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Building the anticipation:
How variation in tension mediates emotions in music

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Running Head: how expectancy and tension mediate emotions

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1 Abstract

Previous research on music-evoked emotions has suggested that people experience heightened tension around expected musical events, which mediates peak-pleasurable emotions. Electronic dance music (EDM) break routines are short and highly emotive music motifs, which are proposed to increase tension to peak levels during build-up passages, prior to highly expected drop passages that evoke peak-pleasurable emotions when listeners' expectations are fulfilled. Continuous tension ratings throughout EDM break routines are therefore useful to better understand tension patterns around music expectations and their relationship with peak-pleasurable emotions. Thirty-four participants listened to break routines, while continuously rating felt tension. Peak-pleasurable emotions were then measured once via the 2-dimensional space of valence and arousal after each break routine. Results showed that tension increased during build-up passages prior to expected drop passages, where it then decreased when expectations were fulfilled. While average tension did correlate with dimensions of peak-pleasurable emotions (valence, arousal, emotional strength, and emotional response), our data reflected continued feelings of average tension after break routines, rather than peak-pleasurable emotions as predicted. This suggests that tension is altered by music expectations, but that greater tension may not always increase peak-pleasurable emotions.

Keywords: expectancy, tension, break routines, peak-pleasurable emotions

2 Introduction

Music evokes a range of emotions, including peak-pleasurable emotions, defined as having high positive valence and arousal which mostly co-occur with physiological reactions, like 'chills' (Blood & Zatorre, 2001; Habibi & Damasio, 2014; Juslin & Sloboda, 2011; Mori & Iwanaga, 2017). One way music can evoke peak-pleasurable emotions is through the continuous alterations in levels of tension and relaxation induced through musical structure and expectations (Lehne et al., 2013; Meyer, 1956). Tension levels during music have been linked to peak-pleasurable emotions, such as excitement and happiness (Granot & Eitan, 2011; Krumhansl, 2002; Robinson, 1994). However, while electronic dance music (EDM) break routines are one musical structure known to modulate emotion (Turrell et al., 2021), the way in which this happens is still little understood. One route could be through changes in tension. In this study we measured continuous tension ratings during presentation of break routines to understand the link between tension and emotions.

Electronic dance music (EDM) *break routines* should be particularly suited to creating tension prior to highly expected moments, leading to strong peak-pleasurable emotions (Turrell et al., 2021). EDM songs often contain multiple break routines, lasting around 20s and featuring intense but highly expected changes in the song's acoustic features and structure (Solberg, 2014; Solberg & Dibben, 2019). Break routines have three passages: the *breakdown* passage is where instrumental layers of the track, such as bass, are removed to reduce its intensity and groove. Then, the *build-up* passage occurs by gradually reintroducing the instrumental layers to build the track back up to a peak moment. Lastly the *drop* passage re-establishes the track's main groove as the bass and bass drum are "dropped" back in (Butler, 2006; Solberg, 2014; Solberg & Dibben, 2019; Solberg & Jensenius, 2017; Turrell et al., 2021; see Supplementary Figure 1 for a visual example). Listeners, even those who are unfamiliar with EDM, should expect drop passages and the reintroduction of the song's main groove after hearing a build-up to a peak moment and held in suspense, increasing tension and peak-pleasurable emotions (Margulis, 2005; Meyer, 1956; Solberg, 2014; Solberg & Dibben, 2019; Solberg & Jensenius, 2017;2019).

Previous research has demonstrated that EDM break routine listening induces peak-pleasurable emotions, such as excitement (Turrell et al., 2021). The special structure of build-up passages delaying highly expected drop passages in EDM break routines can increase valenced tension, as well as magnify peak-pleasurable emotions (Solberg, 2014; Solberg & Dibben, 2019). Music tension can refer to feelings of uncertainty, conflict, and instability over emotional motifs and approaching climaxes, where there is a desire for resolution and the formation of future expectations (Farbood, 2012; Lehne & Koelsch, 2015). Specifically, even listeners not very familiar with EDM break routines likely expect drop passages to occur but may be uncertain of exactly when and how, which increases the salience of delay and uncertainty, which thereby intensifies tension (Butler, 2006; Miller, 1967; Turrell et al., 2021). This increased negative tension prior to expected drop passages can magnify peak-pleasurable emotions when expectations are fulfilled (Huron, 2006; Turrell et al., 2021). EDM break routine structures of build-up and expected drop passages can therefore evoke strong peak-pleasurable emotions.

One theory that can help explain why music structures, such as break routines, create expectations, tension, and peak-pleasurable emotions is the ITPRA model (Imagination, Tension, Prediction, Reaction, and Appraisal; Huron, 2006). Past experiences with any music type enable listeners to learn structures and thus *predict* future music motifs, which they then *imagine*. Such predictions create *tension* as the music can either violate expectations, leading to surprise, or can delay expectations, making listeners uncertain of when or how they may occur (Hunter & Schellenberg, 2010; Huron, 2006; Margulis, 2005; Meyer, 1956). When expectations are fulfilled, listeners experience decreased tension and instead feel peak-pleasurable emotions, including excitement, satisfaction, and happiness, as well as co-occurring physiological sensations, such as chills and elevated heart rate as their immediate *reaction* (Egermann & McAdams, 2013; Grewe et al., 2007; Lehne et al., 2013; Meyer, 1856; Solberg & Dibben, 2019; Steinbeis et al., 2006; Turrell et al., 2021; Zentner et al., 2008). Afterwards, listeners can *appraise* their emotive experience, learning the music's structure and refining future predictions (Huron, 2006; Solberg, 2014; Turrell et al., 2021). This suggests that break routine structures create expectancy, which results in tension that subsequently mediates peak-pleasurable emotions, such as excitement (Huron, 2006; Meyer, 1956; Turrell et al., 2021).

