

Enhancing Visual Perception of Sports Quality in Rhythmic Gymnastics Routine by Increasing Congruence between Music and Movement

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Abstract The use of music in sports routines that involve choreography is inevitable, and the appropriateness between the two is taken into account for awarding points in competitions. In dance, theatre, or in firm music, the use of music in choreography displays the subjectivity of interpretation to a certain extent due to preferences, background of audience, coach, and composer. However, more scientific and fundamental aspects shared between music and movement can provide a better perception of a particular routine. This study reports an experiment on a rhythmic gymnastics routine to investigate whether an increased congruence between music and movement enhances the perception of sports quality from a musical perspective. In the experiment, the original music accompaniment was changed with a new composition to increase the congruence between music and movement using six parameters including tempo, rhythm, phrasing, accent, direction, and dynamic. Fifty-two undergraduate music majors evaluated two videos of the same routine in a questionnaire regarding the qualities of the performance. Apart from motivation, the results show that the sports qualities with the new accompaniment were significantly perceived better than the original version.

Keywords Perceived Congruence, Rhythmic Gymnastics, Music and Movement, Choreomusical,

Music and Sports

1. Introduction

The contribution of music in improving athletic performances from a psychological, psychophysical, and ergogenic perspective has been examined in many studies and has received significant attention [1, 2, 3, 4, 5]. These studies look into various ergogenic effects, such as stamina, motivation, power, endurance, strength, and many others. The types of sports that these studies involved mostly deal with repetitive movements, such as running, cycling, bench press, anaerobic or aerobic exercises, etc. Although music and sports are two different disciplines, certain fundamental parameters are evident in both, such as speed, tempo, rhythm, and intensity [6, 7, 8]. These parameters allow interaction and association between the two fields and therefore encourage various studies in many areas of research.

From another perspective, the use of music in sports routines raises more questions as not only the subjectivity of interpretation and preferences, but the combination of the two fields is a great realm for research. Sports routines

have certain similarities to dance as they comprise a choreography that is planned ahead of the performance and athletes have to comply with the designated music in which the duration of the performance is fixed. In competitions, music is obligatory in rhythmic gymnastics, synchronized swimming, figure skating, and martial arts, and the demands of synchronization between the music and routine is significantly stated in the code of points [9, 10, 11]. However, the issue of suitability, interpretation, and appropriateness of music used in the routine is still discussed, such as in figure skating [12], rhythmic gymnastics [13, 14], synchronized swimming [15], and Tai Chi [16]. Based on the cross-modal interaction and the congruence between music and movements derived from the concept of dance, and audio-visual subjects related to film and multimedia, our study found that congruence between both subjects improved the visual perception of acrobatic levels [17]. This is based on the fundamental parameters gathered from the field of dance, sports, and audio-visual subjects, which are phrasing, tempo, rhythm, accent, dynamics, and pitch direction. From the same project, this article reports another segment to highlight whether the increase in congruence between sports and music also enhances sports quality, which are stamina, energy, excitement, interesting, climax, motivation, and confidence. The idea of the research came from the concept that the visual perception of a subject formed by the combination of the two disciplines could be altered. These effects and perception come from the shared or parallel parameters between music and movement, which are based on three perspectives: 1) synchronization of music and dance, 2) music and sports, and 3) formal congruence in audio-visual subjects, as in the field of multimedia and film. The study aims to emphasize that the quality of the similar movement could be enhanced if the music is appropriately matched, which will be detailed in the following explanation on parallels between music and movement. This experiment also hopes to eliminate the problems of athlete to compromise their movement or choreography to the music. Although the music tracks were chosen and edited by themselves, limitation thus occurs particularly on the duration of certain fragments, speed, articulations and so forth. This is because the conventional approach is that athletes and coaches generally design their choreography based on the existing or selected music tracks. With the approach used in this study that suggested music should be composed after the routine was choreographed, this provides a total freedom for athletes in designing their routines.

