of flanging being automated very slowly.[60] It always continuously changes in pitch, and emphasizes the "backbeats" (beats two and four of every measure) with accents. At first it is in the background and very hard to hear, but it becomes clearer as the track goes on because there are less intervening elements. The transparent, hollow timbre of this sound signifies the science-fictional in a different but related way to the alien abduction in core 2. It represents something futuristic and unusual because it is a pitch that is not generated in the "normal" way, but instead as part of an echo/delay effect.

In buildup 3 the down-up pitch wave fades out, and the ascending hollow tube sound has now clearly taken its place. The continuous ascent of this sound functions similarly to a noise sweep in this section, but it is quieter and does not utilize *all* harmonics in the spectrum like white noise, only many of them. This explains why the continuous ascent here is visible but not extremely obvious in the spectrogram (Figure 7-18). Another new melodic part with clear and repeated pitches is introduced in this section. It is a two-beat pattern that alternates between F and a slightly-flattened F (almost like E) and could be interpreted as $\hat{3}$ and $\hat{2}$ in D minor. Just before core 3 begins, it moves from F to D, ($\hat{3}$ to $\hat{1}$), establishing D minor even more, and acting as an anacrustic cue to the upcoming beat drop. There were no bass parts to ground the tonality in the breakdown 2 section, and only ostinato D's in core 2, so this brings back more elements of the D minor scale that have not been heard since core 1.

[60] For more information on flanging see page 132, and Dodge (1997, 303–304).

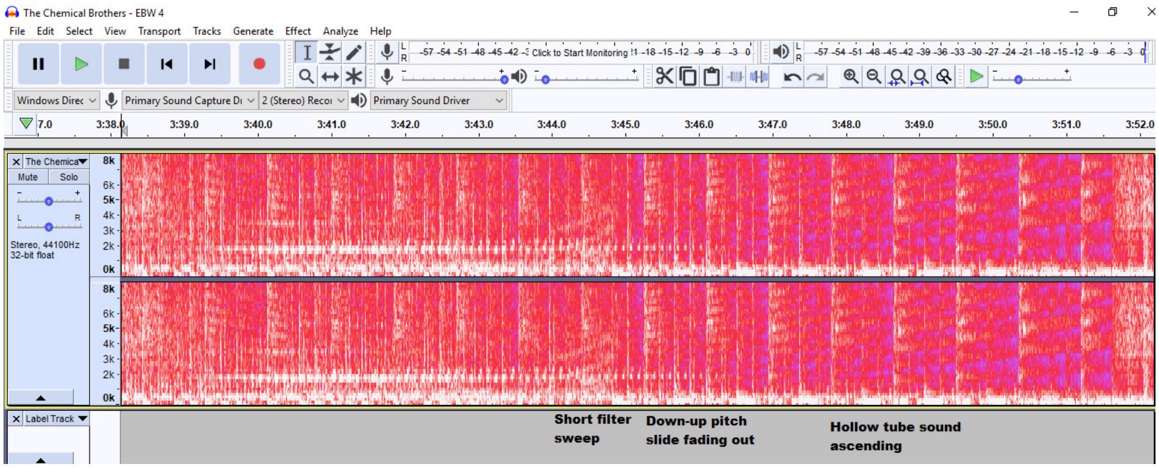

Figure 7-18: Spectrogram of breakdown 2 and buildup 3 (3:38–3:52) in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

Buildup 3 does increase the tension of the track due to the continuous ascent in the hollow tube sound and the cue, but not as much as would be expected from most EDM tracks produced today because these processes are not highly salient. The analytical guidelines can help us explain why. The hollow tube sound does have a distinctive timbre, lasts for a long time, and highlights the start of a new core section, so it has some salience under guidelines 2, 6, and 9, but it does not have much depth or a significant rate of change (guidelines 7 and 8), is not part of a group (guidelines 3 and 4), and it is relatively quiet in the texture (guideline 1).

Core 3 (3:51–4:32)

At 3:51 the final core of the track begins. It is similar to core 1 because it has the same bass line that firmly establishes the key of D minor, but now in core 3 there is no fluttery melody in E-flat layer 3. The continuousness of that layer has now been replaced with the hollow tube sound, which slides up and down in pitch throughout all of core 3. A graph of this is shown in Figure 7-19. Similar to the multiple phases of the periodic pitch wave in core 2 but much less salient, this sound's pitch wave has four phases including the initial ascent that started in the preceding sections, which *continues* ascending for two more measures after the start of the core. This is very unusual, since normally long pitch ascents will release the tension at the start of cores by plateauing and staying high, descending in a symmetrical mirroring of the ascent, or cutting out altogether. Possibly the extended ascension here makes up in some way for the relative lack of tension in the buildup.

