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Peak Experiences with Electronic Dance Music: Subjective Experiences, Physiological Responses, and Musical Characteristics of the Break Routine

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This paper investigates the role of musical features in shaping peak-pleasurable experiences of electronic dance music (EDM). Typically, large structural and dynamic changes occur in an EDM track, which can be referred to as the *break routine*, consisting of breakdown, build-up, and drop. Twenty-four participants listened to four EDM excerpts featuring break routines, and one excerpt without a break routine. Measures were taken of skin conductance, self-reported affect, and embodied aspects of subjective experience, and incidence of pleasant bodily sensations. Participants reported intense affective experience with EDM despite being removed from the club context, and attributed this experience to the drop in particular. They described these experiences as energizing and uplifting, and pointed to an embodied, kinaesthetic experience of the music. Drop sections of the music were associated with significantly higher skin conductance response than other sections of the break routine. Analysis confirms correlation between specific acoustic and musical features and peak-response as observed with other music genres, and also identifies novel musical characteristics particular to EDM associated with peak experience. This shows that pleasurable peak experience with EDM is related to specific musical features, and has embodied spatial and kinaesthetic experiential qualities even when listened to without dancing and away from the club context.

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Key words: electronic dance music, peak experiences, pleasure, skin conductance, expectancy

Music listening can elicit intense, pleasurable experiences and this pleasure is attributable to a range of musical and extra-musical factors (Gabrielsson, 2011; Lamont, 2011). Our focus is on the relationship between these intense experiences and musical features, which has previously been investigated primarily in relation to classical music. Electronic dance music (EDM) is commonly associated with peak-pleasurable experiences, but research into peak pleasure has tended to focus on pleasure associated with preference, liking, personality, mood, and cultural background (Grewe, Nagel, Kopiez, & Altenmüller, 2007a, 2007b), while research on EDM has focused on aspects related to the social context, such as sociability, the use of drugs, and the development of personal and social identities (Malbon, 1999). As yet little is known about the incidence and quality of intense, pleasurable experiences with EDM, nor the extent to which they are attributable to specific musical features of the genre. This paper reports a study that set out to investigate the subjective peak experience of the EDM break routine in order to enhance understanding of the relationships between musical features and intense pleasure in music listening.

Peak-Pleasurable Experiences with Music

Peak experiences (Maslow, 1968), or *strong experiences with music* (Gabrielsson, 2011) are moments of intense pleasure, most frequently described as emotionally powerful and accompanied by physical sensations. These intense experiences can include goose bumps, shivers down the spine, thrills, and tingling—referred to in the music psychological literature as *chills* (Grewe et al., 2007a, 2007b; Guhn, Hamm, & Zentner, 2007; Panksepp, 1995; Sloboda, 1991). These physiological responses—together with self-reports of subjective experiences—are taken as reliable indices of intense, pleasurable experiences with music, and can be measured using electrodermal activity, heart rate, respiration, skin temperature, and blood volume pressure.

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Studies show that chills are subjectively defined as pleasurable and that the presence of this specific sensation is associated with an increase in physiological arousal (Grewe et al., 2007b; 2009; Rickard, 2004). There is also some evidence of a positive correlation between skin conductance (taken as a measure of affective arousal) and ratings of pleasure (Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre, 2009), although the two may not always covary. This shows that chills correspond to peak-pleasurable responses, and demonstrates that even when participants do not report chill responses, the self-reported increase in pleasure is directly associated with physiological arousal. Chills can correspond with other peak responses such as fear and anger/rage, which is the more directly biological function of chills (Braithwaite, Watson, Jones, & Rowe, 2013). Skin conductance response (SCR, phasic change in the electrical conductivity of the skin) is generally regarded as the index of physiological arousal that can most accurately capture peak experience in music; SCR is better able to capture *intensity* in emotion compared to other physiological measures such as heart rate and respiration (Rickard, 2004), it is very sensitive to changes in affective arousal, is not generally amenable to conscious control (Salimpoor et al., 2009), and is characterized by a distinct onset, which makes it easy to compare with specific musical features and reported subjective experience (Rickard, 2004; Salimpoor et al., 2009).

The prevailing model of musical pleasure that has shaped psychological investigations is the expectancy-based account. This means that we experience music as pleasurable when our expectations regarding it are either fulfilled or violated. According to this view, structural expectations prompt affective arousal through our anticipation and evaluation of what is going to happen in it (see Meyer, 1956). Here pleasure and emotional arousal are related to our expectations regarding the musical content being fulfilled, delayed, or violated (Huron, 2006; Meyer, 1956). In turn, the way in which our expectations are either inhibited, delayed, deviated from, fulfilled, or violated can produce emotional arousal experienced as chills and other pleasant bodily sensations. According to this theory, and related neuroscientific evidence, music activates reward systems of the brain (Blood & Zatorre, 2001; Gebauer, Kringelbach, Vuust, Cohen, & Stewart, 2012; Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011) by virtue of anticipation and evaluation of musical expectations being either fulfilled or violated (Gebauer et al., 2012, Salimpoor et al., 2011). According to our expectations for the musical content, the resulting musical pleasure is often accompanied by physiological changes that are measurable through electrodermal activity, heart rate, respiration, and other physiological measures (Gomez & Danuser, 2007; Grewe et al., 2007a; Grewe, Kopiez, & Altenmüller, 2009; Guhn et al., 2007; Rickard, 2004). Furthermore, changes in psychophysiological arousal are associated with specific musical characteristics. Changes or expansions in dynamics, texture, structure, and sound volume seem to correspond to changes in physiological arousal (Gomez & Danuser, 2007; Grewe et al., 2007a, 2009; Guhn et al., 2007; Rickard, 2004). In other words, evidence supports the idea of musical expectancy playing an important role in the shaping of intense affective experiences, one component of which is an individual's psychophysiological state of arousal. These schematic musical expectancies may result from the implicit enculturated knowledge of the listener, and give rise to the subjectively experienced expectations and tensions in music that form a source of pleasurable experiences (Huron, 2006; Meyer, 1956). However, there are also some cross-cultural aspects of expectancy that likely are the result of biological predispositions which Huron's model (2006) in particular accounts for. One example of this is the case of musical dissonance, which seems to have both a biological as well as enculturated component (Juslin & Västfjäll, 2008). These expectancies are believed to arise from statistical learning, which enables listeners to dynamically shape and improve their implicit internal representation of information-theoretic properties of sequential stimuli during the course of listening, with evidence that this influences both their expectations and recognition memory (Agres, Abdallah, & Pearce, 2017).

An alternative, and more recent approach, conceptualizes musical pleasure as a more embodied domain, which is related to our desire to move when hearing musical sound and which in turn creates a perception-production loop (Janata, Tomic, & Haberman, 2012; Overy & Molnar-Szakacs, 2009; Solberg & Jensenius, 2016; Witek, 2016; Witek, Clarke, Wallentin, Kringelbach, & Vuust, 2014). According to this explanation, musical pleasure is a dynamic process whereby pleasure and the desire to move happen simultaneously and reinforce each other. Berridge and Kringelbach (2011) suggest a pleasure cycle consisting of the three stages: 1) wanting, 2) liking, and 3) learning. In this dynamic view of pleasure, it is argued that the lines between these different stages are blurred and happen simultaneously; where wanting is the desire to move your body whereas liking is actually moving your body (Witek, 2013). The fact that we can experience continuous musical pleasure underscores the intimate relationship between pleasure and our desire to move our bodies (Janata et al., 2012;

Witek, 2013; Witek et al., 2014). The reward is that our desire to move is fulfilled, which then leads to a stronger pleasurable experience and motivates us to keep moving (Witek, 2013). This underlines the interactive aspect where pleasure arises from moving, and that moving arises from experiencing music as pleasurable. Both theories of peak-pleasurable experiences with music are predicated on the idea that the ongoing, temporal engagement with musical features affords pleasure. For the purposes of our study therefore we focus on the way in which pleasure is related to musical features.

Electronic Dance Music and Peak-Pleasurable Experiences

Pleasurable peak experiences are an important aspect of EDM club culture. DJs and producers are highly attuned to the musical features that draw dancers into a heightened bodily and affective state (Butler, 2006; Gadir, 2014), and previous research points to the ecstatic, "oceanic" experiences of EDM in the club context (Malbon, 1999). EDM therefore provides an ideal case study for understanding the relationship between musical features and peak affective experience. However, the intense and pleasurable experiences of EDM have most commonly been investigated in the club context from a sociological perspective, with the focus on identity, sexuality, and gender (Fikentscher, 2000; Rietveld, 1998), dancing with others, and the role of strong visual stimuli and drugs (Malbon, 1999). Recent research has begun to explore the musical features associated with these intense experiences, noting the role of the break routine in subjective experience and theorising its role as a source of musical expectancies contributing to peak experiences and the urge to move (Gadir, 2014, pp. 67–68; Solberg, 2014). Thorough analysis of the musical features and structural properties of EDM associated with intense pleasurable experiences remain relatively unexplored from a psychological and embodied perspective.

