Expressive alignment with timbre: changes of sound-kinetic patterns during the break routine of an electronic dance music set

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Abstract

In this work, we describe the changes of sound-kinetic patterns during break routine's sequences (break-down, build-up, and drop sequence) of an electronic dance music (EDM) party, resulting from the expressive alignment between human movement patterns and sonic patterns of music. Expressive alignment refers to synchronization of these two patterns. On one side, the study of EDM's dance has shown that dancers share a movement pattern at the drop moment in some parties, and on the other side, expressive alignment with timbral patterns have not been studied yet. In order to analyze the sound patterns, (i) we registered and described all break routines of an EDM party video, (ii) processed its audio signal to extract acoustical features related to timbre, rhythm and pitch, and (iii) compared these two set of data. To study the human movement, (i) we identified and registered the movement of arms, head and shoulders of 37 kinetic patterns during 15 break routines, (ii) described them with the effort-shape elements from Laban Movement Analysis, and (iii) compared the kinetic patterns. With regard to sound analysis, we identified 65 break routines and observed that they are defined by sound patterns. The drop and the break-down sections are specifically linked to acoustical changes related to timbre. With regard to movement analysis, we identified changes in movement patterns during each step of the break routine, and noted that people develop personal movement patterns, differentiated from those of others by the organization of effort-shape elements. From a musical point of view, acoustical changes of the break routine –strongly based on timbral changes- modify the sonic environmental conditions, and the consequent expressive alignment of the dancers. Although people keep their personal styles of movement, they all change their movement patterns in phase with the sonic changes of music, producing a shared sound-kinetic pattern.

Background

The nature of the relation between music and movement has concerned researchers for a long time. Does the music move us or do we move with music?

The idea that music moves us is strongly based on the theory of affordances. Affordances are relations between an organism and their environment, in which "the environment affords a behavior to the organism" (Chemero, 2003, p. 187). In a musical context, this means that a sound environment affords some possibilities of action to people, and that these affordances change when the sound environment changes. From this perspective, music takes the shape of moving sonic forms (Leman, 2007; Hanslick, 1854), since it is the physical movement of sound which makes us move.

The empirical study of musical affordances has focused on the search for common patterns of music and human movement. The process of synchronizing these patterns is called expressive alignment (Leman, 2016), and is defined as a continuous transition between the environment processing and the intentional and affective states of the person. The result of the expressive alignment of a musical and a human movement pattern is a sound-kinetic pattern. Several studies have shown that the kinetic patterns made with music reflect some aspects of the sound (Kohn and Eitan, 2009; Maes et al., 2014; Krueger, 2013). This leads to the assumption that people move in similar ways with the same music, since they share expressive affordances with its moving sonic forms (Leman, 2016; Leman et al., 2009; Maes et al., 2014). According to Leman, there are two types of expressive alignment of music and human movement patterns: (i) the alignment of the salient time markers of body and musical rhythms -studied in terms of timing framework-, and (ii) the alignment of the continuous sound and body movements –normally studied with motion capture technologies. Most of the studies of kinetic pattern's formation with music are based in the analysis of non-natural situations, mainly of laboratory experiments in which people are asked to move spontaneously to a wide range of musical extracts.

Musical patterns have been studied from two main approaches. One is auditory analysis, which is the traditional and most common way to study musical characteristics, and the other is the computational analysis of the acoustical features of recorded sounds. The role of timbre in the formation of musical patterns has been little studied from both approaches. On the one hand, their auditory analysis is problematic, because we have very few categories to think of our perception of timbre (for a musicological perspective, see Mastropietro, 2014). On the other hand, timbre is studied from an acoustic point of view, looking at the acoustic dimensions which determine our auditory perception of timbre. In monophonic timbres, the spectral centroid, attack-time, spectral flux and roughness seem to be central (McAdams, 1999), and in polyphonic timbres these are the sub-band flux, spectral entropy, zero-crossing rate, and –although less relevant- MFCCs (Alluri, 2012). These dimensions have been successful in the global characterization of musical styles (Acouturier, Pachet and Sandler, 2005; Alluri, 2012), but their power to create musical patterns has been little assessed. Burger et al. (2013) studied the expressive alignment between acoustical patterns related to timbre (sub-band flux and percussiveness) and the continuous body movements that people made with the music.

