Proceedings of the 3rd International Conference on Music & Emotion (ICME3), Jyväskylä, Finland, 11th - 15th June 2013. Geoff Luck & Olivier Brabant (Eds.)

INVESTIGATING RELATIONSHIPS BETWEEN MUSIC, EMOTIONS, PERSONALITY, AND MUSIC-INDUCED MOVEMENT

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Abstract

Listening to music makes us to move in various ways. The characteristics of these movements can be affected by several aspects, such as individual factors, musical features, or the emotional content of the music. In a study in which we presented 60 individuals with 30 musical stimuli representing different genres of popular music and recorded their movement with an optical motion capture system, we found significant correlations 1) between musical characteristics and the exhibited movement, 2) between the perceived emotional content of the music and the movement, and 3) between personality traits of the dancers and the movement. However, such separate analyses are incapable of investigating possible relationships between the different aspects. We describe two multivariate analysis approaches – mediation and moderation – that enable the simultaneous analysis of relationships between more than two variables. The results of these analyses suggest mediation effects of the perceived emotional content of music on the relationships between different features of music and movement. It can therefore be assumed that musical emotions can (partly) account for the effect of music on movements. However, using personality as moderator between music and movement failed to show a moderation effect in most cases, suggesting that personality does not generally affect existing relationships between music and movement. Hence it can be assumed that musical characteristics and personality are independent factors in relation to music-induced movement.

Keywords: music-induced movement, multivariate statistics, emotion

1. Introduction

Music makes us move. While listening to music, we often spontaneously move our bodies. Keller and Rieger (2009), for example, stated that simply listening to music can induce movement, and Lesaffre et al. (2008) conducted a self-report study, in which most participants reported moving when listening to music. Janata, Tomic, and Haberman (2012) asked participants to tap to music and found that participants not only moved the finger/hand, but also other body parts, such as feet and head. In general, people tend to move to music in an organized way by, for example, rhythmically synchronizing with the pulse of the music by tapping their foot, nodding their head, moving their whole body, or mimicking instrumentalists' gestures (Godøy, Haga, & Jensenius, 2006; Leman & Godøy, 2010). Moreover, Leman (2007:96) suggests, "Spontaneous movements [to music] may be closely related to predictions of local bursts of energy in the musical audio stream, in particular to the beat and the rhythm patterns". Such utilization of the body is the core concept of embodied cognition, which claims that the body is involved in or even required for cognitive processes (e.g., Lakoff & Johnson, 1980, 1999; Varela, Thompson, & Rosch, 1991). Human cognition is thus highly influenced by the interaction between mind/brain, sensorimotor capabilities, body, and environment. Following this, we can approach musical engagement by linking our perception of it to our body movement (Leman, 2007). One could postulate that our bodily movements reflect, imitate, or help understanding the structure and content of music. Leman suggests that corporeal involvement could be influenced by three (coexisting) components or concepts: "Synchronization", "Embodied Attuning", and "Empathy", which differ in the degree of musical involvement and in the kind of action-perception couplings. "Synchronization" constitutes the fundamental component: synchronizing to a beat, the basic musical element. The second component, "Embodied Attuning", concerns the linkage of body movement to musical features, such as melody, harmony, rhythm, or timbre. Following this idea, movement could be used to reflect, parse, and navigate within the musical structure. Finally, "Empathy" links musical features to expressivity and emotions, so the listener would feel the emotions expressed in the music and reflect them by using body movement.

A few studies have investigated music-induced movement and suggested several factors to affect the characteristics of such movements: Relationships have been found with individual factors, such as personality (Luck, Saarikallio, Burger, Thompson, & Toiviainen, 2010) or mood (Saarikallio, Luck, Burger, Thompson, & Toiviainen, 2013), as well as with musical features, such as pulse clarity and rhythmic strength (Burger, Thompson, Luck, Saarikallio, & Toiviainen, 2012; Burger, Thompson, Saarikallio, Luck, & Toiviainen, 2013) or the presence of the bass drum (Van Dyck et al., 2013). Besides such factors, the emotional content of the music was found to be related to music-induced movement as well (Burger, Saarikallio, Luck, Thompson, & Toiviainen, 2013).