Tension's significant role in peak-pleasurable emotions is also potentially explained by *contrastive valence* in ITPRA (Huron, 2006). This captures the idea that greater prior tension levels lead to heightened peak-pleasurable emotions when expectations are fulfilled, as prior negative emotions, in this case tension, magnify subsequent positive experiences (Huron, 2006; Lehne & Koelsch, 2015). Thus, higher levels of and more abrupt changes in tension within build-up passages prior to expected drop passages should correlate with increased peak-pleasurable emotions, including happiness and pleasure, when expectations are fulfilled (Huron, 2006; Lehne et al., 2013; Miller, 1967). Therefore, increased tension within build-up passages prior to expected or predicted drop passages, may induce reactions of greater peak-pleasurable emotions when break routine expectations are correctly fulfilled, due to contrastive valence.

Several researchers have applied ITPRA and contrastive valence when explaining musical peak-pleasurable emotions (Lehne & Koelsch, 2015; Pearce & Wiggins, 2012). While many studies have investigated valence and arousal, only a few studies investigated the effects of music on tension (Solberg & Dibben, 2019; Turrell et al., 2021). This is particularly important as tension is a fundamental aspect of ITPRA as well as contrastive valence. Break routines provide a particularly good opportunity to assess the extent to which music structures, expectations generated by structures, and tension created from expectations affect music-evoked peak-pleasurable emotions. Therefore, this study investigated the effects of music on tension using break routines.

Furthermore, most of the prior studies required participants to respond once to each musical clip, which provides a limited understanding of effects of music on emotion. To provide a more granular measure of emotion, a few studies used continuous ratings of emotions (e.g., valence and arousal) during presentation of the music (Farbood, 2012; Krumhansl, 1997; Lehne et al, 2013; Madsen & Fredrickson, 1993; Vines et al., 2006). In this method participants are asked to indicate their felt emotions while listening to music. This provides a richer measure of felt emotion compared to a single rating. Importantly no study has investigated the continuous effect of music on tension. Therefore, the current study examined whether increased tension measured during break routines magnifies peak-pleasurable emotions from drop passages that are expected and then fulfilled.

Using a custom-built app, we measured tension levels continuously across break routines, in particular changes across build-up and drop passages, and assessed whether tension was predicted by peak-pleasurable emotions, as would presumably be derived from contrastive valence. Tension levels were measured continuously on a slider during break routine listening, and peak-pleasurable emotions ratings were once assessed using the 2-dimensional space of valence and arousal at the end of the extract, as both high positive valence and arousal are indicative of peak-pleasurable emotions. Correlations between average tension and emotional ratings were examined to assess the relationship between higher tension levels and greater peak-pleasurable emotions. Furthermore, studies have shown tension can be evoked by acoustic features and expectancy, and accompanied by a range of emotions, including happiness and fear (Krumhansl, 1997; Lehne et al., 2013). Therefore, using the same approach as in Turrell et al., 2021 we investigated the link between various acoustic features and tension.

We hypothesised that continuously rated tension would increase during build-up passages prior to highly expected drop passages and then decrease during drop passages as expectations were fulfilled. We also predicted that higher average tension levels during break routines would correlate with increased peak-pleasurable emotion ratings.

3 Method

3.1 Participants

Data for thirty-four participants were included in the analysis (31 females, age range 17-32, *M(SD)* = 19.21(1.30)), which is in line with past research on this topic (Turrell et al., 2021) (for details of the participants please see the Supplementary document). Participants ranged in musical experience from not playing an instrument to 9 or more years of playing (*M(SD)* = 2.80(2.04); *Mdn* = 0-1 years) and the average rating (on the scale 1 “never heard” to 4 “often heard”) of how often they listened to EDM was *M(SD)* = 3.18(0.67); *Mdn* = 3; and to break routines was *M(SD)* = 3.15(0.70); *Mdn* = 3. Participants were required to have normal or corrected to normal vision and hearing, as well as have access to earphones or headphones, and an iPhone or Android mobile device to run the study paradigm. The protocol of the study was approved by the ethics committee at the University of Kent and participants gave written informed consent in accordance with the Declaration of Helsinki.

3.2 Stimuli

Sixty EDM break routine clips were selected from a collection of 90 used in previous studies, including a range of EDM genres, such as Dub-step, House, and Trance (Turrell et al., 2021). The structure of the EDM break routines was taken from our past research Turrell et al (2021) (see also Solberg & Dibben (2019)) with 16s of breakdown and build-up and 6s of drop. Durations of EDM break routines varied between 18-22s with the moment of drop passages being between 12-16s and lasting 6s (see Supplementary Figure 1). The 4s jitter was added to avoid habituation to the drop happening at a particular time and did not extend the stimuli for an unreasonable time.

To investigate the relationships between musical features and subjective ratings the break routine clips were imported and analysed via the MIR toolbox (Lartillot, Toiviainen, & Eerola, 2008) for MATLAB. We extracted acoustic features related to dynamics (audio and global energy (RMS)), timbre (spectral flux, brightness and roughness), statistics (power spectrum), rhythm (beat clarity), and tonality (mode) (Solberg & Dibben, 2019).