We think that an electronic dance music (EDM) party is an optimal and natural environment to study the expressive alignment of body movements and timbral patterns of music, as much for the non-choreographed characteristic of its dance (Gallo, 2014) as for the perceptual relevance of its timbral features (Anzil, 2016; Marchiano, Martínez and Damesón, in press). The most important musical pattern defined by the

EDM producers and DJs is the *break routine*, formed by the *breakdown - build up - drop* sequence, which constitutes a formal articulation of the EDM set. At the breakdown section, the bass drum –and normally the bass too- is removed, breaking down "the groove and intensity of the track. The build-up section builds it up to a peak which is symbolized by dropping down the bass and bass drum" (Solberg, 2014, p. 67). With respect to the expressive alignment in EDM parties, Solberg and Jensenius (2017) found that dancers share a movement pattern at the drop moment, raising arms together.

In this work we studied the sonic patterns of break routines formed by acoustical features, aiming to determine their timbral status and their power to afford kinetic patterns in EDM's dance.

Method

We designed a mixed method consisting firstly of a qualitative analysis of sound, followed by two quantitative evaluations of sound. Movement was analyzed qualitatively.

Stimulus

The stimuli used was an EDM party audiovisual record of the techno DJ Len Faki, 1 hour and 32 minutes long (Len Faki, 2014). We looked for an EDM music genre with a lot of break routines, and a record with audiovisual characteristics that allowed us to analyze people movements. The record was selected from among the 10 most viewed videos of the Boiler Room Youtube channel (5.1 millions). It is a common practice for DJ's to be at the side of the dance floor, and that people dance around them. The Boiler Room's records normally show the DJ, the people near him/her and the crowd behind them, from the waist up (see Figure 3).

Sound Analysis

Three methodologies for sound analysis were used: aural analysis, computational modelling, and a comparison between both. In all cases, the analysis focuses on the moments of musical changes.

Aural analysis. Firstly, we identified all the break routines of the video and registered them on Elan 5.0 timeline. Secondly, the break routines were divided into breakdowns, build ups, and drops. Thirdly, we made a formal and timbral description. Finally, we identified differences between the break routines, registering five main break routine types defined by their steps sequence.

Computational acoustic analysis. The acoustic signal of the video was processed with MIRToolbox 1.7 on MatLab v2015a. We extracted data of several features related to timbre, rhythm and pitch perception. The set of timbral features extracted was sub-band flux, spectral entropy, MFCCs, zero crossing-rate, roughness and general spectral information. The rhythm feature used was the fluctuation patterns and the pitch feature was the chroma. We decided not to include the percussiveness in the timbre set of features because its relevance in polyphonic timbres has not yet been widely studied and because we thought that it can also be related to rhythm aspects, especially in a computational modelling that search for sudden changes.

The novelty curves of each feature data were then computed, in which the peaks represent the moments of changes in the sound dimension defined by the feature (Lartillot et al., 2013; Hartmann, Lartillot and Toivianen, 2017).

Comparative analysis of aural and computational data.

Temporal coincidences between changes in each acoustical feature and the steps of all break routines were identified by extracting segments of computational analysis corresponding to all aurally identified break routines. Ten seconds after and before them were added, in order to obtain information on the first and the last step of the break routines. Temporal coincidences were searched with a 1 second window around the aural temporal location of each break routine step. The percentage of coincidences for each feature and each step was calculated, and three sets of data were made: (i) general percentages by feature (the percentage of coincidences between the beginning of all break routine steps and the novelty peaks of the feature), and (ii) differentiated percentages by feature and steps.

Movement Analysis

15 break routines from the video were selected, showing people at least from the waist up throughout the segment. We then analyzed the kinetic patterns formed by arms, head and shoulders. In total, 37 sequences of movements were analyzed, from 10 persons dancing at different moments in time at the party.

The movement analysis was done in Elan 5.0 software. The music was silenced during observations. Firstly, we detected the kinetic patterns by real-time annotations and then we reviewed and temporarily adjusted the identified units. Secondly, we characterized each unit -in the context of the sequence- with the effort-shape elements from the Laban Movement Analysis (Laban, 1950). In most cases, the outcome of this process was a new and more global kinetic pattern, formed by the clustering of the local units previously identified.

Movements were described with respect to three main aspects of the Laban theory. One is the motion factors of the effort elements defined by weight (strong/light), time (sudden/sustained), and space (direct/indirect), and the other is the shape of the movement, defined by the vertical (up/down or rising/sinking), horizontal (left/right or widening/narrowing), and sagittal (forward/back or advancing/retreating) spatial axes (Broughton and Davidson, 2016). The third is the movement quantity, which is determined by movement velocity and the quantity of bodily articulations involved. Not all of these factors are relevant in all movements (Laban, 1950). We registered those factors that better describe each kinetic unit and its relation to the changes from the previous and to the following units of the pattern. After these descriptions, we did a comparative analysis between each person's patterns of movement.