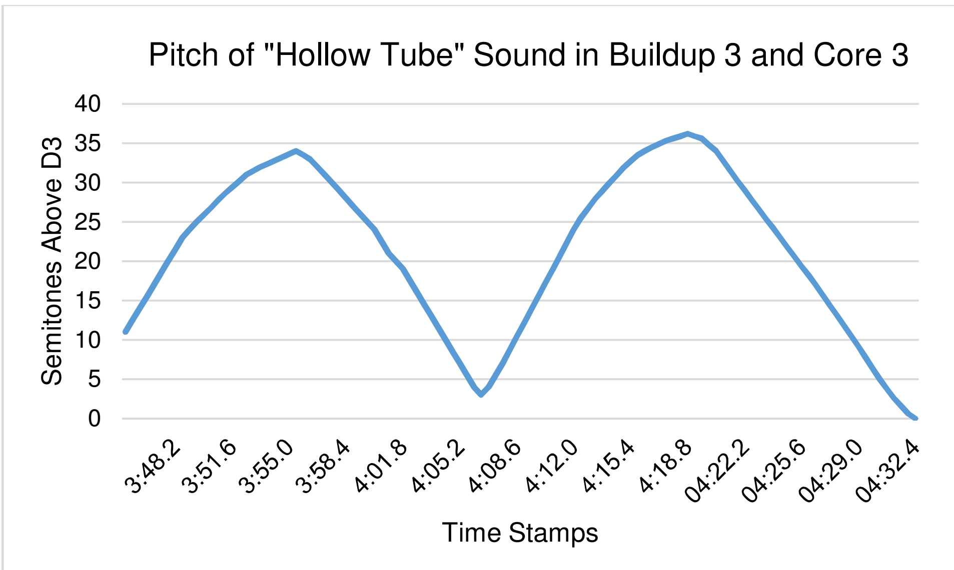

Figure 7-19: Graph of the pitch of the "hollow tube" sound in buildup 3 and core 3 in "Electronic Battle Weapon 4 (Freak of the Week)" by The Chemical Brothers (1998).

As shown in the graph (Figure 7-19), the shape of the hollow tube sound's slides is a periodic sinusoidal curve, since the rate of change does slow down as the pitch approaches peaks and valleys but these high and low points are not sustained as in the sigmoidal curve used in core 2. The pitch also seems to become less definite as peaks and valleys are approached, so it is hard to discuss high and low points as specific notes like

E-flat or D. From 3:55 to 4:07 (measures 3–10 of the section) the hollow tube sound is in phase 2, descending multiple octaves continuously, and then it ascends again in phase 3 (4:08–4:18). The last phase descends and takes place from 4:18 to 4:32, the end of core 3. Phase 1 lasts ten measures, phases 2 and 3 last seven measures each, and phase 4 lasts eight measures, for a total of thirty-two measures that make up all of breakdown 2, buildup 3, and core 3. This means that again the larger duple hypermeter is maintained but the internal hypermeter of large sections is contradicted by continuous processes, as was the case with core 2.

Core 3 does have similarities with core 2 because of the multi-phase periodic pitch waves. However, the pitch wave in core 2 is much more salient and in the foreground than the one in core 3. Another significant difference is that in core 2 the pitch wave undergoes many volume changes simultaneously, whereas in core 3 the pitch-wave layer maintains the same volume throughout while other layers *around* it change volume and come in and out. In both cases the pitch wave layer comes in and out of focus, but for different reasons.

Core 3 also contains many elements from core 1, including the same bass line throughout and eight-measure hypermeter clearly marked by new sounds entering abruptly at those points. At 4:05 (measure 9 of core 3), the repetitive E-flat pitch falls from buildup 1 *and* the repetitive E-flat pitch scoops from core 1 (specifically 1:28) enter at the same time. The falls are an octave lower than the highest octave of the scoops, and more stable since they are from E-flat layer 2 which has less depth in its pitch slide (this is noticeable when compared with E-flat layer 1's greater depth at 4:18).

It is significant that the E-flat layers from earlier in the piece return here because they provided a sense of foreboding instability before core 2 and now they are still around after core 2. There is no happy resolution to the dystopian narrative. Core 3 is in some ways a formal return in this piece, like the A' section in an ABA' ternary form. In some ways though, (as mentioned in the introduction to this large section of the chapter), core 3 is also a synthesis of the entire track, containing extended pitch waves, both scoops and falls on E-flat, *and* a clear bass line in D minor. However, the most distinctive and expressive part of the track is the alien abduction that occurred in the middle section, in core 2.