The Break Routine in Electronic Dance Music

EDM is characterized as an energetic, electronically produced music style with rhythmic focus and a strong repetitive beat, created through the superimposition of *layers*. It includes a variety of genres, including categories such as, house, techno and trance. Typically, an EDM track includes at least one large structural, textural, and dynamic change usually situated towards the last third of the track. These changes create a sudden and large decrease and increase in the track's intensity, which is referred to as the *break routine* and consists of three musical passages; breakdown, build-up, and drop (Butler, 2006; Solberg & Jensenius, 2016). As the names of the passages imply, the overall process of the break routine is the reduction of dynamics, texture, and structure until it consists of only a few remaining musical features (the "breakdown") as illustrated in Figure 1. Often the rhythmic framework of the groove is temporarily removed completely. The track is then gradually rebuilt (the "build up") by adding one musical layer after another before the track eventually reaches its musical peak ("the drop") with the reintroduction of the groove in its layered entirety. DJs and producers use these passages to intentionally create an intensity peak for the listeners/dancers, both in terms of affective and bodily engagement. Indeed, this process is referred to by some as "peaking the floor/crowd" (Fikentscher, 2000; Montano, 2009). EDM tracks normally contain two or more break routines (Butler, 2006; Snoman, 2009), of which the latter is intended to be experienced as the most intense, but can take a variety of forms (Gadir, 2014, pp. 64–66). The effect of this routine is particularly obvious in social dance settings and when investigating the body movements of dancers. Their overall activity level changes throughout the break routine with a sudden decrease and increase, which corresponds to the structural properties of the music (Solberg & Jensenius, 2016, 2017).

This description of the break routine highlights that it is a process involving carefully sequenced changes that are experienced as musical peaks. From the perspective of expectancy theories, the EDM break routine sets up, delays, and gratifies expectations for continuation, and so it is possible to theorize that this will elicit pleasurable peak experiences manifest in subjective experience and indexed by changes in physiological activation (Gadir, 2014, pp. 67–68; Solberg, 2014). Some of the characteristics of the break routine are similar to those already known to be associated with affective arousal and chills, including new and unexpected changes in addition to sudden or gradual expansions in the dynamics, texture, frequency spectrum, tempo, and volume (Gomez & Danuser, 2007; Grewe et al., 2007a, 2007b; Guhn et al., 2007; Panksepp, 1995; Sloboda, 1991). We also know that increase in sound intensity and wider pitch range causes an increase in skin conductance level and more accentuated rhythms are associated with increased arousal (Gomez & Danuser, 2007). These features are present and important in the break routine, and especially the build-up and drop passage. Based on these findings we therefore hypothesize that the drop passage in particular will elicit changes in SC and reports of pleasant sensations, relative to the other sections of the

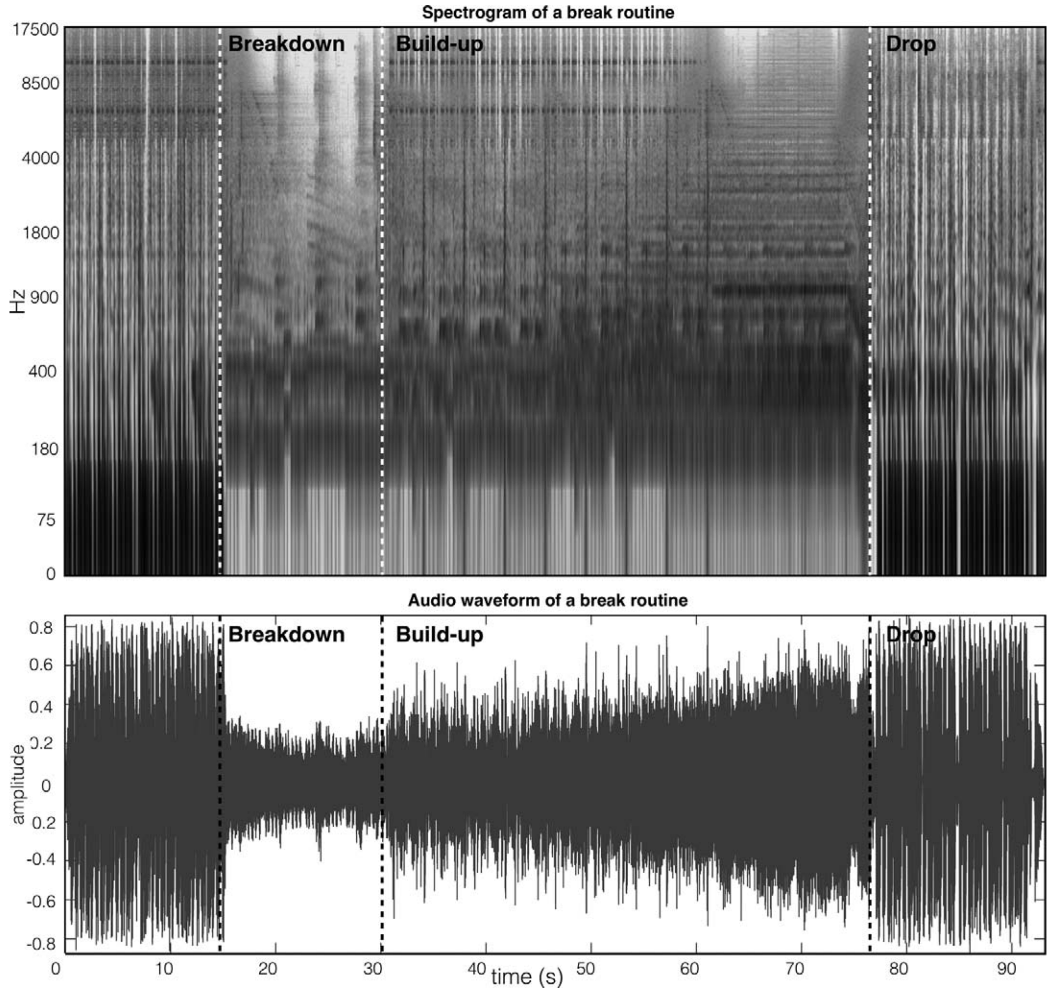

FIGURE 1. Visual representation of a break routine consisting of the musical passages' breakdown, build-up and drop. Above a logarithmic dBV spectrogram with window size 1024, while the audio waveform is presented below. This break routine example is Track 3 used in the listening experiment.

break routine, since it includes these specific musical features—the equivalent to the musical peak.

Interestingly, the terminology and language used to describe both the break routine and the musical features related to it, is of a highly cross-modal and embodied character (Gadir, 2014). For instance, the name of the musical peak, referred to as the *drop* stems from the beat, bass or bass drum being "dropped" back into the groove or track (Butler, 2006; Garcia, 2011). However, it could also refer to specific actions and physical sensations, such as *dropping* the needle onto the groove of the vinyl record. Furthermore, the term *uplifter*, used to label the upward glissandi and/or frequency filter shaped to increase pitch until the moment of the drop, implies a spatial ("up") and kinaesthetic ("lift") experience of the music (Solberg, 2014).

Research Questions and Aims

The review of empirical evidence presented above suggests that intense affective experiences of EDM in a social dance context are likely associated with particular musical moments, namely the build-up and drop of the break routine. Theories of musical expectation also suggest that these structural moments would serve to elicit intense affective experiences, and that they should do so when listening and not just when dancing to this music. For this reason, we conducted a controlled laboratory listening study to investigate the incidence and quality of affective experience to the EDM break routine using a multi-method approach to capture both subjective and objective measures of musical experience. However, we were not only interested in the break routine structure in general, but also the quality and production of specific break routines. We predicted that differences in production and acoustic features would be associated with qualitatively different experiences, as shown in previous motion capture studies on break routines (Solberg & Jensenius, 2016, 2017) We were therefore expecting there to be some variety in responses related to each track employed. Rather than focusing on chills as the index of peak experience we conceived of "pleasant bodily sensations" more broadly and probed pleasurable affective responses through a variety of self-report questionnaire measures: these included validated self-report measures of affective experience and adjective descriptors appropriate to electronic dance music (Solberg, 2014). We chose SC as the index of physiological arousal best able to capture peak experience in music (Rickard, 2004; Salimpoor et al., 2009). Based on our understanding of the previous literature we hypothesized that the drop section of the break routine would elicit more intense subjective experiences than either of the other sections, and that this would be reflected in self-reports, and physiological indices of affective experience.

Method

PARTICIPANTS

Twenty-four participants were recruited via an email invitation sent to staff and students on the University of Sheffield's online volunteer recruitment system (mean age = 28.2, *SD* = 9.2, range = 18–53 years; 14 females). The criteria for participation were to have good hearing, and to enjoy listening and dancing to EDM: all participants reported enjoying listening to EDM (A bit (16.7%), now and then (41.7%), a lot (25%), favorite music (16.7%)), and the majority (19 participants) reported enjoying dancing to EDM, with 83% of participants reporting a desire to move or dance to the music at some point during the experiment. We also measured music reward and listening habits (Barcelona Music Reward Questionnaire, BMRQ; Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, & Rodriguez-Fornells, 2013). No participants showed low sensitivity to music (BMRQ mean = 75.75, *SD* = 9). The majority of participants were unfamiliar with the specific tracks used in this experiment, although for each track there was at least one person (a different person each time) who reported being either "very" or "extremely familiar" with the track.