So far, these different aspects have only been studied separately. However, among them there might be relationships that separate analyses would be incapable of revealing. One variable, the emotional content of the music, for example, could account for the relationship between music and movement, in other words the music would have an indirect relationship with the movement by influencing the emotional expression, which then influences the movement. In this case, the emotional content would act as a so-called mediator variable (Baron & Kenny, 1986; Hayes, 2009; Preacher, Rucker, & Hayes, 2007). Besides or in addition to such an association, another variable, the personality of the dancer for example, could change the effect of the music on the movement. Personality would then act as a so-called moderator variable (Baron & Kenny, 1986; Preacher et al., 2007).

To explore possible relationships between musical features, perceived emotions in music, personality, and music-induced movement, we conducted a motion capture study to connect the different aspects chosen earlier (separate analyses described in Burger, Saarikallio, et al., 2013; Burger, Thompson, et al., 2013; Luck et al., 2010). Therefore, we reviewed recent statistical approaches in the field of multivariate statistics and found mediation and moderation analysis an interesting and potentially useful approach for our inquiry. This paper will first describe the design of the study and then focus on the proposed analysis methods.

2. Method

2.1. Participants

A total of 60 participants took part in this experiment (43 females; average age: 24, SD: 3.3). They were recruited based on a database of 952 individuals containing their scores of the Big Five Inventory (John, Naumann, & Soto, 2008), a 44-item instrument measuring the five primary personality dimensions (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism). We aimed at high- and low-scoring individuals for each of the five dimensions to participate in this study. Participants were rewarded with a movie ticket.

2.2. Stimuli

Participants were presented with 30 randomly ordered musical stimuli representing the following popular music genres: Techno, Pop, Rock, Latin, Funk, and Jazz. All stimuli were 30 seconds long, non-vocal, and in 4/4 time, but differed in their rhythmic complexity, pulse clarity, and tempo, and in their perceived emotional content. The emotional content was assessed in a perceptual experiment, in which 34 participants rated the emotions expressed in the music on scales for happiness, anger, sadness, tenderness, arousal, and valence (for a detailed description of this experiment, see Burger, Saarikallio, et al., 2013).

2.3. Apparatus

Participants' movements were recorded using an eight-camera optical motion capture system (Qualisys ProReflex) tracking, at a frame rate of 120 Hz, the three-dimensional positions of 28 reflective markers attached to each participant. The locations of the markers are shown in Figure 1a, and can be described as follows (L = left, R = right, F = front, B = back): 1: LF head; 2: RF head; 3: LB head; 4: RB head; 5: L shoulder; 6: R shoulder; 7: sternum; 8: spine (T5); 9: LF hip; 10: RF hip; 11: LB hip; 12: RB hip; 13: L elbow; 14: R elbow; 15: L wrist/radius; 16: L wrist/ulna; 17: R wrist/radius; 18: R wrist/ulna; 19: L middle finger; 20: R middle finger; 21: L knee; 22: R knee; 23: L ankle; 24: R ankle; 25: L heel; 26: R heel; 27: L big toe; 28: R big toe. The musical stimuli were played back via a pair of Genelec 8030A loudspeakers using a Max/MSP patch running on an Apple computer.

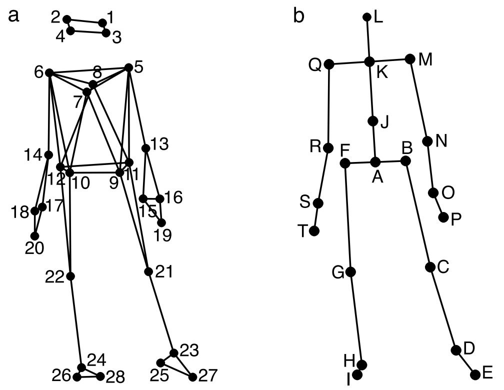

Figure 1. (a) Anterior view of the location of the markers attached to the participants' bodies; (b) Anterior view of the locations of the secondary markers/joints used in the analysis.