1.1. Parallels between Music, Dance, Sports and Audio-Visual Subjects

Parallels between music and dance. The concept of parallels between music and dance was established in Paul Hodgins' [18] choreomusical analysis. He proposes two categories of shared parameters: intrinsic and extrinsic.

The intrinsic category includes rhythm, dynamics, structure, and qualitative and mimetic aspects, consisting of elements of more technical and formal congruence. The extrinsic qualities consist of archetypal, emotional, and narrative aspects, in other words, the more subjective features. McMains and Thomas [19] discussed the analogy of music and dance from two angles: a translation from music to dance and vice versa. The same research also highlighted the interactions between dance and music, where three categories are formed: 1) Dance amplifying an aspect of music, 2) Music amplifying an aspect of dance, and 3) music and dance amplifying each other [19: 210-212]. Another concept is by Sawyer and Parisot [20: 26], which discussed the relationship between music and dance, and established a theoretical concept that all ballet is categorized into three concepts: synchronization, opposition, and assimilation. Given the many parallels between the two entities, these congruences were also perceived by spectators, as found by Krumhansl and Schenck [21], where respondents were aware of the correspondence between music and dance in Balanchine's choreography of Mozart's Divertimento. Even if both subjects are temporarily separated, viewers can recognize the intended match [22].

Parallels in music and sports. The most basic parameters shared between music and sports are perhaps the tempo and rhythm, and this refers to activities that involve repetitive movements performed with speed that leads to pace, momentum, and intensity, which are all associated with music as well. Studies were also done on the categorization and definition of synchronous and asynchronous music and sports [23, 24], where synchronous music involves the repetition of movement in time with the tempo and rhythm of music while asynchronous applies where 'there is no conscious synchronization between movement and music tempo' [25]. The positive effect of the use of synchronous music was evident in many studies, for example, a positive mood generated by the participants from a step-aerobics class [26], benefit in running performance [27], longer endurance in physical tasks [28], optimizing individual running cadence and motivation [29], and many more.

Parallels in audio-visual interaction. Perceptions in audio-visual subjects such as film and multimedia related fields were examined from different perspectives in cross-modal interaction research. The use of soundtrack or sounds to influence the meaning in films in psychomusicology studies is evident in many studies [30, 31]. Sounds and music are able to alter the perceptions in terms of emotion [32], recall, and recognition of film through mood-congruence match [33], affecting viewers' interpretation of characters [34], etc. However, the more fundamental concept of match between music and sound with the visual subjects can be referred to studies of formal and semantic congruence [30]. Formal congruency was defined as 'the matching of auditory and visual temporal

structure’, while semantic congruency means ‘the similarity between auditory and visual affective impression’ [35]. The current article reports on the aspects of formal congruency that examine the synchronization between the auditory and visual accent, also termed in the ‘Micky Mousing’ approach in the film study. Another factor that is closely associated with this theory is derived from the more fundamental approach of the McGurk effect [36], which leads to the technique of ‘capture’ [37]. This leads to the bouncing-inducing effect, where the meeting of two discs will be felt as a bounce of a sound is given at the point when two discs meet [38].

1.2. Six Fundamental Parameters of Music and Movement

Phrasing. The role and function of phrasing that assist in providing a natural sense of direction in communication appear inevitably in language, music, and dance. In auditory fields like music and language, it provides boundaries as structured auditory streams as well as structural units for a melodic line [39]. The boundaries and structural units in describing phrasing have close parallels in dance, which involves movement that contains innate rhythm and phrasing, even in the absence of music [40:19]. These parameters are also clearly defined by Hodgins’s choreomusicology under the intrinsic category [18]. In a direct movement-music context, this is also evident where the phrasing can be perceived from the gesture of an instrumentalist [41].