3.3 Tension & Emotion Recording

A continuous tension rating scale was used to record levels of felt tension throughout the break routine clips. It consisted of a horizontal scale, ranging from low tension (left) to high tension (right; see Figure 1a). Participants responded using one finger from their dominant hand to slide over the screen in response to their experienced tension levels as they listened to each break routine clip. Participants were required to put their finger on the middle of the scale at the beginning of each trial. They were instructed to keep their finger touching the screen throughout while indicating their felt tension. Finger movements to the right corresponded with an increase in tension, with maximum levels at the furthest right, and vice versa with low tension on the left. Participants were encouraged to use the full range of the scale and keep their finger steady if they felt no alterations in tension levels. The continuous tension ratings were measured at a sampling rate of 60 per second.

(a)

(b)

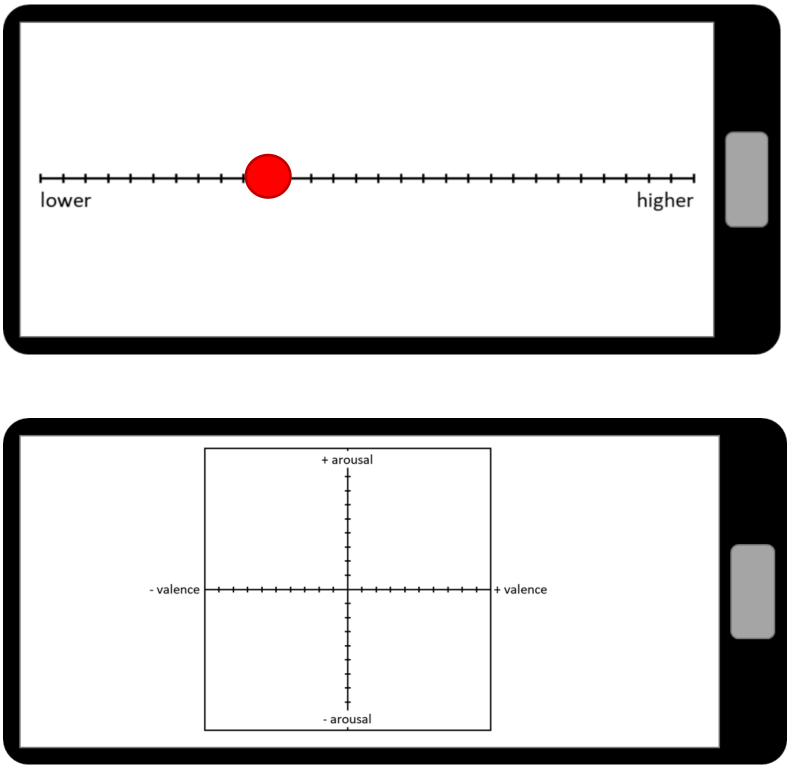

Figure 1. The custom-made software developed for iPhone and Android devices. (a) The continuous tension rating scale as displayed on participants mobile devices. The red dot appeared in the location where participants placed their finger to respond. (b) The 2-dimensional space of valence and arousal as displayed on participants' mobile devices.

The 2-dimensional space of valence (the positivity or negativity of a feeling) and arousal (the alertness/stimulation of a feeling) was presented after each break routine clip, as soon as participants removed their finger from the continuous tension rating scale. Valence was on the horizontal axis and arousal on the vertical axis, both ranging from -100 to 100 as maximum scores around the outer edges of the space and 0 being the central point (see Figure 1b). Participants would then tap where in the 2-dimensional space represented how they felt during listening to the break routine clip. Participants were instructed to answer as quickly as possible within 5s. Trials with no answer on this screen were removed from the analysis. Less than 2% of the trials were required to be removed based on no response.

3.4 Procedure

The study was conducted online: The instructions were delivered via video conference calling and participants used their smartphone to respond. The web service Pavlovia was used to deliver the task online. Participants were asked to use either earphones or headphones. At the beginning of the study, they were presented with a sample song for them to adjust their volume. They had the chance to replay the music if they did not hear the song or needed to readjust the volume. Each trial began with a 5s fixation cross, followed by a break routine clip. During the clip, participants continuously rated their felt levels of tension using their finger. They were told that “Tension can be defined as emotional or mental strain or a sense of apprehension and anticipation”. Following that, participants indicated their felt valence and arousal on the 2-dimentional space (see Figure 2). They were told that “Valence, on the horizontal axes, refers to how positive or negative you felt. Arousal, on the vertical axes refers to how stimulated/alert or unstimulated/not alert you felt”. Stimuli were randomly presented in two blocks with a minimum 30s break in between allowing participants to take as much rest as they need to. All participants listened to all 60 clips.

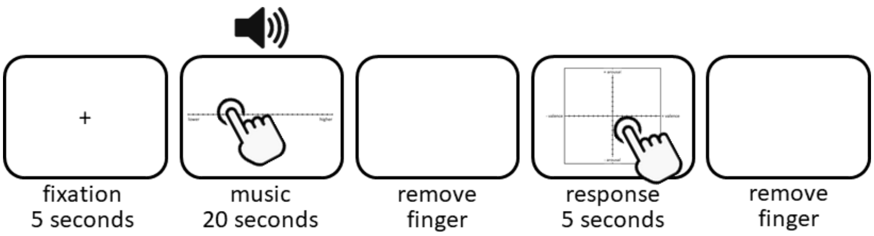

Figure 2. Visual representation of each trial in the music paradigm with the fixation cross, break routine clip and continuous tension rating scale, and 2-dimensional response grid.