2.4. Procedure

Participants were recorded individually and were asked to move to the stimuli in a way that felt natural. Additionally, they were encouraged to dance if they wanted to, but were requested to remain in the center of the capture space indicated by a 115 x 200 cm carpet.

2.5. Movement feature extraction

In order to extract various kinematic features, the MATLAB Motion Capture (MoCap) Toolbox (Toiviainen & Burger, 2013) was used to first trim the data to the duration of each stimulus. Following this, a set of 20 secondary markers was derived – subsequently referred to as joints – from the original 28 markers to reduce marker redundancy. The locations of these 20 joints are depicted in Figure 1b. The locations of joints C, D, E, G, H, I, M, N, P, Q, R, and T are identical to the locations of one of the original markers, while the locations of the remaining joints were obtained by averaging the locations of two or more markers; joint A: midpoint of the four hip markers; B: midpoint of markers 9 and 11 (left hip); F: midpoint of markers 10 and 12 (right hip); J: midpoint of sternum, spine, and the hip markers (midtorso); K: midpoint of shoulder markers (manubrium), L: midpoint of the four head markers (head); O: midpoint of the two left wrist markers (left wrist); S: midpoint of the two right wrist markers (right wrist). From the three-dimensional joint position data, instantaneous velocity and acceleration were estimated using numerical differentiation based on the Savitzky-Golay smoothing FIR filter (Savitzky & Golay, 1964) with a window length of seven samples and a polynomial order of two. These values were found to provide an optimal combination of precision and smoothness in the time derivatives. Subsequently, the data was transformed into a local coordinate system, in which joint A was located at the origin, and segment BF had zero azimuth. From these data, various movement features were extracted, with six being used in the present analysis:

- Magnitude of Head Speed (Joints L).
- Magnitude of Hand Speed (Joints P & T).
- Magnitude of Head Acceleration (Joint L).
- Magnitude of Hand Acceleration (Joints P & T).
- Fluidity: overall movement fluidity (smoothness) measure based on the ratio of velocity to acceleration. The combina-

tion of high velocity and low acceleration reflects fluid movement, whereas the combination of low velocity and high acceleration reflects non-fluid movement.

- Rotation Range: amount of rotation of the body (Joints M & Q) around the vertical axis.

2.6. Musical feature extraction

In order to quantitatively describe the musical content of our stimuli, we performed computational feature extraction analysis of the stimuli used in the experiment. To this end, various musical features were extracted from the stimuli using the MATLAB MIRToolbox (version 1.4) (Lartillot & Toiviainen, 2007), with six being used in the present analysis.

- Spectral Flux of Sub-band 2: indicates the extent to which the spectrum of the frequency band between 50 and 100 Hz changes over time. This feature thus measures the flux in the low frequencies, usually produced by kick drum and bass guitar. For the calculation see Alluri and Toiviainen (2010) and Burger, Saarikallio, et al. (2013).
- Spectral Flux of Sub-band 9: based on the same calculation as spectral flux of sub-band 2, except for the frequency band ranging from 6400 to 12800 Hz. Thus, this feature measures the flux of the high frequencies, usually produced by hihats or cymbals.
- Attack Time: time of the attack at note onsets. The shorter the time, the sharper and more percussive the sound.
- Number of Onsets: sum of note onsets detected in the stimulus. A high number of onsets is related to a high sound density.
- Low Energy: the proportion of time during which the sound (RMS) energy is below the average RMS energy. Vocal music with silences, for instance, will have high values, whereas continuous strings have low values of low energy (Tzanetakis & Cook, 2002).
- Spectral Centroid: geometric center of the amplitude spectrum. It is commonly associated with musical timbre, in particular with brightness (McAdams, Winsberg, Donnadieu, Soete, & Krimphoff, 1995).