Tempo and Rhythm. These two parameters are the closest to dance, sports, and non-human movement subjects such as graphic, animations, and others. In general, tempo and rhythm occur naturally in human activities [42], heartbeat, locomotor movements, and respiratory system, and emotional disturbance affects the tempo [43]. Under the intrinsic category, Hodgins [18] relates the two parameters to accent, meter, and movement integration in dance choreography. These are also the two most prominent and closely associated parameters in sports studies, as both involve timing and speed in a race, exercises, and intensity [23, 24]. From an audio-visual perspective, Iwamiya [35] studied the congruence between tempo and movement with regard to their effect on the speed and brightness of a visual movement.

Accent. As mentioned earlier, this is one of the most important parameters to highlight the effect when two entities meet, as shown in the experiment of McGurk and McDonalds [36]. The parameters fall in one of Jordan’s [44] categories in the imitative and contrapuntal rhythmic relationship between music and dance, where ‘accent’ in music is parallel to ‘stress’ in dance. Looking at the cross-modal mapping between audio and visual subjects, accent is one of the most basic parameters shared by music and movement as it contributes to the effect on viewers’ perception. Termed as the ‘salient moments’ [45], the definition of accent could similarly apply to sports routine

that includes movement such as a jump, drop, throwing of apparatus, etc in dance-like exercises. The musical definition of accent as ‘increased prominence, noticeability, or salience ascribed to a given sound event’ [46: 489] can also apply to a particular movement intended to catch attention. Attention will also be drawn to the visual display by the auditory accent when both the audio-visual temporal accent happen simultaneously [30].

Dynamic. The association of loudness in sound in matching larger objects was evidently tested in children [47], and this was followed by various studies to determine the same relationship, with participants from varying backgrounds [48]. Eitan and Granot [49] found that increase of loudness has more association with acceleration of movement but not the contrary, while a decrease in loudness has a more significant association with spatial descent than the opposite condition. Another study showed that an increase in loudness matches with upward movement muscular activities and vice versa [50]. An analysis of muscular energy found that increase in loudness will increase the number of shaking events [51]. Similarly, under the intrinsic category, Hodgins [18] found the dynamic of music parallels the movement intensity and the volume of the choreographic gesture. Along with other similar parallels, the concept of ‘music visualization’ by St Denis gave a methodical translation of music dynamic intensity with movement intensity [52].

Pitch Direction. The direction of pitch refers to the spatial height of a movement, such as jumps, or a series of steps ending with a jump, together with the throw of the apparatus, which is a common acrobatic move in rhythmic gymnastics. Eitan [53] highlighted earlier research [54] that when discussing pitch and spatial height, participants associated higher pitch with higher locations despite the actual location. The translation of pitch defined by McMains and Thomas [19] includes higher notes in music corresponding to higher space or near space in dance. Again, under the intrinsic category, Hodgins [18] defined pitch as parallel to the position and direction of the gesture in space.

2. Methodology

2.1. Research Design

Based on the six shared fundamental parameters between music, dance and audio-visual subjects, this study uses a rhythmic gymnastics routine for the experiment. Using the same routine, two videos were prepared for a survey; one using the original music by the athlete and another with a new compose accompaniment, with emphasis on the six parameters. The two videos were evaluated by 52 respondents with the ratings in 1-5 Likert scales and the significant differences of the videos was analysed in paired sample t-test. To examine the correlation between the parameters and sports qualities, the

Spearman RHO correlation test was conducted.

2.2. Visual Stimuli

The video recording of the rhythmic gymnastics (RG) routine was done at a primary school gymnasium. After a discussion with the coach, a gymnast was selected to participate in this study. This 15-year-old gymnast had 12 years' training in rhythmic gymnastics and had won medals in various competitions. Taking into account the familiarity and readiness to perform the task, a routine that uses the ribbon apparatus for 90 minutes, the standard duration in all RG routines, was selected. This routine was accompanied by the music composed by Dmitri Malikov entitled *The Swallow*, a Western classical symphonic orchestra featuring the piano solo. Through an interview with the coach, it was gathered that the track used in this routine was edited, and the choreography was based on the edited music. Through evaluation of expertise in rhythmic gymnastics, the music and movement in the routine were considered highly matched. A total of five performances were recorded and the best was chosen for the experiment.