3.5 Analysis

To achieve ratings with similar durations across all clips, the continuous tension responses with 18-22 seconds duration were scaled and shifted to have exactly 20 seconds duration, with the beginning time of drop passages at 14 seconds. Following methods used by past researchers (Farbood, 2012; Krumhansl, 1996; Lehne & Koelsch, 2015), participants' individual tension responses on the continuous slider rating scale were recorded. These ratings were averaged across participants over the time course of each break routine clip to extract a profile tension rating for each of the 60 clips across time. Valence and arousal ratings were also recorded and averaged for each break routine clip, which were then also used to calculate emotional strength (amplitude values) and emotional response (angle values; see Figure 3) ratings and averages. Emotional *strength* was a number between zero and 100×√2, with 100×√2 being the strongest feeling on the outer four corners of the response screen. The emotional *responses* were angles between 0 and 360°, with the right middle being zero, the top middle being +90°, the left middle being +180°, and finally the bottom middle being +270° (Figure 3). For example, excitement would have an emotional response angle of around 45°.

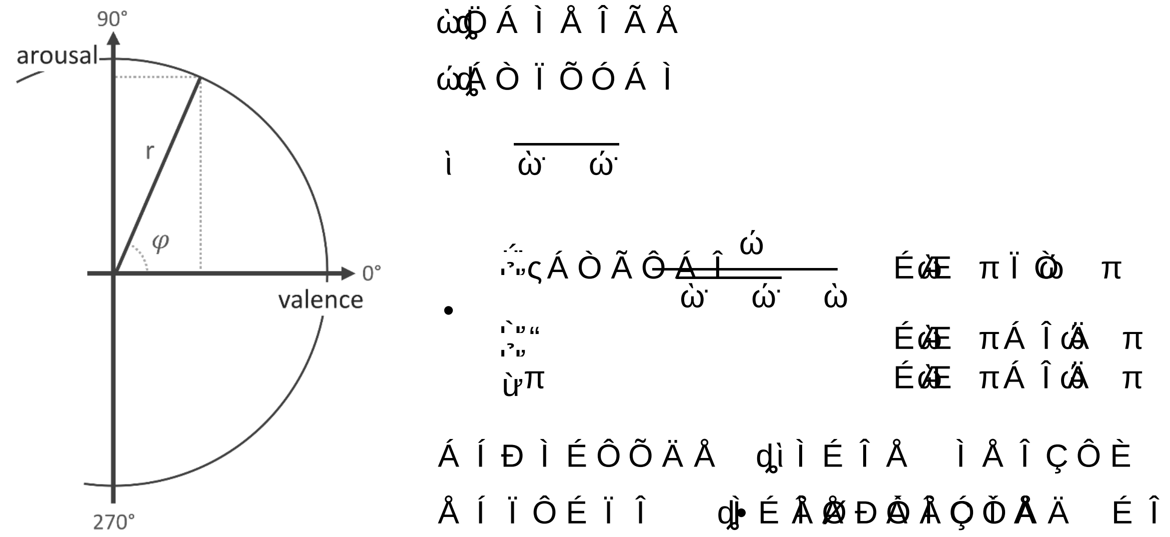

Figure 3. Calculation of emotional strength (amplitude) and emotional response (angle) based on polar analysis of valence and arousal. Emotional strength is a value between [illegible] and emotional response is a value between 0 and 360°.

To assess how tension ratings changed over break routine time, three Spearman's rho correlations between median tension ratings (see samples shown in Figure 3) and time (whole break routine, 0-14s, and 14-20s) were run to assess the relationship between changes in tension and break routine segments. However, sudden changes in tension may be missed by correlations. Therefore four Wilcoxon signed-rank tests were conducted on tension ratings: (1) comparing average tension ratings for 1s at the beginning of break routines (0-1s) and 1s at the end of build-up passages (13-14s), (2) comparing average tension scores from the last second of build-up passages (13-14s) with the first second of drop passages (14-15s), (3) comparing tension ratings at the first second of drop passages (14-15s) with the last second of break routines (19-20s), and (4) comparing average tension ratings at the first (0-1s) and last second of break routines (19-20s).

To examine whether higher tension ratings were correlated with greater peak-pleasurable emotions, four Spearman's Rho correlations between average tension ratings across the whole 20s of clips, and valence, arousal, emotional strength, and emotional response ratings were conducted. False discovery rate (FDR) correction for multiple comparison was used (Benjamini & Hochberg, 1995; Finner & Roters, 2001).

3.6 Access to Stimuli and Data

For a full list of songs used to create break routine clips and their details, see the associated data via DOI link https://doi.org/10.17605/OSF.IO/YS3QD. Data can be requested from the corresponding author.

4 Results

4.1 Tension Graphs

Each participant's tension response to each break routine was shifted to begin from 0s. Individual and median continuous tension ratings were plotted on axes of minimum tension (-100) to maximum tension (100) by time (0-20s) for each break routine (see Figure 4 for examples of higher and lower individual and median tension ratings).