Results

Sound Analysis

From the aural analysis, 65 break routines were identified.

Firstly, during the registering of the break routine sequences and in addition to the break-down, build-up and drop steps, we found that in the selected EDM set the drop was usually preceded by a break-beat –a short percussive musical fragment-, apparently working as an anticipation (14 break routines with break-beats; 20.6% of the total).

The formal analysis of all break routines showed marked differences in the order of appearance of the steps and the quantity of steps. For the purpose of this study, we categorized the break routines in five types: basic, basic with breakbeat, minimum non-directional, minimum directional, and complex break routines (Figure 1). We describe the *basic* type in the background section, because it is the most well-known and it seems to represent the basic structure of break routines. It is formed by a break-down, build-up and drop sequence, and its structure is the most directed to the drop. However, this was not the most frequent type in the analyzed set (15.38%). Sometimes, the DJ introduces a break-beat before the drop in the basic sequences, so we named it *basic with break-beat* type. The next two break routines present only two steps, occasionally with a break-beat between them: the *minimum non-directional* type is formed by a break-down and drop sequence and it is the most frequently played in our set (50.76%), and the *minimum directional* type is composed of a build-up and drop sequence. These two break routines are normally short and seem to have less structural significance in the complete EDM set, while the basics types work as formal articulators. The last type is the *complex* break routine, and it has many steps, ordered differently from the well-known basic break routine sequence. This type tends to be temporarily longer than the others.

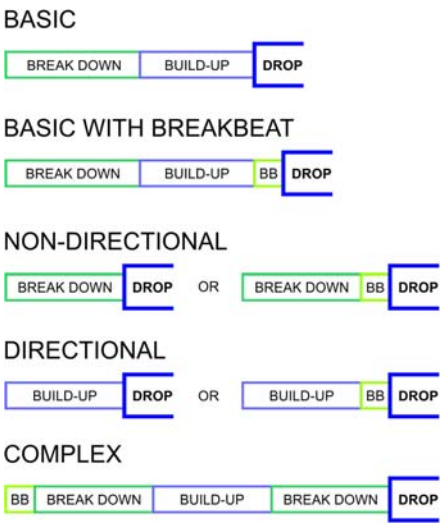

Figure 1. Types of breaks routines.

Finally, we identified two main types of break-downs, defined by their timbral identity: one is defined by the removal of low frequencies, and the other removed the higher zone. The break-downs were then divided into low-cut and high-cut procedures for the statistical analysis.

Computational analysis shows that the break routine is defined by acoustical patterns. From the general percentages by feature, we observed that some of the analyzed features are temporally aligned with the break routine sequence (Table 1). These are some timbral features, chroma and percussiveness, while fluctuation patterns –the feature related to rhythm- does not show relevant temporal coincidences. The Sub-Band Flux is the feature with the highest percentage of coincidences (68.15%).

Table 1. General percentage by features: percentage of total coincidences between all break routines steps and features changes (values without build-up coincidences).

	Features	Coincidences (%)
Timbre	Spectrum	43.31
	Sub-Band Flux	68.15
	MFCCs	28.02
	Roughness	31.84
	Zero-crossing rate	48.4
	Entropy	30.57
Pitch	Chroma	40.12
Rhythm	Fluctuation patterns	17.19
	Percussiveness	43.31

In a more specific analysis of the break routine sequence, we found significant differences in the temporal coincidences for each step (Figure 2). The drop and -in second place- the low-cut break-down moments have the highest quantity of temporal coincidences. The acoustical pattern that defines the drop is formed by Sub-Band Flux and Percussiveness changes, while the one which define the low-cut break-down is formed by Sub-Band Flux and zero-crossing rate changes

The drop and the low-cut break down steps are characterized by a change in the low-zone frequency –the first introducing the lowest layers, and the second removing them. If we assume that percussiveness plays a role in our perception of timbre –as some studies claim (Burger et al., 2013)-, it seems that the timbral features have more marked relevance in the definition of low frequencies changes in EDM than other features. If not, and if this feature also plays a role in some rhythmical aspect, then the sound pattern of the drop moment would be timbral and rhythmical, and this is intimately related to the drum bass re-introduction at the drop moment. This feature needs to be specifically studied for further analysis. In any case, the actual relevance of the acoustical features related to timbre in the definition of the drop moment and the low-cut break-down beginning does not discard any change in other musical or sonic dimensions, as shown by the descriptions of rhythm, texture, intensity, and general spectral characteristics of Anzil (2016) and Solberg (2014, 2016).