2.3. Music Stimuli – Original and New Accompaniment

To examine the effect of music on the perception of the same routine, two videos of the same routine with different music accompaniments were prepared for the questionnaire. The first video (V1) uses the original music from the gymnastics and the second video (V2) with a new composition that enhances the six parameters. Both videos were edited using Logic Pro 8 so that they have a similar quality of sound, and to avoid the difference in ambient or background noise. Before composing the new enhanced accompaniment, the original music in the choreography was analysed to obtain the characteristics of the use of music in this routine. While choreography was rated to have expertly matched the music, a few traits were gathered on how the music and movement interact in the original video (V1). Most highlights of movements were matched with selected pitch in a melodic figure, and leaps were matched with accented chords, while the music given to jump or the acrobatic moves in throwing or catching the apparatus was less significant. Another trait was that most of the starts of a movement, including the execution of a 360° rotation, began at the middle of a musical phrasing, neglecting the preceding melodic figure. In general, emphasis on movements and initiation of a movement sequence followed the intended pitch within theme, motif, or melody. However, patterns of the apparatus (ribbon) such as spirals, circles, and snakes were observed to be congruent with the running-note figure or arpeggios in the piano.

In the second video (V2), the original music was removed, and a new music composition in a similar symphonic orchestra style, featuring piano solo as in V1 was inserted. As the purpose was to examine if the

enhanced congruence affects the quality of sports routines, the six parameters - phrasing, rhythm, accent, dynamics, tempo, and pitch direction – were emphasised. For phrasing, the start and end of a sequence of dance steps, runs, or hand movements were matched with musical phrasing. This also included the starting and ending of a 360° rotation, which is enveloped within a short phrase. This version increases the musical tempo from 125 to 143 crotchets per minute due to the fast movement and steps generated. To enhance the parallels in rhythm, the dance steps aligned with the rhythm in the melodic line or music accompaniment were targeted. Additionally, the rhythm also focused on matching hand strokes in handling the apparatus to generate different patterns. The musical accent emphasized by the climax of a chord and orchestrated with cymbals or timpani was aligned with movement accent such as a jump, the throw, or catch of the apparatus. Accents were also used to highlight the climax of the sequence of movements, leaps, or height. Gradual loudness of the music was added along with a series of steps leading to a jump, or the adjustment of apparatus pattern such as small spiral or circular movement to a larger one. Intensification and abatement were also matched with the amplification and reduction of a series of hand movements. As with spatial height, the higher pitch was associated with jumps, and lower pitch motifs or themes were designated to lower movements in the routine. Interval patterns that show a high-low pitch also accompanied the ribbon movement, such as repetition of vertical patterns.

2.4. Participants

The study employed 52 undergraduate students from a government university as participants. All of them were between the ages of 20 and 23 and had at least 10 years of formal musical training. The experiment was conducted in groups of five to eight students in a lecture room, and the purpose of the study and the procedure were explained in each session. To avoid an irrational primacy effect and bias on the videos, 26 students evaluated video 1 (original) followed by video 2 (new accompaniment) and the other 26 students did the opposite order. The video was projected in a lecture room and the evaluation was completed in 30 minutes.

2.5. Questionnaire and Data Analysis

The two sections of the questionnaires that are involved in this article are the demographic details of the participants, including the age and musical background; and the level of perceived sports quality in the video in terms of energy, stamina, motivation, climax, together with the level of excitement and how interesting the performance of the athlete was. The ratings in each question (Table 1) were in the form of 1 to 5 point Likert scales, where 1 is poor and 5 is excellent. The comparison

of the ratings was analysed using a paired-sample t-test, and a threshold of $p < 0.05$ was used to examine the statistical significance with a confidence level of 95%.