All features apart from the number of onsets resulted in time-series, subsequently being averaged to obtain one value per stimulus.

3. Results

3.1. Emotion as mediator

In Figure 2, two models of relationships between variables are depicted: the total-effect model and the mediation model. The total effect is the effect of an independent variable on a dependent variable, whereas a mediator is a variable that accounts for the effect of an independent variable on a dependent variable (Baron & Kenny, 1986; Hayes, 2009; Preacher et al., 2007). Mediation occurs if the effect of the independent variable on the dependent variable is reduced when the mediator is included (i.e., the regression coefficient is smaller for c' than for c, preferably c' being non-significant). Furthermore for mediation to occur, the indirect effect needs to be estimated, which can be assessed by computing confidence intervals for the indirect effect using bootstrap methods: Confidence intervals in which both lower and upper bound are either positive or negative (i.e., the confidence interval does not contain zero) are considered significant (Hayes, 2009). The effect size of the indirect effect can be assessed by calculating kappa-squared (κ^2): a small effect would be around .01, a medium effect around .09, and a large effect around .25 (Preacher & Kelley, 2011).

We hypothesized that the emotional content accounts for the relationship between music and movements, since musical features and emotional content are related with each other and both of them might have influenced participants' movements.

Although it is possible that an indirect effect exists between two variables even if these two variables are not associated when the mediator variable is absent (Hayes, 2009), we will concentrate for the time being on the combinations, in which all the three variables show at least moderately high mutual correlation with each other. Therefore, as the first step of the analysis, correlations between movement, emotions, and musical features were assessed,

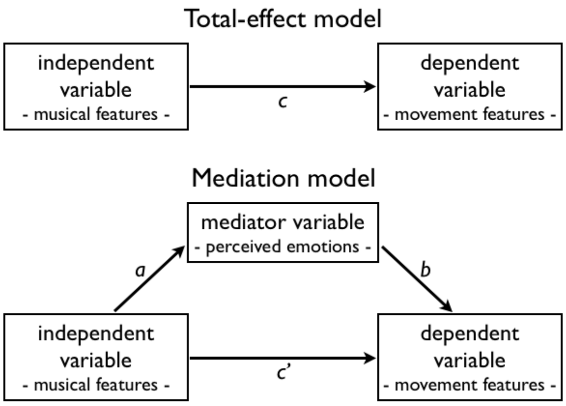

Figure 2. Total-effect model and mediation model. A mediator model decomposes the total effect, *c*, into the indirect effect, *ab* (product of the indirect paths *a* and *b*) and the direct effect, *c*' (with the effect of the mediator removed). The total effect can be describes as $c = c' + ab$, and hence the indirect effect as $ab = c - c'$.

of which the significant ones ($p < .05$) are presented in Table 1.

Table 1. Correlations (n=30) between emotions, movement features, and musical features. Asterisks indicate the significance level of the lowest coefficient of the three pairwise correlations.

		SHe	SHa	AHe	AHa	Fl	Rot
Aro	Ons	*		**	**	**	
	SBF2	**	**	**	**	**	
	SBF9	**	**	**	**		
	AT			*	**	**	
Val	LE						*
	Ons					*	
	SBF2					*	
Hap	SC						*
Ang	LE						*
	Ons					**	
	SBF2					*	
Sad	AT				*	*	
Ten	LE						*
	Ons	*		**	*	**	
	SBF2	**		**	**	*	
	SBF9	*		*	*		