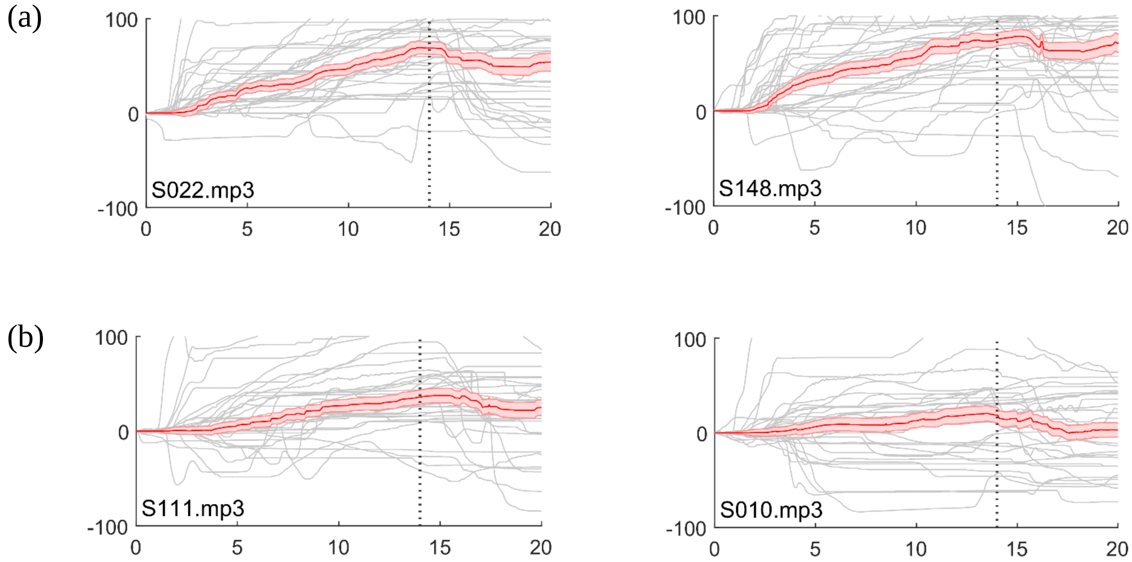

Figure 4. Participants' individual and median continuous tension ratings for four example break routines: a) two break routines with higher median tension ratings and b) two break routines with lower median tension ratings. Grey lines represent individual tension ratings. The solid red line represents median tension ratings across each break routine and the red shading shows standard error of the mean. The vertical dotted line indicates the beginning time of drop passages at 14s.

The median of all tension ratings for all break routines were plotted as an overall visual representation of how tension levels changed across break routine build-up and drop passages. This showed a steady increase in tension ratings during build-up passages to a peak moment at the beginning of drop passages (around 14-15s) followed by a slight reduction (see Figure 5 and Figure 6).

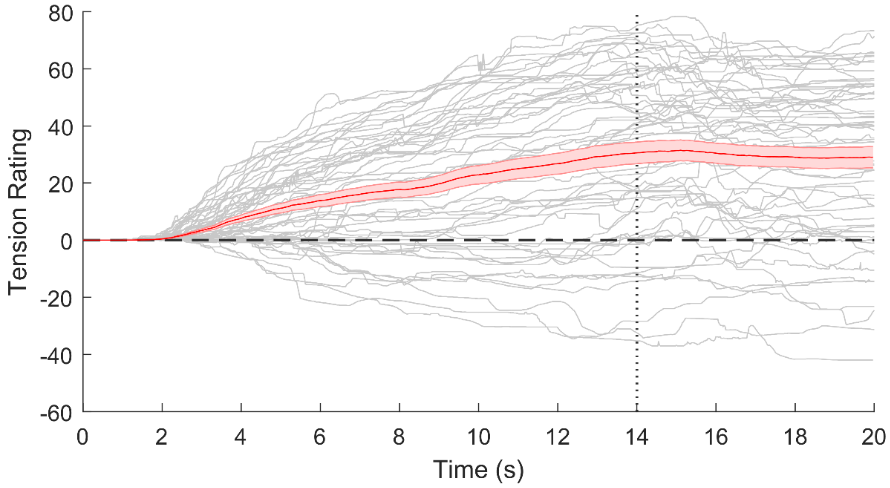

Figure 5. Median continuous tension ratings across and break routines. Grey lines show tension ratings for each clip. The solid red line represents median tension ratings and the red shading refers to standard error of the mean. The vertical dotted line indicates the beginning time of drop passages during break routines (14s).

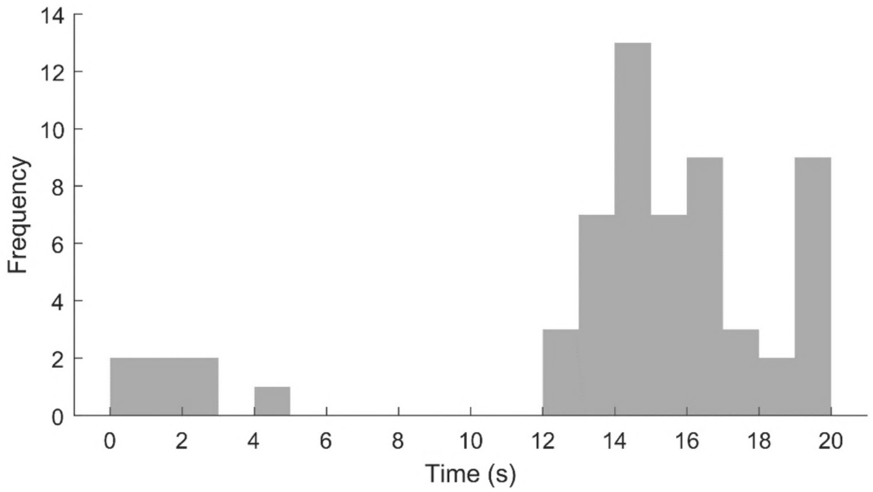

Figure 6. Frequency of peak median tension ratings across the time of break routines. This plot shows that the peak tension rating was around 14s, where the drop passage began.

4.2 Tension and Time

Continuous measures of tension ratings (as shown in Figure 5) significantly correlated with break routine time, $r_s(1198) = 0.942$, $p < 0.001$ (60 samples/second × 20 seconds = 1,200 samples), suggesting that tension ratings increased over the course of break routines. Results showed a significant positive correlation between tension and time during build-up passages (the first 14s) ($r_s(838) = 0.998$, $p < 0.001$) and a significant negative correlation between tension and time within drop passages (the last 6s) ($r_s(358) = -0.853$, $p < 0.001$). These results supported our hypothesis that tension would increase during build-up passages and then decrease within drop passages as musical expectations are fulfilled.