The group included people with varied musical taste and music training (< 1 year formal or informal music learning = 7 participants; > 5 years formal or informal learning = 9 participants; median = 1-5 years of formal or informal musical learning). Nineteen of the participants played an instrument. The group was heterogeneous regarding education and geographical background. The distribution of personality types as measured by the Ten Item Personality Inventory (TIPI; a short self-report questionnaire that measures individuals' personality traits on a five-factor model) is similar to population norms (Gosling, Rentfrow, & Swann, 2003). The participants were aware of the overall aim of the experiment—to study the relationship between musical features of electronic dance music and listeners' affective and bodily experiences—but they were naïve to the study's hypotheses. Participants were entered into a price draw of one Amazon gift card (£30). The study was approved by the Department of Music Ethics Committee in accordance with the University of Sheffield's Research Ethics Approval Procedure.

MATERIALS

Commercially available EDM tracks were chosen as the stimuli source for this study in order to create an ecologically valid listening experience to which the participants could relate. The selected tracks formed part of a series of experiments and were chosen by the researchers so as to fulfil the following criteria: from the same EDM genre of contemporary house music, and released within the previous 5 years, to avoid interstimuli confounds of genre preferences; mostly instrumental; with a strong, energetic and quantized rhythmic four-to-the-floor beat; electronically produced; tempo between 118–128 bpm; and a sequence-based principle of adding, changing and removing musical layers after 2, 4, 8, or 16 bars. Additionally, the music varied in tempo, texture, rhythmic, and harmonic/melodic complexity and loudness. Four of these tracks (the *drop tracks*) were selected because they comprised a break routine, consisting of breakdown, build-up and drop passages, manifest via different musical means, i.e., combinations of different musical parameters, thereby allowing us to generalize from the particular structural features of the break routine in a single track to a wider variety of break routines: Track 2: "Icarus" by Madeon (2012), Track 3: "Running (Disclosure Remix)" by Jessie Ware and Disclosure (2013), Track 4: "Ladykiller (Original Mix)" by Vanilla Ace (2014), and Track 5: "Strobe" by DeadMau5 (2010) (Table 1). Tracks with few or no break routines are also common in EDM (Gadir, 2014, pp. 64–66) and a fifth track was chosen because it was comparable to the others in terms of style and release date, but comprised a flat structural development: Track 1: "Thoughts of She" by Detroit Swindle (2014). Due to our research interest in the effects of the break routine, Track 1 is not analyzed

TABLE 1. *Overview of the Experimental Stimuli*

Music example	Duration of excerpt		Length of break routine		Genre
2) “Icarus (Extended Mix)” – Madeon (2012)	00:58	58 s	00:09-00:41	32 s	House / Electro House / Nu-disco
3) “Running (Disclosure Remix)” – Jessie Ware and Disclosure (2013)	01:33	93 s	00:15-01:17	62 s	House / Garage House / UK Garage
4) “Ladykiller (Original Mix)” – Vanilla Ace (2014)	01:35	95 s	00:15-01:18	63 s	House / Nu-disco / Indie Dance
5) “Strobe” – DeadMau5 (2010)	02:05	125 s	00:10-01:47	97 s	Progressive House

in depth for the purposes of this study, but in the following we refer to the original numbering of the tracks to avoid confusion.

Tracks were edited so that they were between 1–2 minutes in total duration, determined by the duration of the break routine plus an additional 10–15 seconds of the track both before and after the break routine to establish the tracks' groove prior to and after the break routine. Since our focus is on the structures within the break routine, these short excerpts ensured the listening study would not fatigue participants while also capturing sufficient data for analysis.

Subjective measurements were gathered via a paper-based questionnaire after each track and an online questionnaire at the end of the experimental session. The paper-based self-report questionnaire asked participants to rate specific experiences of each stimulus: their level of familiarity with and pleasure in the track (1 = *not at all familiar* to 5 = *extremely familiar*; 1 = *unpleasant* to 4 = *very pleasant*), whether they had experienced any pleasant bodily sensations while listening (*yes*, *no*, or *unsure*), and when, in the course of the music, those sensations had occurred. A semantic differential scale gathered information on participants' affective state while listening using a 3-dimensional model of activity, valence, and tension (Schimmack & Grob, 2000) where each dimension was represented by the average of three bipolar Likert items: activity (awake-sleep, wakeful-tired, alert-drowsy), tension (tense-relaxed, clutched-calm, jittery-restful), and valence (pleasant–unpleasant, positive-negative, good-bad). Participants were also asked to indicate how they felt while listening to each excerpt using ten Likert item adjectives: Grounded, Floating, Heavy, Light, Falling, Flying, Uplifting, Driving, Enthusiastic, Strengthened. Based on previous research into the experience of EDM (Garcia, 2011; Solberg, 2014), we deemed existing adjective measures for music listening to be insufficient because the descriptors reference largely disembodied, affective states; the descriptors we included were intended to capture embodied and cross-modal experiences. Adjective descriptor ratings for how the participant felt when listening to each stimulus were analyzed to check for any differences between the feelings elicited with each excerpt. After the experimental session participants listened back to tracks to identify specific moments in relation to their reported experiences. Although this has the disadvantage of using recall, it has the advantage of not distracting participants from their immediate listening experience.

The final online questionnaire gathered demographic information and reflections on the experiment as a whole. This comprised questions about participants' gender, age, nationality, occupation, education, personality (TIPI; Gosling et al., 2003), which were included to characterize our population sample and check it against population norms. Music reward and listening habits were also measured using BMRQ (Mas-Herrero et al., 2013), desire to move during the listening task, and an open question that asked participants to relate this to musical characteristics, plus information on their dancing and club habits, comparison of their experience of the music while listening in the laboratory setting compared to their experience in a club setting, and their familiarity with and liking for EDM, which are explored in the subsequent analysis.

EQUIPMENT

Physiological measures were taken using the biofeedback hardware ProComp Infiniti System and the BioGraph Infiniti software produced by Thought Technology via a PC. Sensors placed on the participants' non-dominant hand measured skin conductance (SC) in microsiemens (μS). Heart rate (HR) and respiration (RESP) were also measured for the purpose of a different study and are not reported here. HR and RESP are useful when measuring and comparing changes occurring over longer time periods which is not the focus of the present paper. For the purpose of this paper we focus on SCR because it can be related to short duration increases in tempo, sound intensity, and pitch range (Gomez & Danuser, 2007), all of which correspond to musical characteristics of the break routine. Moreover, SCR is characterized by a sudden and distinct peak that can be aligned to musical features and sudden changes occurring in the break routine. During the listening tasks, the participants were equipped with closed headphones and the stimuli were played through a MacBook Pro. To secure a loud, albeit comfortable volume of the sound, we performed a short test of the sound level with each participant prior to the experiment.

PROCEDURE

Upon arriving at the Music Psychology lab at the University of Sheffield, participants were seated in a comfortable chair facing the wall. All participants received an information sheet prior to the experiment and signed an informed consent form. For the physiological measurements, we used Ag/AgCI electrodes. SCRs were measured on the distal phalanx of the index and ring finger (secured with Velcro straps), while heart rate was measured using photoplethysmography (cardiac related changes in blood volume) via a sensor on the middle finger of the participant's non-dominant hand, which rested on a table in front of them. Respiration was measured through a respiration belt worn over their clothing. Participants were recorded individually and each session lasted approximately 45 minutes. As is standard and necessary in music listening studies in which physiological data is collected via sensors, they were instructed to sit still, relax, and focus on the music while the measures were taken. The instruction to sit still was essential to our research aim to investigate peak-pleasurable experiences while not moving to EDM, and had the advantage of reducing measurement noise. In the analysis and limitations sections we consider potential disadvantages and whether there were any unintended effects of requiring participants not to move to what is a highly movement-inducing music genre.

Before the measurements were taken, we tested the equipment used to record the physiological responses and monitored participants' physiological responses until they were (relatively) stable, to achieve a resting start-point. The stimuli were played to participants in randomized order using an incomplete counter balanced Latin square design to counteract carry-over effects.

The session included five listening trials, each comprising a 30-s silent rest period, presentation of one of the music stimuli for approximately one to two minutes (see durations in Table 1), and completion of a self-report questionnaire during a three/four-minutes-long silence that gathered ratings of familiarity, pleasure, and adjective descriptors for the stimuli just heard. If participants experienced any pleasant bodily sensations while listening then they were also asked to describe any musical characteristics associated with them. The long silence and starting rest period were included to allow the biosignals to return to a steady state and reduce carry-over effects between trials. The five trials were followed by a questionnaire gathering demographic and non-stimuli-specific information. Participants reported finding the experiment enjoyable and interesting.

DATA PROCESSING

The SC data were exported from the BioGraph Infiniti software and imported into the Ledalab MATLAB toolbox (Benedek & Kaernbach, 2010). Here all data processing and analyses were performed. The data were down-sampled from 256 Hz to 32 Hz in Ledalab to speed up the analysis, which did not significantly influence the quality and important details of the SC data. We performed artefact correction in the Ledalab toolbox by the means of spline interpolation. Artefacts are signals that exceed the typical range of the SCR amplitude, which is 2–3 μS (Braithwaite et al., 2013), and they typically arise from errors in the recording or inadvertent movements by the participant. In addition, SC measures for the first 10 s from each music excerpt onset were excluded to avoid physiological manifestations of the orientation response.