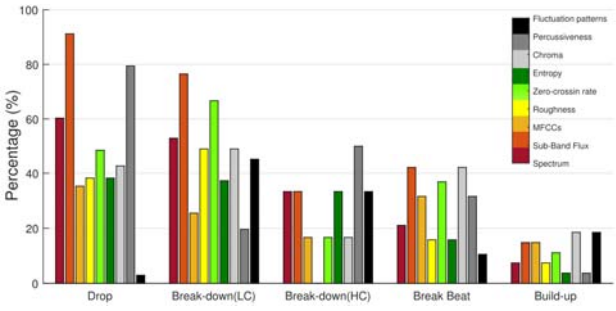

Figure 2. Temporal coincidences between all break routine's steps and features' novelty

We suggest that the reason for the low percentage of the build-up steps is that they never have a sudden onset. As inferred by its name, the build-up develops a slow and

progressive transformation of some textural layers, and there is not a perceptual or an acoustical event that determines its beginning. Given the methodological failure to grasp the acoustic background of this step, we removed it from the general percentages (Table 1).

We did not observe any relevant or new links between the acoustical features and the break routine types.

Movement Analysis

With regard to the Laban Movement Analysis of each kinetic pattern, we firstly observed that dance movements with EDM can be described with effort-shape elements. People organize their movements emphasizing some elements of effort (weight, time, space) or/and shape (vertical, horizontal, sagittal). Their specific combination and sustainment over time form a kinetic unit. For example, the unit can be made of a simple rise, direct and slow movement of arms and a sinking movement of head (Figure 3, 3.2 build-up moment, man), or of a more complex movement like that of the girl on the left before the break routine (Figure 3, 1.1 and 1.2). Secondly, we observed that people shift these units of movements, forming kinetic patterns in the form of a chain (if the units and their changes are temporarily and constructively clear) or a perpetual stream (if their units connect with others in a continuous transition).

Based on this analysis, we compared the kinetic patterns of the same person at different moments in time at the party, and of different persons at the same moment. The first result showed that people in EDM parties do not share kinetic patterns or even their units of movements. As it can be seen in Figure 3, in the break-down segment (2.1), the girl on the left and the man make really different movements, and after the drop moment (3.1 and 3.2) while these two use an important amount of space moving their arms, the girl on the right barely moves them. At this point it is necessary to clarify, that in this specific break routine most of the dancers raise their arms at the drop moment, as Solberg (2017) has already observed, producing a shared kinetic pattern. However, this generalized movement was observed only in this break routine, which constitutes one *basic* and the most directional type of movement. Moreover, it is possible that the upward movement of the DJ's arms may also have led to this behavior. The role of the DJ's movements in the crowd's shared kinetic patterns would need to be studied for further analysis. The differences found in this study compared to that of Solberg may be related to EDM genre differences (house vs. techno; Solberg, 2016), to differences between set-ups (a club-environment recreated in a laboratory and an audiovisual record of some dancers in a real party), and to some probable cultural distance between the dancers of the two studies.

The second result is that people develop personal movement patterns, differentiated from those of others by the organization of effort-shape elements. On the one hand, we noted that each person frequently repeated certain movements that were not shared by others. For example, the marked directions of movement of the right girl and the man (Figure 3, 1.1 and 1.2) define one of the movements of each of these persons that give identity to their personal dance styles, at least in the sense that they repeat them a lot throughout the entire party. The arm, head and shoulder of the girl move from left to right, while the limbs of the man move in different directions. On the other hand, both the kind of temporal organization and the level of variation of the movements are key aspects in the definition of personal styles. Some people repeat a basic movement for a long time, changing only details (as the men in the picture, who repeats the described unit for 30 seconds, with little changes in his arm movements), and others change rapidly from one movement to another (the girl's unit take only 5 seconds).

We noted that underlying this, there is a common background of movements shared by EDM dancers. We identified two: one is the swaying in sync with some pulsation, and the other is the sagittal movement of arms from the chest to the front. But even these basic movements, mostly defined by shape elements, take different effort and timing factors depending on the person.

Figure 3. Laban Movement Analysis of some movements shapes during a break routine (originally made on Elan).