Non-parametric Wilcoxon tests enabled the comparison of average tension ratings at significant time points during break routine structures. Average tension ratings for 1s segments at the beginning, the last part of build-up passages, the start of drop passages, and at the end were compared. Results showed that average tension ratings at the beginning of break routines (always as 0 on the tension scale) were significantly lower than tension ratings at the end of build-up passages and at the end of break routines (see Table 1 and Figure 7). This confirmed that tension ratings changed from 0 during break routines and showed that tension increased within build-up passages.

Average tension ratings also increased significantly between the end of build-up passages and the beginning of drop passages (see Table 1 and Figure 7). Average tension ratings decreased between the start of drop passages and break routine endings but not significantly after FDR correction, suggesting less of a reduction or release in tension during drop passages (Table 1 and Figure 7).

Table 1. Results from Wilcoxon signed-rank tests comparing tension ratings at different time points during break routines

Comparison	***Z***	***p***
Beginning vs Build-up	-5.54	<.001**
Build-up vs Drop	-2.40	.016*
Drop vs Ending	1.96	.050[†]
Beginning vs Ending	-5.54	<.001**

Notes. Beginning: the first second of break routines (0-1s); Build-up: the last second of build-up passages (13-14s); Drop: the first second of drop passages (14-15s); Ending: the last second of break routines (19-20s); [†]: effect no longer significant after FDR correction for multiple comparison; * $p \leq .05$; ** $p < .001$.

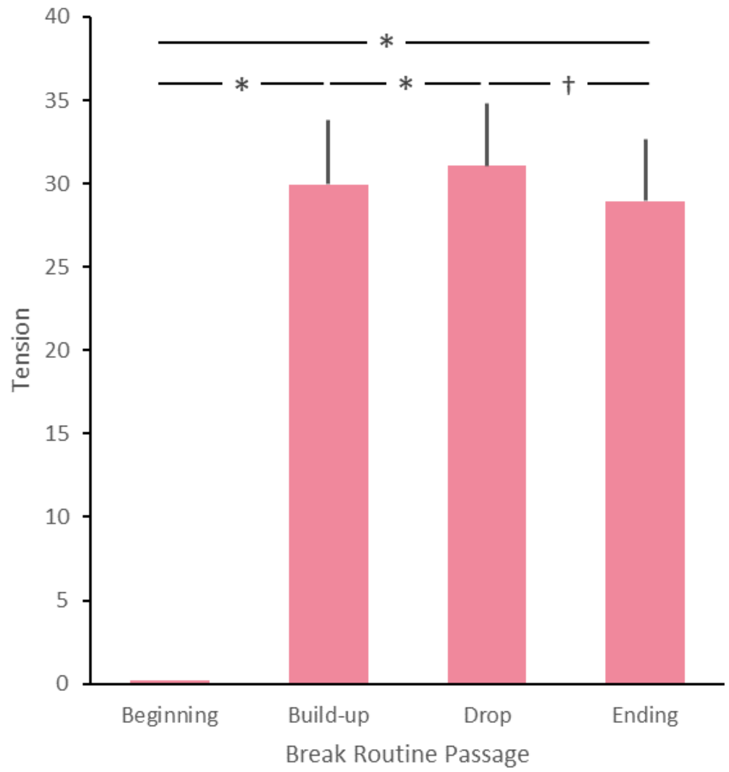

Figure 7. Bar chart of average tension ratings for the 1s segment of each break routine passage; Beginning: the first second of break routines; Build-up: the last second of build-up passages; Drop: the first second of drop passages; Ending: the last second of break routines. Error bars represent one standard error (SEM); † effect no longer significant after FDR correction for multiple comparison; * $p \leq .05$, ** $p < .001$

4.3 Tension and Peak-Pleasurable Emotions

Correlations between average tension ratings with peak-pleasurable emotion dimension ratings (valence, arousal, emotional strength, and emotional response) indicated that tension levels were linked to rated emotions (see Table 2). Tension correlated positively with arousal, emotional strength, and emotional response ratings. However, tension correlated negatively with valence ratings, indicating the higher tension predicted stronger but more negative emotions.

Furthermore, to check for possible associations between subjective ratings of tension and musical features, we carried out correlational analyses between subjective ratings and acoustic features in the break routine clips (see Table 2). Results of the analyses indicated no significant correlations between the ratings of tension and any of the acoustic features.

Table 2. Correlations between average tension ratings during break routines with peak-pleasurable emotion dimension ratings (valence, arousal, emotional strength, and emotional response) and various acoustic features

		Average Tension	
Category	**Measure**	**r_s**	***p***
Emotion Ratings	Valence	$r_s(58) = -.69$	<.001**
	Arousal	$r_s(58) = .92$	<.001**
	Emotional Strength	$r_s(58) = .62$	<.001**
	Emotional Response	$r_s(58) = .91$	<.001**
Acoustic Features	Audio	$r_s(58) = -.14$	0.271
	Global Energy (RMS)	$r_s(58) = -.13$	0.289
	Spectral Flux	$r_s(58) = -.10$	0.409
	Brightness	$r_s(44) = .21$	0.162
	Roughness	$r_s(58) < .01$	0.954
	Spectrum	$r_s(58) = .02$	0.859
	Beat Clarity	$r_s(58) = .06$	0.613
	Mode	$r_s(58) = .19$	0.126

Notes. Brightness could not be calculated for some of the songs; r_s: Spearman's Rho coefficient; ** p<.001.