Table 1. Questions on Sports Qualities in Two Videos

Questions	
1.	Rate the energy of the athlete.
2.	Rate the stamina of the athlete.
3.	Rate the level of motivation in this gymnast’s performance.
4.	In your opinion, do you think the performance delivered a convincing climax?
5.	Rate the confidence level of the athlete.
6.	Rate the level of excitement performed in the acrobatic movements (jumps, catching ribbon, etc).
7.	This routine is interestingly performed.

3. Result

3.1. Perceived Level of Congruence

Table 2. T-Test for Perceived Level of Congruence on the Six Shared Parameters

	Video 1		Video 2		t	sig-t
	M	SD	M	SD		
<i>Parameters</i>						
Overall Rating	3.35	0.93	4.25	0.78	4.284	0.000*
Phrasing	3.45	0.87	4.06	0.74	4.004	0.000*
Tempo	3.60	0.93	4.18	0.88	3.415	0.001*
Rhythm	3.66	0.99	4.04	0.92	2.060	0.044*
Accent	3.42	0.91	4.26	0.84	5.224	0.000*
Dynamic	3.96	0.94	4.22	0.80	2.302	0.025*
Pitch Direction	3.70	0.93	4.06	0.79	2.657	0.010*

Note: Significant level at $p < 0.05$ indicated as *

Before looking at the results about the sports qualities, the perceived level of congruence between the six parameters in two videos was reported in the same project to examine the difficulty of acrobatic level [17]. However, this data required to be stated here to demonstrate the correlation between the level of congruence and sports quality. Both videos presented a significant difference in the level of congruence for the six parameters (Table 2). This means that the respondents could significantly perceive the change or the enhancement of the level of congruence in video 2. Cohen’s effect size values were also calculated, where a large effect size was obtained from the overall congruence ($d = 1.05$) and accent ($d = 0.96$); moderate effect size for phrasing ($d = 0.76$) and tempo ($d =$

0.64); and small effect size for rhythm ($d = 0.40$), dynamic ($d = 0.30$), and pitch direction ($d = 0.42$). [The effect size was based on the criteria of Cohen (1992): 0.20 = small; 0.50 = moderate; and 0.80 = large].

3.2. Perceived Sports Performance Qualities

From the paired-sample t-test, both the perceived level of energy ($t = 2.552$; $p = .014$) and the stamina ($t = 2.003$; $p = .047$) of the gymnast increased significantly with the changed music, although the perceived motivation did not show a significant difference (Table 3). For the performed routine, the video with the new accompaniment was rated with a significantly higher level of perceived climax ($t = 3.620$; $p = .001$), while the respondents also felt that the change in music produced a significantly more exciting ($t = -2.184$; $p = .033$) and interesting routine ($t = 2.591$; $p = .012$). Cohen’s effect size suggested a moderate practical significance was obtained for climax ($d = .70$), while other variables, including energy ($d = .38$), stamina ($d = .29$), excitement ($d = .34$), and interesting ($d = .45$) suggest a low significance.

Table 3. T-Test for Perceived Congruence on Sports Qualities

	Video 1		Video 2		t	sig-t
	M	SD	M	SD		
Energy	4.00	0.899	4.32	0.779	2.552	0.014*
Stamina	4.19	0.761	4.40	0.689	2.033	0.047*
Climax	3.57	0.888	4.17	0.826	3.620	0.001*
Excitement	4.02	0.796	4.28	0.717	2.184	0.033*
Interesting	3.85	0.928	4.23	0.750	2.591	0.012*
Confidence	4.23	0.824	4.49	0.697	2.132	0.038*
Motivation	4.11	0.776	4.30	0.749	1.696	0.096

Note: Significant level at $p < 05$ indicated as *

3.3. Correlation between Parameters and Sports Qualities

The Spearman RHO correlation was used to analyse the relationship between the parameters and sports qualities. Not all the correlations in Video 1 exhibit a significant relationship between parameters and sports qualities. A variable with an insignificant correlation is the accent parameter, along with its association with energy, stamina, confidence, and motivation (Table 4a). Other insignificant associations include energy and tempo, motivation and tempo, and confidence and direction. A stronger and significantly positive correlation was revealed between the level of interest and overall congruence ($r = .708$, $p < .01$). Except for stamina and phrasing, all the correlations between the parameters and the sports qualities in Video 2 were significant at the alpha level of $p < .01$ and only two correlations at $p < .05$.