The examples given above are based in the shape of the movements because is the only aspect that we can appreciate in a photograph, but this analysis was done for all effort-shape elements, and the illustrative examples are a synthesis of the results of all 37 analyzed kinetic patterns.

With regard to the alignment of the kinetic and sound patterns, we found that people change their movements when the music changes during the break routine, which means that there is also a temporal alignment between people movements. Although they do not share the same effort-shape characteristics of movement, at certain moments all or most

people make a change in some aspect of their ongoing kinetic pattern. The shared thing is the change.

The sound-kinetic pattern in each step of the break routine is analyzed showing that the most relevant expressive alignment happens at the drop moment. In 35 of the 37 kinetic patterns analyzed (94.5%) an important change occurs. Four of these 35 persons change their movements some instants before the drop, all during a break-beat step, and maintain the new unit after it. The rest of the people shift their pattern at exactly the same moment or until one second after the drop. The accuracy of this change on the kinetic patterns seems to be clearly related to the strong acoustical change that defines the drop moment. The kinetic change can take two forms: the occurrence of a new or previously little used movement that looks like a kind of kinetic accent, or just the change to a common personal movement that sometimes is played with a higher amount of movement quantity or a stronger weight effort. We did not find any link between these two types of changes and the sound characteristics, and neither did we find logic in the kinetic possibilities of each person.

Movements do not change immediately at the start of the break-down section. In a high percentage of cases, the previous kinetic pattern remains for a few seconds, and then slowly begins to decrease the quantity of movement. Sometimes the fight attitude of the motion factors (strong, sudden, direct) gradually changes to light, sustained and indirect, while maintaining the shape of the movement. Other times the dancer simply stops moving. This is visible in Figure 3, where the girl on the left side and the man are dancing at the beginning of the break-down (2.1), and seconds later stop moving, appearing distracted from the music (2.2). Although the aural and the acoustic analysis showed that this section has a clear beginning, we consider that their non-temporarily accurate movement's alignments may be due to an unpredictable start.

By contrast, in the build-up section, most people gradually increase the movement quantity of their kinetic patterns, and this slow change is clearly linked with the slow changes in the music. The bodily behaviors during break-downs and build-ups seem almost a direct embodied interpretation of the music: the movement disappears with the lower layers in the break-down step, and it reappears and takes strength when the layers build up again until the drop.

In summary, the different nature of all these kinetic alignments maintains a close relationship with the acoustic characteristics of the beak routine's steps. But the temporal organization of break routine's steps also plays a role in kinetic affordances. So finally, we reviewed our movement's analysis grouping the types of break routines, searching for similarities and differences. Firstly we noted that in both the minimum directional and the non-directional type, the kinetic patterns have less variability. Secondly, we noted that during the complex break routines, sound and kinetic patterns are not so clearly aligned (the non-change of the movements of the two persons at the drop moment happens in a complex break routine). The behavior of the people is quite different to the previous description: in some break-downs people dance more than in build-ups. Its musical structure seems to be bodily unpredictable, but we also consider that what looks like a simple shift of the order of the steps, in fact implies a deeper change of the function of the steps. For example, some break-downs before the drop seem to work almost us a build-up, as if the lack of sounds builds up greater tension.

Conclusion

In this work, we found that there are sound-kinetic patterns that emerge as outcomes of the expressive alignment between musical patterns and dance movements. This alignments consists of the temporal coincidence of changes in sonic and kinetic patterns. The sonic change at the drop moment affords a more generalized and accurate change in human movements, while in the break-down and build-up sections the kinetic patterns change more slowly and gradually. This structure of the movement pattern is related to the acoustical kind of change of each break routine's steps: the drop is generated by a sudden change of some timbral features, and the break-down –especially those that only eliminate the lowest frequencies- also happen as a sudden but less strong change. In fact the beginning of the build-up is neither acoustically nor auditorily clear.

We identified some formal differences between break routines. However, we did not find particularly relevant links between break routines and the acoustical features and kinetic patterns of dance. Both these links and their status in the EDM culture require further study.

The general idea that people move similarly with the same music has no support in EDM dance. Each person makes movements which are defined differently in terms of their effort-shape elements from those made by other people at the same moment in time. The EDM dancers develop personal styles, which seem to be constructed over a limited repertoire of movements that they combine in several and creative ways. However, beyond these personal styles, people shared a kinetic pattern based on the change of the movement unit at the same time. These common changes are aligned with –and afford to- the acoustical changes during the break routine's steps.

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