4.4 Post-hoc Correlations between Break Routines

Further Spearman's rho correlations assessed whether previous break routines had a cumulative influence on subsequent break routines for tension, valence, arousal, emotional strength, and emotional response. Correlations were run between average tension ratings at the last second of previous break routines and the first second of subsequent break routines. Results indicated that prior ratings did not influence ratings in subsequent break routines, as indicated by small correlation coefficients and insignificant *p* values (see Table 3).

Table 3. Correlations between the last second of previous break routines and the first second of subsequent break routines for emotion ratings (tension, valence, arousal, emotional strength, and emotional response)

Emotion Ratings	**r_s(58)**	***p***
Tension	0.18	.177
Valence	<.001	.998
Arousal	0.16	.232
Emotional Strength	0.26	.047[†]
Emotional Response	0.18	.182

Notes. r_s: Spearman’s Rho coefficient; [†]: effect no longer significant after FDR correction for multiple comparisons.

5 Discussion

This study offered a novel exploration of tension and peak-pleasurable emotions during electronic dance music (EDM) break routines. Continuous tension ratings showed tension increased during build-up passages prior to highly expected drop passages, then decreased as expected drop passages were correctly fulfilled. Greater average tension positively correlated with arousal, emotional strength, and emotional response ratings, but negatively correlated with valence after each break routine. This suggested that higher tension during break routines correlated with stronger negative emotions, rather than peak-pleasurable emotions (as indicated by greater arousal, emotional strength, emotional response, and lower valence ratings; Eerola & Vuoskoski, 2012; Russell, 1980; Salimpoor et al., 2009; Salimpoor et al., 2011). Therefore, tension changed across break routine structures as predicted but effects of increased and decreased tension across break routines on peak-pleasurable emotions were contradictory to contrastive valence.

5.1 Tension during break routines

This study demonstrated that tension levels altered around break routine expectations in tension resolution patterns, such as tension curves. These suggest an optimal pattern of tension is created from musical expectations, with increased tension alongside greater anticipation and uncertainty prior to expected musical events, such as EDM break routines (Huron, 2006; Koelsch et al., 2019). Greater tension is accompanied by an increased desire to complete the tension curve by decreasing and releasing tension when expected music events finally occur (Eerola & Vuoskoski, 2011; Sloboda & Juslin, 2001; Vines et al., 2005; You et al., 2021). Tension curves that are fully resolved, with equal increases and decreases in tension, can then evoke peak-pleasurable emotions, such as reward, pleasure, and liking (Lehne & Koelsch, 2014; Lehne & Koelsch, 2015; Steinbeis & Koelsch, 2008). This suggests that the elevated uncertainty created during the build-up passage of the break routine in the current study increased tension. Subsequently, the anticipation or desire to resolve tension intensified tension levels through expected drop passages.

However, average tension ratings during break routines suggested a continued increase in tension between build-up and subsequent drop passages, contradicting the assumption that fulfilled music expectations would decrease tension. The increased tension seemed to only occur for the first few seconds of drop passages, indicating a possible postponed decrease in tension when processing fulfilled expectations. Delays of anywhere from 3 and 8s can occur between music processing, emotional experiences such as tension, and the actual occurrence of behavioral responses (Kim et al., 2010; Krumhansl, 1996; Schubert & Dunsmuir, 1999; Sloboda and Lehmann, 2001). Thus, decreased tension from the fulfilment of expected drop passages was not represented in average tension values taken from 1s into drop passages. However, decreased tension during drop passages, as reflected by correlations between tension and time, alongside median tension plots, did occur but after a delay of around 2-3s.

5.2 Tension and Peak-Pleasurable Emotions

5.2.1 Arousal

Based on Table 2, higher average tension correlated with greater arousal ratings during break routines. Previous research suggests tension and arousal are similar constructs, some indicating that tension is equivalent to arousal. They are often used to describe or assess one another, such as ‘tension arousal’ and measuring muscle tension as an indication of arousal (Dillman Carpentier et al., 2007; Eerola et al., 2012; Granot & Eitan, 2011; Huron, 2006; Kruhmansl, 1997; Rickard 2004; Rozin et al., 2004; Trolio, 1976). Tension is often considered a sub-emotion of arousal, meaning greater tension always co-occurs with increased arousal but high arousal may not always occur with greater tension (Lehne & Koelsch, 2015; Trost et al., 2012). Highly significant correlations found here between tension and arousal could therefore have derived from tension being a sub-emotion of arousal, suggesting they increased simultaneously during break routines, rather than greater tension influencing arousal.

The hierarchical organization of acoustic features and break routine structure can similarly evoke arousal and tension (Butler, 2006; Meyer, 1956; Schäfer & Sedlmeier, 2011; Solberg, 2014; Turrell et al., 2021). Acoustic features present during EDM break routines, such as fast pace, faster tempo, higher timbral roughness, and greater loudness induce higher arousal and tension during music (Dean et al., 2011; Dillman Carpentier et al., 2007; Droit-Volet et al., 2013; Farbood & Price, 2017; Granot & Eitan, 2011). Such features can have a cumulative and interactive effect on arousal alongside break routine structures of delay and uncertainty prior to highly expected drop passages, enabling moments of tension and release (Butler, 2006; Farbood, 2012; Lehne et al., 2013; Lehne & Koelsh, 2015; Robinson, 1994). Our analysis, however, showed no significant correlation between the tension ratings and various acoustic features. Therefore, the strong correlation between tension and arousal ratings was not due to low-level acoustic features and break routine structure.