The SC data was analysed using Continuous Deconvolution Analysis (CDA) in Ledalab (Benedek & Kaernbach, 2010). CDA excerpts the phasic and tonic activity: tonic activity describes the SC level and indicates the general level of sweating while the phasic activity refers to the SC response and shows event-related activation occurring over a short period of time (Benedek & Kaernbach, 2010). This method is robust and based on a standard deconvolution algorithm that separates the SC data into a continuous data stream of tonic and phasic activity through deconvolution of the SC data. Additionally, this method shows a zero baseline. CDA has many advantages over other methods of SC analysis because it avoids the issue of large inter and intraindividual differences and overlapping SCRs, where the next SCR occurs while the previous is still declining. For example, several listening studies using SC measurement (Craig, 2005; Rickard, 2004; Salimpoor et al., 2009) compare SCRs to the baseline collected at the beginning of the experiment. However, this does not account for continuous drift in the tonic part of the SC data and large inter and intraindividual differences in SCL, nor the failure of the phasic response to fully return to pre-trial baseline after an event-related activation (Benedek & Kaernbach, 2010). Moreover, most studies use the "trough-to-peak" method of calculating SCR, which focuses on measuring the difference between an SCR local minimum and maximum (Guhn et al., 2007). Here the maximal SCR amplitude is seen in relation to its onset, and the data is for example transformed into a percentage-reactivity measure (Rickard, 2004), or range-normalized by establishing the maximum and minimum of the entire recording and calculating the difference between these values (Egermann et al., 2011). The disadvantage with the trough-to-peak technique is that it underestimates or overestimates the SCR amplitude and does not reflect the real onset and amplitude of each response (Benedek & Kaernbach, 2010). CDA avoids these problems.

Event-related activation in the phasic driver was excerpted with the window size [-2 s + 13 s] for the breakdown, build-up, and drop section of each track. For tracks with longer build-ups we separated them into several windows before these values were added and averaged. This was done because the setting for the window size in Ledalab does not exceed 20 s. The following data were exported: 1) the average phasic driver activity within the response window (SCR), 2) the integrated skin conductance response (ISCR: integration of the phasic driver signal for a defined window), and 3) a list of SCRs with time stamps. ISCR is used because it decreases biases of overlapping SCRs and looks at the continuous shape of phasic responses. Additionally, it avoids the issue of pinpointing the local minima and maxima and the detection of distinct peaks.

The music examples were imported and analyzed via the MIR toolbox (Lartillot, Toiviainen, & Eerola, 2008) for MATLAB and used to explore relationships between musical features and SCRs. We extracted acoustic features from the MIR toolbox related to dynamics, timbre, rhythm, and tonality. Spectrograms were created using Sonic Visualizer for visual inspection.

Analysis

SKIN CONDUCTANCE

Given the large variability in SCR to stimuli in the general population we first carried out a check for non-responders; i.e., participants who did not display changes to SCR (Braithwaite et al., 2013, p. 42; Dawson, Schell, & Filion, 2000). The typical range of SCR in the general population is 0.1 to 1.0 μS, and non-responders are defined as those participants whose SCR does not exceed 0.05 μS (Venables & Mitchell, 1996). All participants' SCRs exceeded this threshold so no participants were excluded.

The exported data from Ledalab were imported as data sets into SPSS and MATLAB for statistical testing and graphic representations. All measures of SCR were significantly non-normal: they were positively skewed as is usual with SCR data (Benedek & Kaernbach, 2010; Braithwaite et al, 2015; Dawson et al., 2000). The SCR values were normalized and standardized using the formula $y = \log(1 + x)$, which improved the distributional properties of the SCR signal, before averaging across participants, and for raw phasic driver data, the procedure was adapted to $y = \log(1 + |x|)*\text{sign}(x)$, in order to account for the possibility of negative values (units labeled "log μS").

SUBJECTIVE MEASURES

The subjective measures comprised ratings of pleasure (Likert 4-point scale), familiarity (Likert 5-point scale), pleasant bodily sensations (coded as 1 = *yes*, 2 = *no*, 3 = *unsure*), and ten adjective descriptor ratings (Likert 7-point scale) for how the participant felt when listening to each stimulus. Nonparametric tests were used to explore the self-report data.

ACOUSTIC FEATURES AND MUSIC ANALYSIS

The following acoustic features for each track were extracted and analyzed in the MIR toolbox (Lartillot et al., 2008): audio amplitude, global energy (RMS), spectral flux, spectrum, brightness, roughness, and mode. Rhythm features (beat spectrum and pulse clarity) were also extracted, but not reported in detail in this study as they did not show any specific relationship with the SCR. We hypothesize that this is related to the experiment condition of sitting still while listening. Mean values were calculated for the (a) pre-break, (b) breakdown, (c) build-up, and (d) post-drop segments. We limited analysis to these features, which relate to dynamics (audio amplitude, RMS) and timbre (spectral flux, spectrum, brightness and roughness) since (alteration of) these specific features are central to the break routine in EDM (Butler, 2006; Solberg, 2014; Solberg & Jensenius, 2016). As summarized in the materials section, the musical excerpts and segments within them were also descriptively analyzed (Appendix A). A spectrogram and audio waveform of each drop passage were also generated for visual inspection. Between each listening trial the participants were asked if they experienced any pleasant sensations during the excerpts and if they could describe the musical characteristics of these moments. We coded these free-response descriptions, provided by participants directly after each stimulus was heard, in terms of whether or not the participant mentioned musical features (see Figure 6 presented later for three example descriptions).

In order to identify musical similarities between the excerpts we analyzed the break routines (see Appendix A for detailed descriptions of each track). The

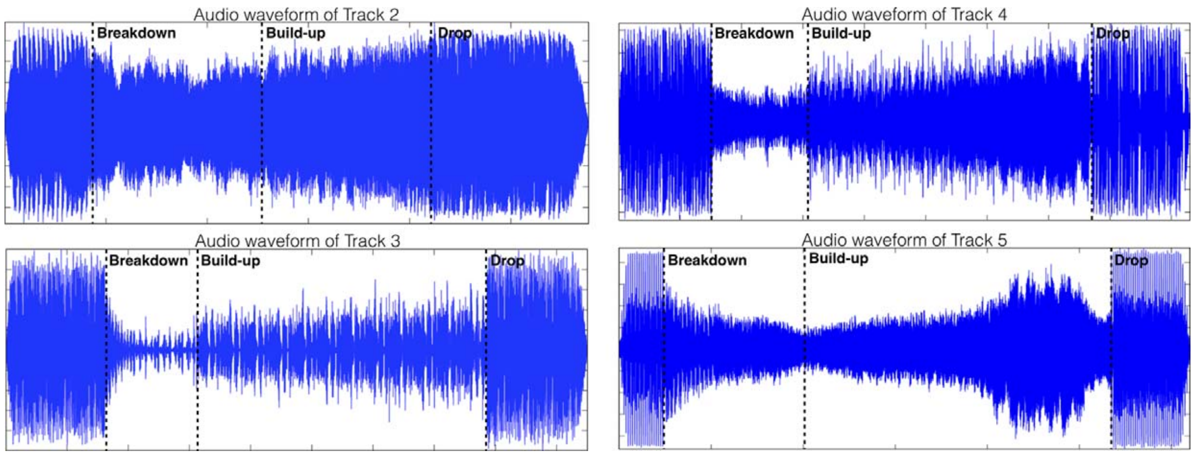

FIGURE 2. Audio waveform of the four EDM excerpts.

descriptive analysis reveals specific similarities in the break routines of the four drop tracks:

- A characteristic U-shaped amplitude profile with a sudden decrease at the break down, gradual build up during the build-up, and maximum amplitude at the drop (Figure 2 and Figure 3).
- Large changes in the frequency register during the break routine, especially in the transition between build-up and drop (Figure 4).
- Sudden removal and gradual reintroduction of several of the musical features, especially the bass and bass drum (Figure 4).
- Use of sounds and/or sound effects going in a specific pitch direction: ascending towards the drop (often referred to as *uplifter*, *riser,* or *sweep*), then descending to mark the drop (Figure 4).