* $p < .05$, ** $p < .01$

Abbreviations: Emotions: *Aro*: Arousal; *Val*: Valence; *Hap*: Happiness, *Ang*: Anger; *Sad*: Sadness; *Ten*: Tenderness – Musical features: *SBF2*: Spectral flux of sub-band no. 2; *SFB9*: Spectral flux of sub-band no.9; *AT*: Attack time; *Ons*: no of onsets; *LE*: Low Energy; *SC*: Spectral Centroid – Movement features: *SHe*: Head speed; *SHa*: Hand speed; *AHe*: Head acceleration; *AHa*: Hand acceleration; *Fl*: Fluid; *Rot*: Rotation Range

Subsequently, we performed mediation analysis using PROCESS, a tool developed for conditional process modeling in SPSS[1] (Hayes, 2013). In all analyses presented below, the significance of the indirect effect was obtained by computing 95% confidence intervals using 10 000 bootstrap samples.

Testing all significant correlations listed in Table 1 would go beyond the scope of this paper. Thus for Arousal and Tenderness, we will only report relationships involving the two Spectral Flux features, since they were found to significantly contribute to shaping music-induced movement (Burger, Thompson, et al., 2013) and neglect the musical features Low Energy, Number of Onsets, Attack Time, and Spectral Centroid. For the other emotions (Valence, Happiness, Anger, and Sadness), all feature combinations as indicated in Table 1 are analyzed.

Arousal was found to mediate the effect of Spectral Flux of Sub-band 2 on Hand Speed, Hand Acceleration, and Fluidity, and the effect of Spectral Flux of Sub-band 9 on Head Acceleration and Hand Acceleration. For all, there were significant total effects, and including the mediator caused the direct effects to become insignificant, while the indirect effects were significant, with the indirect paths being as well significant (cf., Fig. 2) The confidence intervals did not contain zero, and the κ^2-values indicated large effect sizes. Thus, Arousal could successfully mediate the relationship between these variables. The remaining combinations showed mediation effects as well, although the effect of the direct paths remained significant when including the mediator. The statistical results are presented in Table 2.

Valence was found to mediate the relationship between Low Energy and Rotation Range. However, Valence failed to mediate the effect of Spectral Flux of Sub-band 2 on Fluidity and the effect of No of Onsets on Fluidity, as the respective confidence intervals contained zero. The statistical results can be found in Table 2.

Furthermore, Happiness was found to mediate the effect of Spectral Centroid on Rotation Range (results in Table 2).

[1] www.ibm.com/software/analytics/spss/

With Anger we failed to determine any significant mediation effects, as in all three cases the respective confidence intervals contained zero (see Table 2).

Sadness also failed to act as a mediator between Attack Time and both Hand Acceleration and Fluidity, as both indirect effects were shown insignificant (see Table 2).

Table 2. Non-standardized regression coefficients and model significance of total effect *c*, direct effect *c′*, and both indirect paths *a* and *b*, as well as non-standardized and standardized regression coefficients of indirect effect *ab* with 95% bootstrap confidence interval, and effect size κ^2 with 95% bootstrap confidence interval. Insignificant direct effects are indicated in bold. Insignificant models are shaded in grey.