5.2.2 Emotional strength

Another peak-pleasurable emotion dimension that closely links with tension, and is sometimes interchangeable with it, is the calculated emotional strength (amplitude values; Luck et al., 2008; Vuoskoski & Eerola, 2011). Tension and emotional strength often simultaneously increase during music and mediate music-evoked emotions (Hallam et al., 2011; Juslin & Sloboda, 2011; Rickard, 2004; Rozin & Rozin, 2008). Emotional strength increases according to acoustic features, such as loudness, roughness, beat clarity, and spectral flux which combine into temporal music structures and often intensify during break routine build-up passages (Luck et al., 2008; Roda et al., 2014; Solberg, 2014; Turrell et al., 2021). Music expectancy also links to emotional strength. This is akin to the scenario where the tension in anticipation of forthcoming key moments is intensified if the expected peak pleasure from fulfilling those expectations is greater (Lehne & Koelsch, 2015; Steinbeis et al., 2006; Turrell et al., 2021). This suggests that emotional strength and tension are comparable and occurred simultaneously during break routine passages, rather than representing peak-pleasurable emotions mediated from greater tension within break routines due to contrastive valence.

5.2.3 Emotional Response

The combination of valence and arousal to create emotional response, referring to the angle of ratings within the 2-dimensional space, also correlated with tension. Combinations of high arousal and positive valence represent emotions such as happiness and excitement, which appear in the top right quadrant of the 2-dimensional emotional space. Combinations of high arousal and negative valence like anger and tension, appear in the top left quadrant of the emotional space (Eerola & Vuoskoski, 2012; Hunter & Schellenberg, 2010; Remington et al., 2000; Russell, 1980). Greater tension during break routines shifted the angle of emotional responses to areas measuring higher arousal and valence but more likely corresponded to emotions with high arousal and greater negative valence, including tension and intensity (Cohrdes et al., 2017; Greenberg et al., 2015; Remington et al., 2000; Russell, 1980). Therefore, increased angles of emotional response ratings could suggest higher feelings of tension after break routines, rather than predicted peak-pleasurable emotions mediated by tension and fulfilled expected drop passages (Butler, 2006; Huron, 2006).

5.2.4 Valence

Higher tension during break routines correlated with greater negative valence ratings, suggesting that higher tension does not always lead to peak-pleasurable emotions (Eerola & Vuoskoski, 2011; Garrido & Schubert, 2011). Break routine clips, compared to other genres of music, may have been more skewed to the perception of tension than peak-pleasurable emotions, like excitement, as they mostly included tension intensifying build-up passages (0-14s; Butler, 2006; Lehne & Koelsch, 2015; Meyer, 1956; Solberg, 2014). However, drop passages, where peak-pleasurable emotions were proposed to be experienced, were shorter (14-20s; Butler, 2006; Solberg, 2014). Longer times listening to build-up passages, as well as participants rating how they felt during break routine listening, may have negatively skewed valence ratings, as participants predominately felt increasing tension. Therefore, negative valence ratings at the end of break routine clips may have correlated with tension levels due to them both measuring tension during break routine listening, instead of peak-pleasurable emotions mediated by this tension. To investigate this, future studies could look at varying the duration of different sections of break routine (i.e., breakdown, build-up and drop) as well as asking participants to rate their tension only during certain sections of the music.

Also, shorter drop passages may have prevented tension curves from being fully resolved and tension completely released. Researchers have suggested that for music tension to evoke peak-pleasurable emotions, tension curves need to be fully completed with equal amounts of increased and decreased tension before and after expected music events (Koelsch, 2014; Sun et al., 2020a; Vines et al., 2005). When tension curves are not completed after fulfilled music expectations, the full sense of resolution and negative emotions are less likely to occur, such as further tension and anticipation (Lehne & Koelsch, 2015; Meyer, 1956; Sun et al., 2020a; Vines et al., 2005). Break routine clips used here may have not enabled the full completion of tension curves due to shorter drop passages, resulting in the continued experience of tension after break routine clips, and impeding peak-pleasurable emotions. Therefore, to investigate this further, break routine clips could be developed to control for duration of different sections of the clip, in particular drop passages.

5.3 Future directions

Not all tension ratings followed tension resolution patterns (increases during build-up passages and decreases in drop passages) as some break routines had negative tension values, indicating listeners decreased tension ratings during build-up passages. This suggests that sustained tension from previous break routines may have influenced ratings of later clips, making participants begin tension ratings in the middle of the continuous tension rating scale. However, post-hoc correlations between previous and subsequent break routine ratings indicated no significant relationships between tension or other emotional dimensions. Thus, higher starting tension ratings may have occurred due to other tension-inducing factors, such as anticipation for the next break routine clip, as well as other music elements present during break routines, including acoustic features (Farbood et al., 2012; Huron, 2006; Ilie & Thompson, 2006; Lehne et al., 2013). Future research could assess how tension levels are affected at the beginning of, across, and between break routines, using different stimuli such as silence or various music passages, like longer EDM break routine clips with equal times of build-up and drop passages or whole EDM tracks (Solberg & Dibben, 2019; Solberg & Jensenius, 2017).

While tension was continuously recorded throughout break routines, peak-pleasurable emotion dimensions of valence, arousal, emotional strength, and emotional response were measured after each break routine clip. This makes fully understanding the relationship between tension and peak-pleasurable emotions during break routines more difficult, as emotional dimension ratings were completed post hoc. Future research could apply continuous measures of peak-pleasurable emotions, such as repeated 2-dimensional ratings, continuous sliders, or physiological measures (including heart rate and skin conductance) so relationships between changing tension and emotional dimensions can be assessed throughout break routines, (Egermann et al., 2013; Rickard, 2004; Salimpoor et al., 2009; Schubert, 2013; Soleymani et al., 2011).

6 Open Practices Statement

Associated data can be accessed via DOI link https://doi.org/10.17605/OSF.IO/YS3QD.

7 Disclosure of interest

The authors report no conflict of interest.

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