We are especially interested in comparing Track 2 to the other tracks because this track has previously been shown to elicit body movements in groups of dancers and has been rated as highly pleasurable (Solberg & Jensenius, 2016). One difference between Track 2 and the other tracks lies in the mean values of audio amplitude and spectral flux, as presented in Figure 3. Analysis of the tracks by structural segments shows that all drop tracks follow the same pattern: each track includes a sudden decrease at the breakdown, then an increase to the drop, and the post-drop segment. Track 2's mean values of the audio amplitude and spectral flux are consequently higher than the other drop tracks. Moreover, the audio amplitude and spectral flux of the post-drop segment is as high as the pre-break segment. This is not the case for the other tracks where the post-drop segment is lower compared to the pre-break segment. This means that Track 2 has a higher sound level than the other tracks, and is especially loud after the drop compared to the other drop tracks. This is

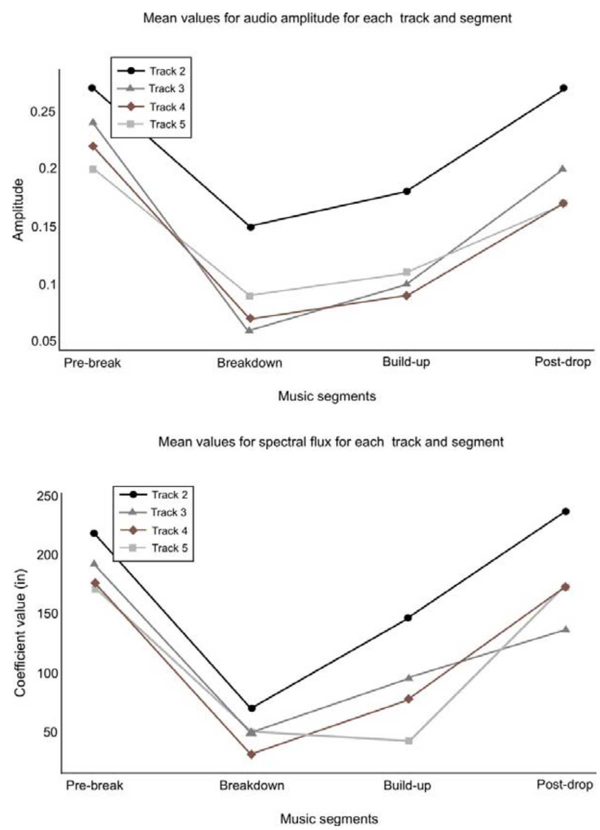

FIGURE 3. Line plots of the mean values for two acoustic features for all tracks and the segments "pre-break," "breakdown," "build-up," and "drop." Above: Mean values of the audio amplitude. Below: Mean values of the spectral flux.

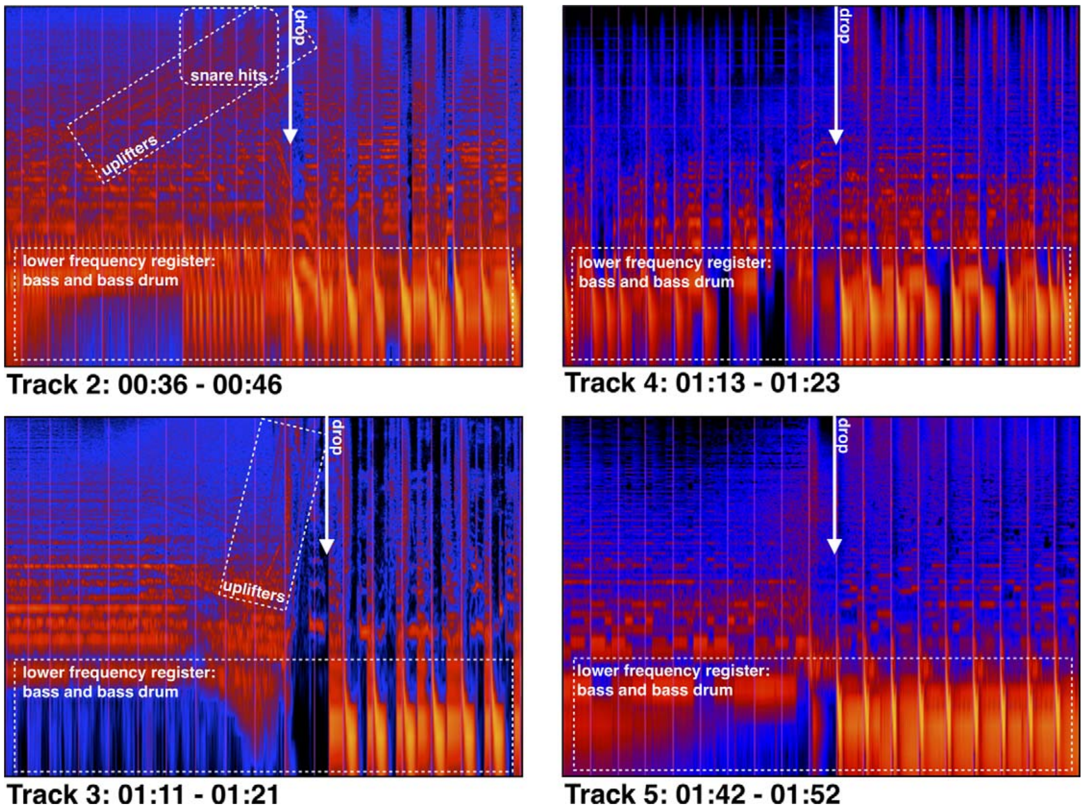

FIGURE 4. Spectrograms of drop passages for the four tracks. Each of the spectrograms displays the frequency spectrum for a 10 second segment of the music starting from the end of the build-up to when the main groove is re-established. The arrows indicate the drop moment while the dashed squares mark the specific features for each track: changes in the lower frequency register, uplifters and for Track 2 the five syncopated snare drum hits prior to the drop.

supported by the mean values for the audio amplitude: as seen in Figure 3, Track 2 has the highest sound level for the whole excerpt, in addition to the highest sound level after the drop.

A second feature that distinguishes Track 2 from the other drop tracks is the temporal course of the formal structure. Track 2 has the shortest break routine (32 s, compared to Track 3 = 62 s, Track 4 = 63 s, and Track 5 = 97 s; duration of break routine: $M = 63.5$ s, $SD = 26.6$ s). It also has the shortest build-up segment (Track 3 and 4 = 47 s, Track 5 = 69 s). However, this track includes the only contrasting breakdown: while the other tracks reduce the main groove to core features, Track 2 introduces a contrasting, new groove with sustained whole-note based chords, which makes it less rhythmic compared to the other break routines. The build-up manifests more intensely than in the other tracks, and includes a drum roll and extensive use of uplifters. Track 3 and 5 also include uplifters to some extent, but they are not as present in the mix and are relatively brief as opposed to the long duration of the uplifters in Track 2, which start at the beginning of the build-up and also include a volume increase with the consequence that it becomes louder the closer to the drop. Volume increase is also added to the drum roll, which starts at the beginning of the build-up. This drum roll culminates in five syncopated snare drum hits that indicate the arrival of the drop. The other tracks use different techniques to announce the drop: drops in Track 3 and 5 are indicated by withholding the drop, and by holding and repeating the last measures before the drop; Track 4 opens up the low-pass filter completely.

Results

Before embarking on the analysis, we checked whether the requirement for participants to sit still while listening to dance music altered participants' experiences in a way that interfered with their ability to have strong encounters with the music. Notably, 75% of participants said that were they to be moving or dancing to this same music in a club they would expect to experience

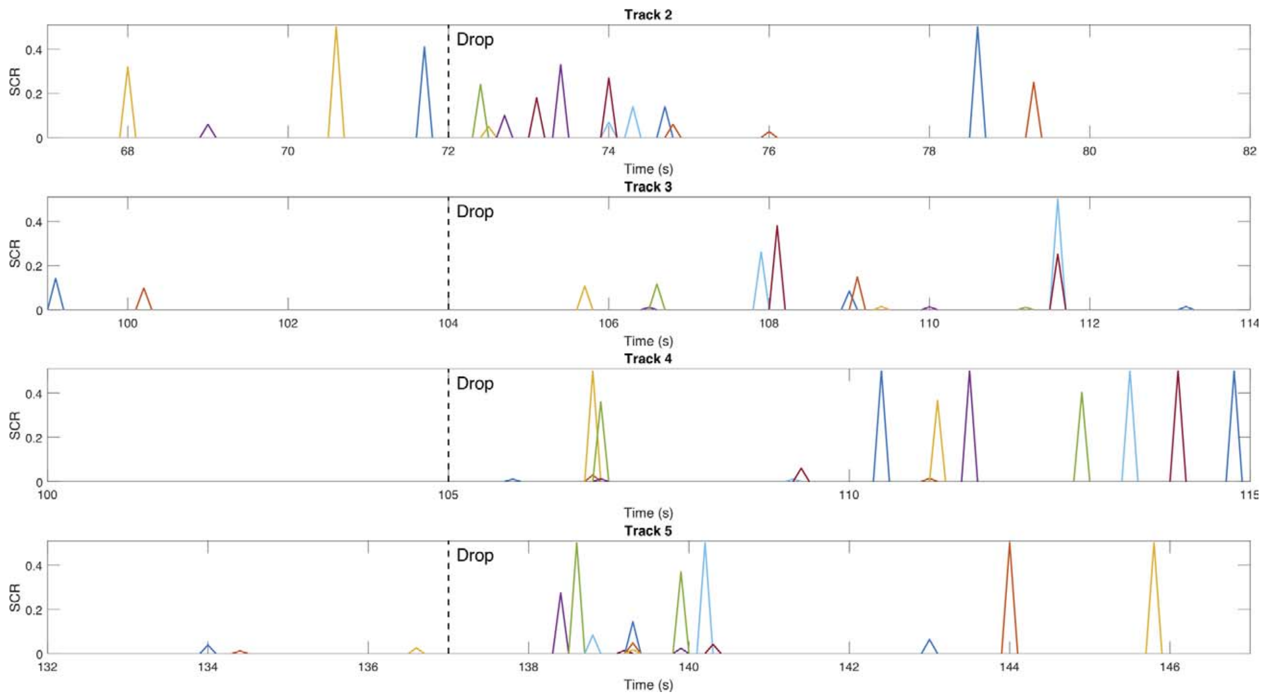

FIGURE 5. Overview of the position for each participant's maximum SCR amplitude in relation to the drops for Tracks 2 through 5.

stronger feelings. We return to this point in the limitations section.