	model	*b(c), p*	*b(c′), p*	*b(a), p*	*b(b), p*	*b(ab)*, [CI]	*β(ab)*, [CI]	κ^2, [CI]
Aro	**SBF2/SHe**	1.05, .00	.80, .0004	.05, .003	5.11, .02	.25, [.03, .60]	.17, [.002, .04]	.22, [.05, .44]
	SBF2/SHa	2.84, .01	1.41, **.21**	.05, .003	29.06, .02	1.42, [.28, 3.50]	.23, [.05, .53]	.23, [.05, .45]
	SBF2/AHe	15.73, .00	9.71, .001	.05, .003	122.86, .0002	6.02, [2.49, 11.87]	.27, [.12, .47]	.33, [.15, .51]
	SBF2/AHa	39.17, .003	13.38, **.22**	.05, .003	526.39, .0001	25.79, [10.03, 50.06]	.35, [.15, .60]	.36, [.15, .57]
	SBF2/Flu	-.0003, .02	.00, **.79**	.05, .003	-.01, .00	-.0003, [-.0006, -.0002]	-.45, [-.66, -.22]	.50, [.28, .66]
	SBF9/SHe	3.22, .0001	2.25, .01	.15, .01	6.42, .01	.98, [.25, 2.19]	.19, [.05, .44]	.22, [.06, .44]
	SBF9/SHa	13.90, .0001	10.51, .003	.15, .01	22.32, .03	3.39, [.64, 8.16]	.16, [.03, .38]	.18, [.04, .38]
	SBF9/AHe	43.08, .002	20.66, **.06**	.15, .01	147.59, .0001	22.42, [7.64, 45.28]	.29, [.10, .55]	.32, [.10, .55]
	SBF9/AHa	138.91, .003	60.47, **.10**	.15, .01	516.37, .00	78.44, [25.50, 151.89]	.30, [.10, .54]	.33, [.09, .54]
Val	**LE/Rot**	1.56, .03	.63, **.39**	5.30, .006	.17, 0.1	.93, [.25, 1.95]	.23, [.06, .52]	.22, [.05, .48]
	SBF2/Fl	-.0003, .02	-.0002, **.30**	-.05, .0004	.003, .14	-.0001, [-.0004, 0001]	-.19, [-.46, .07]	.16, [.01, .38]
	Ons/Fl	-.0001, .003	-.0001, **.06**	-.01, .0003	.002, .34	.00, [-.0001, .00]	-.12, [-.40, 10]	.11, [.005, .33]
Hap	**SC/Rot**	.0001, .046	.0001, **.31**	.0003, .03	.17, .01	.0001, [.0000, .0001]	.19, [.06, .40]	.19, [.05, .38]
Ang	LE/Rot	1.56, .03	1.01, **.16**	-4.77, .05	-.11, .04	.55, [-.03, 1.44]	.14, [-.01, .35]	.13, [.01, .35]
	Ons/Fl	-.0001, .003	-.0001, .04	.01, .004	-.002, .16	.00, [-.0001, 0.00]	-.14, [-.34, .06]	.14, .01, .31]
	SBF2/Fl	-.0003, .02	-.0002, **.22**	.04, .01	-.003, .08	-.0001, [-.0003, .00]	-.17, [-.36, .07]	.17, [.01, 33]
Sad	AT/AHa	-39629.34, .01	-31772.85, .03	25.56, .05	-307.33, .15	-7856.47, [-29489.44, 1839.10]	-.10, [-.33, .02]	.10, [.01, .30]
	AT/Fl	.40, .01	.32, .04	25.56, .05	.003, .17	.08, [-.06, .39]	.09, [-.08, .43]	.10, [.002, .36]
Ten	SBF2/SHe	1.05, .00	.89, .001	-.05, .00	-2.95, .35	.16, [-.24, .57]	.11, [-.17, .39]	.12, [.003, .35]
	SBF2/AHe	15.73, .00	11.70, .01	-.05, .00	-73.63, .14	4.03, [-2.28, 10.88]	.18, [-.11, .47]	.19, [.01, .45]
	SBF2/AHa	39.17, .003	28.83, .09	-.05, .00	-189.04, .36	10.33, [-12.05, 33.46]	.14, [-.17, .42]	.12, [.003, .32]
	SBF2/Flu	-.0003, .02	.0001, **.73**	-.05, .00	.01, .001	-.0004, [-.0007, -.0001]	-.48, [-.76, -.18]	.41, [.12, .64]
	SBF9/SHe	3.22, .0001	2.45, .002	-.11, .04	-7.20, .01	.77, [.15, 1.82]	.15, [.03, .34]	.18, [.04, .37]
	SBF9/AHe	43.08, .002	28.79, .02	-.11, .04	-133.82, .002	14.29, [3.25, 32.35	.18, [.05, .38]	.21, [.05,.41]
	SBF9/AHa	138.91, .003	108.21, .02	-.11, .04	-287.56, .07	30.71, [2.56, 85.76]	.12, [.01, .30]	.13, [.02, .30]