The change in musical accompaniment (V2) affected

eight correlations (Table 4b) that recorded strong $r = .725, p < .01$, associations, including motivation and pitch direction (r

Table 4a. Correlation between Level of Congruence and Sports Qualities in Video 1

		Phrase	Tempo	Rhythm	Accents	Dynamic	Pith Direction	Overall congruence
Energy	Correlation Coefficient	.440**	.231	.349*	.127	.684**	.388**	.387**
	Sig. (2-tailed)	.001	.095	.010	.365	.000	.004	.004
Stamina	Correlation Coefficient	.463**	.286*	.315*	.065	.473**	.302*	.384**
	Sig. (2-tailed)	.000	.038	.022	.642	.000	.028	.005
Confidence	Correlation Coefficient	.511**	.272*	.320*	.039	.478**	.155	.535**
	Sig. (2-tailed)	.000	.049	.020	.780	.000	.267	.000
Motivation	Correlation Coefficient	.460**	.260	.339*	.159	.605**	.419**	.456**
	Sig. (2-tailed)	.001	.060	.013	.255	.000	.002	.001
Climax	Correlation Coefficient	.678**	.524**	.485**	.474**	.670**	.666**	.576**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
Excitement	Correlation Coefficient	.496**	.491**	.469**	.215	.497**	.515**	.444**
	Sig. (2-tailed)	.000	.000	.000	.121	.000	.000	.001
Interesting	Correlation Coefficient	.642**	.604**	.625**	.458**	.609**	.602**	.708**
	Sig. (2-tailed)	.000	.000	.000	.001	.000	.000	.000

** : Correlation is significant at the 0.01 level (2-tailed).

* : Correlation is significant at the 0.05 level (2-tailed).

Table 4b. Correlation between Level of Congruence and Sports Quality in Video 2

		Phrase	Tempo	Rhythm	Accents	Dynamic	Pith Direction	Overall congruence
Energy	Correlation Coefficient	.427**	.386**	.442**	.592**	.690**	.496**	.458**
	Sig. (2-tailed)	.001	.004	.001	.000	.000	.000	.001
Stamina	Correlation Coefficient	.267	.300*	.370**	.502**	.565**	.374**	.343*
	Sig. (2-tailed)	.053	.029	.006	.000	.000	.006	.012
Confidence	Correlation Coefficient	.387**	.401**	.462**	.341*	.532**	.397**	.380**
	Sig. (2-tailed)	.004	.003	.000	.012	.000	.003	.005
Motivation	Correlation Coefficient	.500**	.610**	.602**	.598**	.651**	.725**	.523**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
Climax	Correlation Coefficient	.705**	.548**	.629**	.576**	.562**	.678**	.674**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
Excitement	Correlation Coefficient	.561**	.568**	.681**	.590**	.723**	.725**	.518**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000
Interesting	Correlation Coefficient	.715**	.736**	.682**	.690**	.581**	.738**	.822**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000

** : Correlation is significant at the 0.01 level (2-tailed).

* : Correlation is significant at the 0.05 level (2-tailed).

interesting and pitch direction ($r = .738, p < .01$), climax and phrasing ($r = .705, p < .01$), interesting and phrasing ($r = .715, p < .01$), interesting and tempo ($r = .736, p < .01$), dynamic and excitement ($r = .723, p < .01$), and interesting and overall congruence ($r = .822, p < .01$).