THE RELATIONSHIP BETWEEN THE BREAK ROUTINE SECTIONS AND SCR

A two-way repeated measures ANOVA was conducted that examined the effect of track (Tracks 2 through 5) and section (breakdown, build-up, drop) on ISCR. There was no statistically significant interaction, but there was a simple main effect of Section on ISCR, $F_{(1.55,\ 1.47)} = 5.65$, $p < .01$, $\eta = .197$, which is a large effect size. Pairwise comparisons reveal a significant difference between the breakdown and drop sections ($p < .05$), and the build-up and drop sections ($p < .01$), but not the breakdown and build-up. This confirms our hypothesis that SCR for the drop section would be significantly higher than for the other sections.

We also investigated the number of peak responses associated with each section (nSCR). This showed that all participants had at least 4 significant (above threshold) SCRs across the stimuli. But not all participants had a significant SCR to all tracks. Figure 5 shows the position of each individual's maximal SCR response, and illustrates the variability both in the intensity and timing of participant responsiveness. One-way repeated-measures ANOVAs revealed no significant difference in the number of SCR (nSCR) responses per section (the response window), nor nSCR responses per track. There were no significant correlations between nSCR nor ISCR and familiarity with each track.

In order to examine the temporal development of responses to the music, the profile of SCR was compared to reported experience of the stimuli for each individual. Figure 6 displays examples of three participants' SCR to some of the tracks and their description of the musical characteristics occurring when they experienced pleasant sensations. These illustrate that in some cases SCRs co-occurred with reported experiences of peak sensations and that participants linked these to specific musical features and processes, supporting the central role of the drop moment in the experiential qualities of the break routine.

THE RELATIONSHIP BETWEEN PLEASURE AND SCR

As seen in Figure 7, all four tracks were rated similarly "fairly pleasant" (3 on 4-point scale: see Table 2 for descriptive statistics); a greater proportion of participants found Track 2 "very" rather than just "fairly" pleasant but a Friedman analysis revealed there was no significant difference in pleasantness. A point biserial correlation on ratings of pleasure and whether or not participants reported a pleasant bodily sensation (coded as 1 = *yes* 2 = *no*) and excluding participants who reported being *unsure*) for each track revealed a significant correlation for one track: Track 2 Pearson

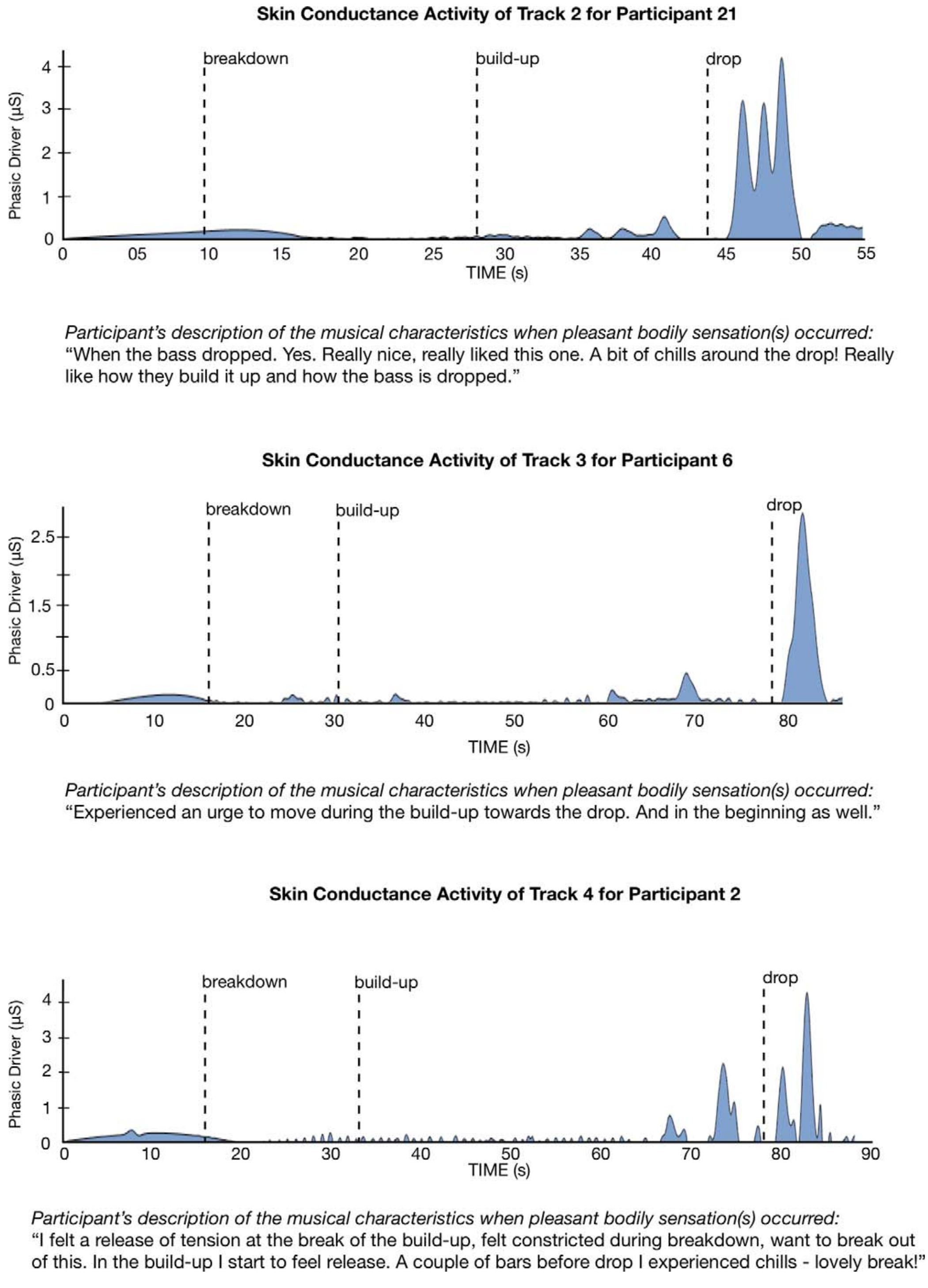

FIGURE 6. Qualitative descriptions of the experience of the break routines along with skin conductance responses (phasic driver (µS)) for participants 21, 6 and 2 to Tracks 2, 3, and 4, respectively.

rpb = -.54, p = < .01, N = 22 (two participants who reported being "unsure" were excluded for the purpose of this test for Track 2). This indicates that a significant amount of the variation in the occurrence of pleasant bodily sensations with Track 2 is associated with the degree of pleasure reported with this track. There were

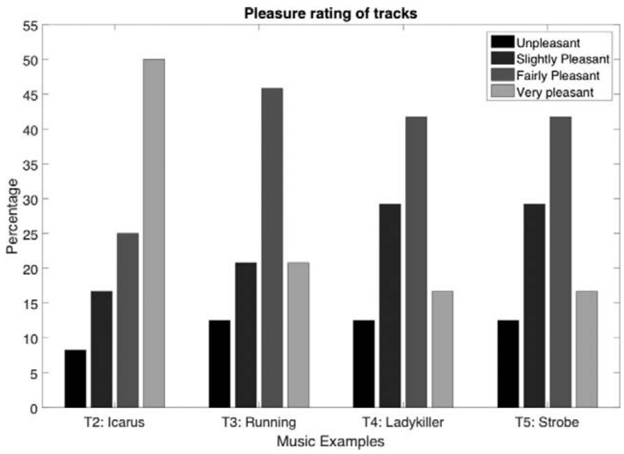

FIGURE 7. Participants' self-reported pleasure for the four music excerpts.

TABLE 2. *Mean Reported Pleasure for Each Track*

Track	Mean	*SD*
2	3.17	1
3	2.75	.94
4	2.63	.92
5	2.62	.92

Note: 1 = *not at all pleasant*; 5 = *very pleasant*; *N* = 24

no statistically significant associations between BMRQ scores and pleasure ratings, nor between BMRQ scores and ISCR for any track, nor track section, when tested using bivariate nonparametric Spearman correlations. This suggests that sensitivity to musical reward as measured by BMRQ does not account for self-reported pleasure and SCR in this study. We did find a positive correlation between BMRQ scores and two of the dancing indices as would be expected given the overlap between some aspects of the two measures: "dance by yourself at home," *rho*(24) = .5, $p = .01$ (two-tailed), and "dance together with others at club," *rho*(24) = .43, $p = .04$ (two-tailed). BMRQ did not correlate with liking of EDM, frequency of listening to it, familiarity with the tracks, nor with TIPI scores. Pleasure ratings correlated with TIPI scores for Agreeableness in relation to Track 2, *rho*(24) = .48, $p = .02$ (two-tailed), and Track 3 *rho*(24) = .42, $p = .04$ (two-tailed); and with Emotional Stability for Track 3, *rho*(24) = .43, $p = .04$ (two-tailed).

Ratings of pleasure for each track were positively correlated with mean ISCR for Track 3, Spearman *rho*(24) = .42, $p = .04$ (two-tailed), and for the breakdown sections of Track 2 and Track 3: Track 2 breakdown ISCR with pleasure, *rho*(24) = .47, $p = .02$ (two-tailed); Track 3 breakdown ISCR and pleasure, *rho*(24) = .48, $p = .01$ (two-tailed). This association between SCR and pleasure partially supports the findings of Salimpoor et al.'s (2009) study, but it should be noted that Salimpoor et al. focused on chill responses and continuous self-report measures, whereas our study was designed to capture a greater variety of pleasant bodily responses.