Abbreviations: see Table 1

Tenderness acted as mediator in the relationship between Spectral Flux of Sub-band 2 and Fluidity. Tenderness also mediated the effect of Spectral Flux of Sub-band 9 on Head Acceleration (direct path still significant), as well as on Head Speed (direct path significant) and on Hand Acceleration (direct path significant and *b*-path non-significant). The results for the models for Spectral Flux of Sub-band no 2 with Head Speed, Head Acceleration, and Hand Acceleration did not show any mediation effect of Tenderness. The statistical results are presented in Table 2.

3.2. Personality as moderator

If the strength of a relationship between two variables is dependent on the level of a third variable, this third variable is said to act as a moderator (Baron & Kenny, 1986; Preacher et al., 2007). Moderation effects are usually understood as an interaction between the independent variable and the moderator variable in predicting the dependent variable, where the effect of the independent variable depends on the level of the moderator. Figure 3 depicts the conceptual and the statistical model for moderation analysis.

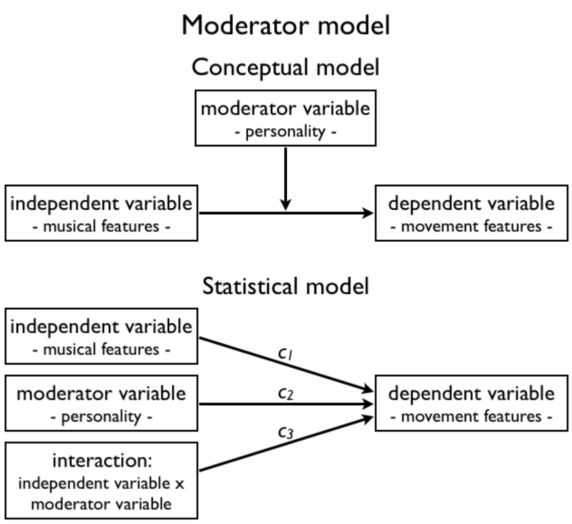

Figure 3. Conceptual and statistical model for moderation.

We hypothesized that personality of the dancers would act as a moderator. Thus, the level of personality trait would affect the relationship between musical features and movement characteristics. For instance, extrovert participants would make use of a certain movement feature to a higher extent than non-extrovert participants given a specific musical characteristic.

For analyzing the effect of personality, we first divided the 60 participants into three groups of 20 high-scorers, 20 mid-scorers, and 20 low-scorers for each personality trait separately and removed the mid-scorers from the analysis. The remaining two groups of participants were coded binary (instead of keeping the original scores). A similar approach was used in Luck et al. (2010).

For moderation to occur, we assume a relationship between the independent and the dependent variables, in our case the musical and movement features respectively. Therefore, we correlated the musical features with the movement features and present the result in Table 3.

Table 3. Correlations (*n*=30) between musical features and movement features.

	SHe	SHa	AHe	AHa	Fl	Rot
LE						*
Ons	*		**	*	**	
SBF2	***	*	***	**	*	
SBF9	***	***	**	**		
AT			*	**	**	
SC						*

* $p < .05$, ** $p < .01$, *** $p < .001$

Abbreviations: see Table 1

Subsequently, we performed moderation analysis employing the SPSS modeling tool PROCESS (Hayes, 2013)[2]. The results indicate that only two combinations showed moderation effect: we found significant interactions between Extroversion and Spectral Flux of Sub-band no 2 on Head Acceleration and between Conscientiousness and Number of Onsets on Fluidity. The results of both regression models are reported in Table 4.

[2] In moderation analysis, it is common to transform the predictors using grand mean centering before analysis, so that we obtain the effect of one predictor when the other predictor is its mean value (and not zero).