Outro (4:32–6:05)

The final section of the piece is quite long and almost entirely relies on discrete processes. There are only a few short continuous processes in some small interludes at 4:46 and 4:53, where it sounds like the reverse cymbal effect is used not only on percussion sounds but also on the pitches, which are A-flat and F, forming a diminished triad with the ostinato D's that precede it and follow it. The reverse cymbal effect creates a short crescendo before each attack point, making it difficult to define when the articulation of a note begins.

The first part of the outro retains some pitches and a sense of D minor, possibly suggesting that D wins that battle of pitch classes over E-flat. Its period of victory does not last long, however, because at 5:00 everything pitched drops out and there is an extended drum solo. The use of only drums, even if they are fast and energetic, suggests emptiness and loneliness, as if the drummer is playing in a desolate landscape.

Concluding Discussion

"Electronic Battle Weapon 4" utilizes continuous processes in many ways throughout most of the track. They interact with discrete processes to create an energized piece and a groove that allows listeners to dance, while rarely being completely comfortable without lacking tension. This is because the continuous processes are most salient in the cores, and create a sense of the science-fictional with unstable and unpredictable movements. The cores, and especially the main core in the middle, are never fully allowed to feature clear drum patterns and bass lines without freaky, psychedelic continuous processes and effects interrupting. Continuous changes in pitch, volume, speed, timbre, reverb, and pitch definiteness are used to make the music feel unstable. There is also tension generated by a narrative of D and E-flat as competing pitch classes, with E-flat being the tonal center for the first minute and D being the center for most of the rest of the track, but E-flat remaining salient as a dissonance throughout.

Another factor in creating the instability and unpredictability of the track is the large number of loops that are not utilized for long periods of time. There are some sounds that only occur in one or two sections of the track, and these often involve continuous processes. For example, the hollow tube sound only occurs in the last part, and multiple different pitch waves (the "squeaking" and "squealing" parts) that are quick and salient are used at the end of core 1 and the interlude, but they are never heard again after that. It seems as if the track is always coming up with something new. Even in the main part, core 2, the multi-part wave is a unique thing that is saved for that time and never used again. The usage of special techniques like this that are not repeated or featured in multiple sections is unusual in EDM.

The form of the track is also unusual, with intro and outro sections that are quite different from the rest of the track. Core 1 and core 3 are similar, with core 2 being different in its lack of a melodic bass line and usage of more percussion layers. Core 2 also features the most prominent science-fictional wave (representing the alien abduction) that utilizes continuous changes in many parameters. It is the main body of the track and therefore the track as a whole can be viewed as a symmetrical form. However, core 3 is not just a repeat of core 1. Although they are similar, core 3 is in some ways a recap and synthesis of the entire track, not just core 1. This is because it contains sound layers from buildup 1 (the E-flat pitch falls), core 1 (the E-flat pitch scoops and D minor bass line), and buildup 3 (the hollow tube sound) at the same time. Also, the usage of the hollow tube sound references back to core 2, because it goes through a long, multi-part wave and has a transparent sound quality to it that also signifies the futuristic and science-fictional.

In EBW 4, continuous processes are always interacting with discrete processes to create a high amount of tension without ever resulting in complete disorientation. There is a sense in which the music is always “on edge,” and this contributes to the dystopian aesthetic. The breakdown sections, while having thin textures and minimal layers, maintain the beat very clearly and contain little to no continuous processes. This means that the listener is more likely to maintain a state of attention and readiness to dance throughout the entire track; they do not have a clear opportunity to rest.

The functions of continuous processes in the track are varied, but generally they increase tension with crescendos and filter sweeps at appropriate times such as in buildups, and add tension in cores as well. They mostly function as “effects” in this piece, which complement the clear, discrete drum and bass parts. In terms of shapes, the wave stands out as a common type of shape in this track, and therefore the shape itself is somewhat motivic. In a kind of motivic variation, sometimes the waves are more sigmoidal in shape, with long-lasting plateaus, and other times they are more sinusoidal (like the hollow tube wave) because the top and bottom parts of the wave are not held.

The varying degrees of salience for continuous processes is also an important part of the track, since some of the continuous effects are much more in the background than others, and some have much less depth and a smaller magnitude for rate of change. For example, in core 1 the pitch falls from E-flat gradually get deeper and further away from the original pitch with the entrance of each new layer. The depth of the pitch wave for the hollow tube sound is also greater (about three octaves) than that of the pitch wave in core 2 (about two octaves), so by guideline 7 it is more salient than its predecessor (compare Figure 7-16 and Figure 7-19). However, the pitch wave in core 2 is part of a group of many continuous processes occurring at the same time, so by guidelines 3 and 4 (multiple parameters and sound layers) the wave in core 2 is more salient. It is also generally much louder than the hollow tube sound, so the wave in core 2 is also more salient according to guideline 1. These guidelines also explain why the wave in core 2 is more significant narratively, since it represents the key moment of the UFO's descent to earth and ascent back into outer space. During core 1, the people in the dystopian world are vaguely aware of something unusual, perhaps flying near their land. Then in core 2, the people are very conscious of the spaceship coming down to meet them, and then in core 3, the decreased salience of continuous processes indicates the decreased awareness and alertness of those still left on earth.