TABLE 3. *Friedman ANOVA Test Comparing Ratings of Adjective Descriptors Across Tracks (N = 24)*

Adjective	$\chi^2(3)$	Track 3 *T*	Track 4 *T*	Track 5 *T*
Strengthened	8.6*	ns	ns	ns
Uplifting	10.02*	29.5	17	ns
Active	12.36**	30	30	29.5
Passive	8.01*	ns	ns	ns
Happy	8.01*	ns	37.5	ns

Note: Wilcoxon Signed-Rank post hoc tests with Bonferroni correction applied (α = .0125). Stimuli were compared with Track 2. (Adjectives showing no significant difference: Driving, Enthusiastic, Falling, Floating, Flying, Grounded, Heavy, Light, Rising, Sad, Relaxing, Tense). *$p < .05$ **$p < .01$

THE RELATIONSHIP BETWEEN SUBJECTIVE EXPERIENCE AND TRACKS

All tracks scored high on the same adjectives felt while listening: Uplifting, Light, Driving, Enthusiastic, Flying, Rising. All tracks scored low on: Grounded, Falling, Heavy. There were only a few significant differences between Tracks on adjective ratings (Table 3). Friedman ANOVA tests on ratings for the 3-dimension affect terms revealed that the ratings of feelings experienced differed on the energetic-arousal dimension (Active, Passive) ($p < .05$), but neither the Valence nor Tension dimension. Wilcoxon tests were used to follow up the significant findings, with a Bonferroni correction applied such that effects are reported at .008 level of significance, correcting for the comparisons of each of the four tracks to each other. This reveals that Track 2 was associated with significantly higher ratings of feeling "Active" and "Uplifting" than Track 3 and 4, and significantly higher ratings of feeling "Happy" than Track 4. We can conclude from this that all 4 tracks are characterized by crossmodal experiences while listening, which are spatial and kinaesthetic in character as much as they are "emotional," and are about an energized state of movement at height. It is perhaps no coincidence that Track 2 (scoring significantly higher on "flying" than the other tracks) is titled "Icarus"—a reference to the man in Greek mythology who flew too close to the sun, using wings made of feathers and wax, and fell into the sea.

TABLE 4. *Distribution of the Participants' Answers*

Music example	Yes	No	Unsure
2. Icarus	45.8%	50.0%	4.2%
3. Running	25.0%	66.7%	8.3%
4. Ladykiller	37.5%	58.3%	4.2%
5. Strobe	25.0%	58.3%	16.7%

Note: Participants responded to the question "Did you experience any pleasant bodily sensations such as chills, tingling feelings, goose bumps, shivers down the spine or similar notions while listening to this excerpt?"

THE RELATIONSHIP BETWEEN PLEASURE, PLEASANT BODILY SENSATIONS, AND MUSICAL CHARACTERISTICS

Participants reported experiencing "pleasant bodily sensations" while listening (Table 4). In order to check for associations between specific musical features of the break routine and self-reported pleasant bodily sensations and pleasure, we analyzed participants' descriptions of the musical characteristics they associated with any pleasant bodily sensations they had reported. Track 2 elicited more mention of musical features (and in more detail) than the other tracks.

The excerpts elicited descriptions of specific musical characteristics that participants associated with their pleasant bodily sensations. For Track 2, 11 of 13 participants attributed their experience of pleasant bodily sensations to the build-up and drop. Features such as texture changes, rhythm, and quality of the groove were mentioned and various bodily sensations were reported in relation to the drop, including tingling in arms and feet/legs, desire to dance, or tapping of feet. All descriptions of Track 3 mentioned that structural properties of the track "caused" pleasant sensations. Interestingly, participants' descriptions were quite specific. For example, three participants mentioned a hi-hat pattern in the build-up as causing a pleasant sensation while five participants described the short break and delay in the downbeat occurring at the drop moment. Most of the statements for Track 4 related to the break routine. Two participants mentioned the low-pass filtering applied in the breakdown and build-up as inducing pleasant bodily sensations. Track 5 was the most rhythmically complex track as well as comprising the longest break routine. This excerpt elicited nine comments about musical characteristics and pleasant bodily sensations. Four mentioned the synths used in the track, and four participants pointed to the break routine.

Eighty-three percent of the participants reported a desire to move during the listening session as a whole (*yes*/*no* or *unsure*), and followed this up with a free description of the musical characteristics at the moment(s) this specific desire to move occurred. We grouped these statements into two categories according to the type of musical features the participants mentioned: (a) general features related to the quality of the groove (mentioned by 6 participants), (b) specific features related to the structural principle; the break routine (mentioned by 10 participants). Three participants mentioned Track 2 specifically, while Track 5 was mentioned twice and Track 3 once.

Given that the tracks we included in our study share certain acoustic features it is possible that the responses we observed in SCR are reactions to specific acoustic features rather than to structural aspects of the music. In particular, peaks in SCR at the drop section may simply be a reaction to increased loudness at this moment. In order to check for such associations we carried out correlational analyses between SC and acoustic features excerpted from the stimuli (Table 5). Results of the analyses indicate significant correlations of SC with audio amplitude, spectral flux, and spectrum, but not with loudness nor beat clarity. Moreover, Track 2 and 4 show the same trend regarding which acoustic features have a positive linear statistically significant relationship with SC. Notably, these are the two tracks where the difference in SCR between breakdown-drop and build-up-drop are greatest. Track 3 and 5 share acoustic features significantly associated with SCR, but in this case the difference in SCR in the three sections is not as great.

TABLE 5. *Spearman Correlation Coefficients Between Skin Conductance Response (SCR – the Average Phasic Driver Within Response Window) and Various Acoustic Features*

	SCR				
	All Tracks	Track 2	Track 3	Track 4	Track 5
Dynamics					
Audio	.607*	1.000*	1.000*	1.000*	1.000*
Global Energy (RMS)	0.536	1.000*	0.5	1.000*	1.000*
Timbre					
Spectral Flux	.832**	1.000*	1.000*	1.000*	0.5
Spectrum	.615*	1.000*	0.5	1.000*	0.5
Brightness	0.56	1.000*	−0.866	1.000*	1.000*
Roughness	0.497	0.5	0.5	1.000*	1.000*
Rhythm					
Beat Clarity	−.134	.5	−.866	0.866	0.000
Tonality					
Mode	0.175	−0.5	1.000*	0.5	1.000*

*Correlation is significant at the 0.05 level (two-tailed).
**Correlation is significant at the 0.01 level (two-tailed).

Discussion

Our study investigated subjective peak experiences of EDM by exploring associations between physiological arousal, pleasurable experiences, and musical features. We found that break routines of EDM tracks were associated with feelings of "activation," and sensations of flying, rising, and being uplifted, pleasure and pleasant bodily sensations, increased SCR during the drop section, a desire to move to the music, and for these sensations to be attributed to specific musical processes and features by listeners.

Differences in SCR, an index of physiological arousal associated with peak experience, were statistically significant when comparing drop sections to other sections of the break routine. Crossmodal and kinaesthetic experiences were particularly strong with Track 2, which suggests there may be something distinctive about it in terms of its ability to elicit peak-responses.

As presented in the analysis section, Track 2 has the highest sound level and the briefest break routine. Additionally, this track uses three specific production techniques, which the other drop tracks do not include: (a) contrasting breakdown, (b) extensive use of uplifters with volume increase, and (c) drum roll. The association of these musical characteristics with an intense response is consistent with previous research (Gomez & Danuser, 2007; Grewe et al., 2007a, 2007b; Guhn et al., 2007; Panksepp, 1995; Sloboda, 1991): the contrasting breakdown is an unexpected change, the use of uplifters is a gradual expansion and change of the frequency spectrum, and pitch range, the increased volume is an increase in sound intensity, and the drum roll is a sudden change in texture. The association between increased SCR and increased sound intensity and wider pitch range is also consistent with previous research (Gomez & Danuser, 2007). This music analysis provides some evidence of the kinds of musical features that elicit the most intense responses in EDM. Interestingly, the observed changes in SCR align with how people respond to such break routines when moving together with others. People change the quality and quantity of their body movements in response to the structural, dynamic, and textural changes in the break routine (Solberg & Jensenius, 2016, 2017). In other words, the distinct peak in SCR just after the drop co-occurs with movement observed on dance floors where, we argue, peak pleasure is expressed through body movements. This suggest that there is a close relationship between our affective engagement and embodiment.

EMBODIED FEELING STATES

The tracks share many similarities in terms of the embodied feeling states captured by the adjective ratings, and by one of the 3-dimensions of the affect space, namely feelings of "activation," but not by the tension and valence dimension. One possible interpretation of this is that the selected tracks happened to be well matched in terms of their ability to induce a particular affective state. In addition, it could suggest that the affect space does not comprehensively characterize listeners' experiences of EDM. In this regard, our results support recent critiques of psychological research, which frame music listening primarily in terms of disembodied affective states to the neglect of other domains of musical experience (Clarke, 2014).