Table 4. Regression results of the moderation models with significant interactions.

Extroversion/SBF2/Head Acceleration, $R^2 = .13$

	β	*SE*	*t*	*p*
Extr	.28	25.29	10.25	.00
SBF2	.21	2.69	6.92	.00
Extr x SBF2	.07	2.69	2.32	.02

Conscientiousness /Ons/Fluidity, $R^2 = .04$

	β	*SE*	*t*	*p*
Cons	.03	.0007	1.22	.22
Ons	-.18	.0000	-6.42	.00
Cons x Ons	-.06	.0000	-2.00	.045

4. Discussion

We described two analysis approaches of multivariate nature – mediation and moderation – to enable the simultaneous inclusion of several variables into one analysis to investigate underlying relationships among them.

The results of the analysis suggest that such analyses serve as insightful ways of looking at relationships between different variables. We found the perceived emotional content of the music to mediate the effect of musical features on movement features in case of Arousal, Valence, Happiness, and Tenderness, which suggests to assume that the emotional content could account for the relationship between musical features and participants' movements. Thus, participants might have taken the emotions expressed in the music into consideration when moving to it. This could serve as support for Leman's theory of corporeal articulations (Leman, 2007), in particular for the concepts of "Embodied Attuning" and "Empathy". Participants' movements reflected both musical features and emotions perceived in the music, suggesting that participants have even tried to integrate them into a coherent outcome. This could also indicate that music and emotions are interconnected and co-existing, so "Empathy" could be maybe seen as an abstraction of "Embodied Attuning".

As regards personality as moderator, we found only two instances where moderation occurred, whereas in the remaining 88 combinations, no moderation occurred. This result, especially taken the low R^2 values of both models, would suggest that generally the level of personality did not change the relation between music and movement. In other words, if a relationship between a musical feature and a movement feature exists, it remains unaffected by the personality. One might even propose that an existing relationship between musical features and movement features can suppress the influence of personality. Furthermore, this result could indicate that musical characteristics and personality are independent factors that are related to music-induced movement in different, non-interactive, ways.

Interesting to note is that individual differences, such as personality, do not appear as a concept in the theory of corporeal involvement proposed by Leman (2007). However, if, for instance, movements are seen as being gestural expressions of a certain emotion expressed in the music (as in the concept of "Empathy"), then it seems likely to assume that movements can be seen as gestural expressions related to individual factors of a performer/listener/dancer. Thus, the integration of individual factors into approaches of body-related musical behavior might be a fruitful strategy to formulate a holistic theory of music-related and -induced corporeal articulations.

Further analysis attempts will include additional and more complex model configurations, in particular having several independent, dependent, and intervening variables. Using, for instance, more than one musical and more than one movement feature simultaneously in the analysis would provide a more holistic view on our data and might reveal more general results than with the present approach. Another attempt will combine both emotion and personality into one analysis – for example, in an approach called moderated mediation (Preacher et al., 2007) – to test if the magnitude of the indirect effect (emotions) is dependent on the moderator (personality). The method of path modeling (Schumacker & Lomax, 2010) might provide further opportunities for integrating both aspects into the same analysis. Moreover, structural equation modeling, an approach for testing and estimating causal relations between factors and/or observed variables (Schumacker & Lomax, 2010), will be tested. It offers the possibility to build latent factors from the observed variables, so higher-order relationships – in our case, "music" versus "movement" with intervening factors, such as "emotions" and "personality", might be testable as one comprehensive model. However, one issue regarding the latter approach is the small sample size of our data, as for structural equation modeling, a large sample size is a prerequisite for incorporation of latent variables.

Acknowledgments

We thank Mikko Leimu for help and technical assistance during the motion capture data collection, Jonna Vuoskoski for collecting the personality data, and Asko Tolvanen for support in multivariate statistics. This study was funded by the Academy of Finland (projects 118616, 125710, 136358).

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