Continuous processes are an important part of how EBW4 is constructed, and they greatly affect how the piece is listened to, as evidenced most obviously by the alien abduction section in core 2. In addition to the discrete processes and sudden changes that give the track energy and groove, continuous processes contribute to this very unique big-beat track and its science-fictional, psychedelic aesthetic.

Conclusion

This dissertation has examined the salience, shapes, and functions of continuous processes in contemporary EDM. As the many examples heard demonstrate, continuous processes contribute significantly to the musical structure and style of EDM tracks, both as "effects" that embellish or ornament, and as clear sonic instructions that influence the dancing experience. There are many types and categories of continuous processes, and they have a variety of salience levels, but in general continuous motions are as important to EDM as discrete processes are.

The relative balance of discrete and continuous alterations of musical parameters in EDM means that both discrete and continuous analytical methods are needed to discover the impact this music has on its creators and fans. This dissertation has provided some analytical methods for the continuous aspects of this repertoire, such as categories of processes by parameter, length, clarity of continuousness (presence of microrhythm), and shape, as well as analytical guidelines for comparing salience, and a list of common functions for continuous processes.

The analytical tools used in this dissertation were created with the repertoire of contemporary EDM, and a specific focus on genres related to progressive house and trance, in mind. With some adaptations, however, they could be applied in a wide variety of repertoires, including electroacoustic music, classical and contemporary Western art music, as well as pop and rock songs. There are continuous processes such as crescendos and glissandos in all of these types of music. Pitch slides in particular have different saliences, shapes, and functions in different contexts, for example when they are produced by violins, guitars, or voices in different genres. The ways in which continuous processes work in different stylistic contexts can be explored much further.

Given that the analytical methods in this dissertation were developed for EDM, however, they can also be more directly applied and expanded upon in future EDM analysis. One way in which they can be explored more is hermeneutics. Why specifically are continuous processes effective at invoking the paranormal and science-fictional? What other extramusical meanings and tropes are invoked when continuous processes are used in this repertoire? For example, are they ever used for humorous effect as they sometimes are in films and television?[61] Another way that the analytical tools in this dissertation can be applied is in the analysis of shapes as related to musical form. Sometimes in EDM, the shapes of continuous processes (not just the processes themselves) can function motivically. This can happen at multiple different levels and

[61] Goldmark (2007, 64–67); Larson (1996, 66).

scales. In what ways do ascending and descending wave shapes, for example, permeate entire sections, tracks, or live sets?

The most obvious way in which the work in this dissertation can be expanded though, is in connection with studies of EDM genres. There has been much scholarship on genres in EDM,[62] but the usage of continuous processes in different genres is one avenue that has yet to be thoroughly explored. In chapter 6 there was a brief discussion that hinted toward this on short continuous processes specifically, saying that in genres such as techno, jungle, drum and bass, dubstep, breakbeat, electro house, and acid house, they are used more frequently and often featured in cores, whereas in genres such as trance, big room, progressive house, and deep house, short continuous processes are more often used to add instability in breakdown sections. The techniques and processes that are noticeable and valorized in specific works depend on genre.[63] One specific example is the "wobble bass" that dubstep is known for.[64] This could be explored in much more detail.

Another similar question relates to how different EDM genres use long continuous processes such as risers. How often are they used, with what shapes, and with what different levels of salience? How has this changed in EDM as a whole in the last several decades? This question has been hinted at already in some scholarship, but a more thorough discussion would be highly useful.[65] The application of analytical tools for continuous processes could add a new level of precision to studies of genre in EDM.

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[62] Snoman (2009, chaps. 11–18); Wiltsher (2016a, 416–419).
[63] Wiltsher (2016a, 418).
[64] Osborn (2018).
[65] Butler (2006, 226); Solberg (2014, 65).

This repertoire that is cherished by so many deserves to be studied in a multitude of different ways. By drawing attention to the roles of continuous processes, this dissertation has shown how they saturate contemporary EDM on many different levels, both in the foreground and background of perception. They are an important part of how EDM is created and understood, both by producers and fans, and they contribute significantly to the joy that is created through riding the emotional waves in this music.

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