PLEASANT BODILY SENSATIONS AND DESIRE TO MOVE

Unlike previous research (Salimpoor et al., 2009) we did not find evidence of a consistent (positive) correlation between skin conductance and ratings of pleasure, nor with the occurrence of pleasant bodily sensations. However, it should be noted that Salimpoor et al.'s study focused on skin conductance at self-reported chill responses together with continuous self-report measure of pleasantness, whereas ours measured SCR throughout the listening experience and was designed to capture a greater variety of pleasurable bodily responses.

Participants' desire to move to the music during the experiment (reported by 83% of participants) was attributed by them to either the general quality of the groove or to specific features of the break routine, with both mentioned equally. Previous research on EDM indicates that people differentiate between a general desire to dance and an intense desire to dance, where the latter category is related to the break routine (Gadir, 2014; Solberg & Jensenius, 2016). We would therefore have expected a greater number of participants to attribute their desire to move to the specific moment of the drop rather than general qualities of the groove. It may be that this result reflects the breadth of the question, which allowed participants to understand it either as a request to focus on a specific moment or the music as a whole. However, it is also consistent with the dynamic musical pleasure model, in which we can experience continuous sensations of pleasure over a longer time period when we move to music (Witek et al., 2014).

CONCLUDING REMARKS

Overall, this study provides empirical evidence of the role of the break routine in eliciting an intense subjective and physiological response to EDM. Moreover, it reveals that the character of this response is one of energetic activation, experienced as pleasurable feelings of flying, rising, and being uplifted, which, according to our qualitative data, are most strongly associated with the moment of the drop rather than other structural moments of the break routine. Three potential limitations should be considered. First, the context for musical experience in this study was a laboratory setting in which people listened alone, and without moving to the music. This is quite different from the club setting, where the music is usually experienced while dancing with others. That being the case, we might doubt that any strong experiences were elicited and that if they were they were of a quite different character than would be the case in the club context. The physiological data and self-reports suggest that there were differences in the intensity of the experience, with club contexts likely to elicit stronger experiences for most participants.

Second, the intended ecological character of this exploratory study meant that we presented excerpts from commercially available EDM tracks in which a variety of acoustic and structural parameters were present, making it difficult to disentangle the contribution of specific musical features. In future research it would be possible to manipulate music excerpts to test more specific hypotheses regarding the acoustic features involved, and to avoid potential confounds with loudness, for example.

This study provides the first psychological and physiological evidence of peak experience in electronic dance music and its relationship to musical features characteristic of the genre. Previously EDM has been looked at in terms of its compositional structure, and its social and cultural significance. We offer a new perspective focused on musical detail and individual experience. We have shown that peak-pleasurable experience with EDM is related to musical features and processes. While some of these features are specific to EDM, they can nonetheless be understood in terms of a goal-directed expectancy theory. This highlights the opportunity for future research to look across a greater range of music and identify common underlying psychomusical features and processes. Lastly, the findings of our research indicate that EDM has an embodied spatial and kinaesthetic experiential quality even when listened to without dancing and removed from the club context. This highlights the need to consider experiential qualities of music more broadly, to encompass the embodied and gestural, in addition to the affective and perceptual aspects of musical materials that have hitherto tended to dominate research into the subjective experience of music listening.

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Appendix

APPENDIX A. ***List of the five excerpts' musical characteristics***

Track 1 – Thoughts of She (control track, time points in original mix: 04:59 – 06:05)

(a) Musical characteristics of main groove:
Function as control track and does not include drop. The excerpt is collected from the outro of the original track. Typical house drum groove (four-to-the-floor with percussive elements, such as congas and claps), which includes a 8th-note driven bass line and one syncopated synth chord. After 8 bars, one or several layers are removed until only drum groove remains.

Track 2 - Icarus (target track, time points in original mix: 01:54 – 02:52)

(a) Musical characteristics of main groove / pre-break:
A four-to-the-floor groove with strong rhythmic focus and rich texture, which includes a lead melody synth, sustained synth chords and a live sampled bass line. The collage-based groove consists of many short and rhythmic samples and layers, which creates a "sound wall".

(b) Musical characteristics of breakdown:
The breakdown is characterised by the removal of several of the rhythmic and percussive features of the main groove. The track is reduced to a few music features and therefore stands in large contrast to main groove. The bass drum and the other percussive features are replaced with a simple bass line and a set of sustained string synth pads.

(c) Musical characteristics of build-up:
The build-up starts with handclaps on 2 and 4. Gradually elements are added, such as a melodic synth feature gradually mixed into the soundscape. Uplifters/risers are added in addition to a drum roll at the end of the build-up. The drum roll ends in a brief switch of rhythm, through a syncopated five-on-four polyrhythmic figure. This figure indicates the arrival of the drop.

(d) Musical characteristics of drop / post-drop:
A drum roll which ends in syncopated five-on-four polyrhythmic figure, white-noise uplifters towards bass slide down, then a loud bass slide down on first beat and the rest of groove is introduced on the second beat.

Track 3 – Running (target track, time points in original mix: 02:50 – 04:23)

(a) Musical characteristics of main groove / pre-break:
Four-to-the-floor groove with several hi-hat patterns and various percussive elements. It also includes a syncopated synth (Synth 1) doubled with bass in addition to some vocal samples (with reverb and volume automation), and a small white noise uplifter that leads up to breakdown.

(continued)

Appendix A. **(continued)**

(b) Musical characteristics of breakdown:
The breakdown starts out with space sounds (some pitched in downward direction) and a new synth feature, vocal sample (reverb and volume automation, panned around), new (syncopated) square-sound synth transposed in different keys (synth 2). All the percussive elements, the bass line and Synth 1 is removed in the breakdown.

(c) Musical characteristics of build-up:
When the build-up sets in, a percussive pattern enters (hi-hat/tambourine, snare drum) together with a new voiced vocal sample ("keep me running") and space sounds. Then uplifters/risers (pitched white noise) are introduced and lead towards the final segment of the build-up: the synth stays at one key, a new vocal sample (a sustained "aaah" in background) in addition to the existing vocal sample are audible, then a massive downward pitch sweep towards drop moment. Remaining features from breakdown are synth 2 and space sounds.

(d) Musical characteristics of drop / post-drop:
Before the main groove is reintroduced a brief silent occurs before the drop is marked by a loud snare drum hit. The groove after the drop is the same as main groove before, only one small element is added after 8 bars into the groove.

Track 4 - **Ladykiller** (target track, time points in original mix: 03:36 – 05:14)

(a) Musical characteristics of main groove / pre-break:
Typical four-to-the-floor house groove consisting of many short layers, piano chords and a short melodic feature in addition to several guitar elements, which shape a call-and-response. The bass line doubles the piano riff, and there are also some short vocal samples in the background.

(b) Musical characteristics of breakdown:
The breakdown starts with a deep resonating sound (called *impact*), and then delay is added to the remaining features in addition to low-pass filtering. Only some of the guitar elements remain, and the rhythmical framework, bass and piano elements are temporally removed.

(c) Musical characteristics of build-up:
Ladykiller uses a long, gradual low-pass filter opening of the main groove, where the bass and bass drum reenters, then sustained strings after 8 bars, and after 16 bars the low-pass filter is open enough to hear some of the percussive elements. Right before the drop, the vocal samples start on the last upbeat before the drop (so that the last word in the vocal phrase coincides with reintroduction of groove). The drum groove is temporarily paused while this occurs; low pass-filter is fully reopened at the beginning of drop.

(d) Musical characteristics of drop / post-drop:
The low-pass filtering is completely reopened at the drop, and all musical features is reintroduced and shapes the same groove as before the break routine.

Track 5 – Strobe (target track, time points in original mix: 04:57 – 07:02)

(a) Musical characteristics of main groove / pre-break:
The most complex of the five excerpts. Includes many poly-rhythmic figures, which leads to the feeling of a shift of time signature during the break routine. The main groove consists of lead synth and synth chords, both syncopated - together creates three-on-two rhythmic figure, bass doubles the synth chord. The track is a variety of three-against-four, which eventually goes completely over to three instead. The synth/bass element contains a syncopated figure of the polyrhythm three-against-four (drums).

(b) Musical characteristics of breakdown:
As the breakdown begin, is marked by a cymbal hit/white noise (with volume automation), four-to-the-floor is removed, syncopated synth features and bass remains, however the bass is gradually removed by adding an automatized high-pass filter (most of the sub is removed) and the synth sound gets more clean, diverse atmospheric sounds in background, when the synth features change rhythm also new bass figure introduced. The groove remains in 4/4 time the whole break routine, while the chords establish a measure in three after six bars. Since the groove is still in 4/4 the bass/keys are relocated one beat, together with the polyrhythm this gives a further dislocation.

(c) Musical characteristics of build-up:
The syncopated synth features are enriched with delay, which eventually changes and creates a new poly-rhythmical figure, this marks the beginning of the build-up; when the riff goes onto being a new first beat and now "on grid" instead for syncopated. Hence the feeling of a new time signature. The lead synth develops and the bass line changes according to this new rhythmic figure (variant of three-on-two), gradually a new synth theme emerges, in combination with an organ in the background, which gradually is mixed louder and louder into the mix.

(d) Musical characteristics of drop / post-drop:
All elements besides lead synth fades away (and the synth with shorter and shorter release), white noise sweep towards snare drum hit, then a brief silence occur before the main groove is reintroduced.