4. Discussion

The increase in congruence in V2 for the six parameters shared by music and movement was significantly perceived by respondents in this study. The intended match in this sports routine further justifies the perceived congruence in music and dance [18, 21, 22, 52,] audio-visual subjects [30], and gestures of instrumentalists [41, 55], which has been discussed earlier. This study emphasizes that the six parameters shared by various subjects are considered fundamental to our body movement, as many findings suggest that the precursors of music perception emerge in the early stages of human development [56]. Studies reveal that children as young as three can relate to dynamics and tempo in their movements, such as walking and running [57]. Phrasing in both areas serves as a sense of structure and evidence shows that even infants are sensitive to musical phrase structure [58], as they can detect temporal regularities that appear periodically [59]. Many studies also suggest that the relationship between high and low pitch in mapping with verticality in a spatial context might be inborn, and appear in speech, language, and cross-cultural anthropological studies [60]. Given that the relationship of some parameters exists as early as in the stage of infancy or childhood, the level of perception towards congruence between these parameters in the cross-modal context can vary due to training, cultural backgrounds, expertise, language, etc. [61]. As music is the main theme for evaluating the level of perception in this study, the experiment focused on respondents who have a musical background to examine if the enhanced level of parameters is perceived among musicians.

The perceived higher ratings of many sports qualities achieved with an increased level of congruence between music and movement in Video 2 thus correspond with studies in sports and music to a certain extent. In sports studies, synchronous music has been shown to lead to ergogenic, psychological, and psychophysical benefits [23, 62, 63]. In terms of energy, 'synchronous music may reduce the energy cost of exercise by promoting greater neuromuscular metabolic efficiency' [64] as, due to minor adjustments and muscle relaxation, less energy was required for replicated kinetic patterns [64]. Although motivational and outdeterous musical conditions elicited faster timings in repetitive sports than in conditions with no music, motivational music conditions may not be of critical importance when synchronous music is applied to aerobic tasks [63]. However, a faster tempo is associated with the qualities of motivational music in the Brunel Music Rating 1 and 2 developed by Karageorghis et al. [65], who stated that the key characteristic of motivational music is that it 'has a fast tempo (>120 bpm), a strong rhythm, enhances energy, and promotes bodily movement'. In sports studies, motivational synchronous music has thus been shown to enhance in-task affect and increase endurance [23]. In the current case, although the gymnast was not significantly

perceived as more motivated, the perceived confidence in the athlete increased.

However, these experiments focused on sports with regular kinetic movements, contrary to the sports event in this study, which includes a dance-like routine. Taking this into consideration, one of the most important parameters could be phrasing that provides the basic architecture and structure to both music and movement. The intended match of phrasing with the starting and ending of the sequence of movements in the routine align with studies on instrumentalist gestures where phrase structures are reliably presented in bodily motion [66]. The length of phrasing in musical structures are comparable to dance in stratification and/or hierarchical structure ranging from units, to cells, to sections [67].

Musical accents added to highlight the peak of jumps, the swing off and catching of the apparatus (ribbon), thus corresponding to the climax of a movements, or even the routine, as described by Lipscomb [68:38] as 'point of emphasis' in the field of aural and visual sensory in multimedia. Further, matching accent to a point of movement is also in line with the theory of audio capture that leads to a bounce-inducing effect [38], although the level of effect for a particular jump or swing could be examined in future studies. Indirectly, the intended accent that creates the attention indeed contributes to the perceived excitement and interesting qualities in this routine.

While this study looks at the overall effect of music and movements in a complete routine, parameters may also be perceived and interact with one another, as 'both loudness and pitch and pitch and tempo significantly interact in conveying distance change' [53:180]. This also explains why the perceived dynamic in Video 2 was effective with the phrase structure matching the sequence of movement. In addition, pitch direction (high and low) adjusted in video 2 to match the ascent and descent (verticality) of the jump that contributed to the climax indirectly provided a significant level of excitement and interest. The perceived increase in the level of energy in Video 2 may also be the result of increased accents, dynamics, and tempo in the revised music. These three parameters thus support the findings of Eitan [53:178] in an analysis of the imagined motion, in which loudness, tempo, and intensification (crescendo is included in the current study) change the effects of vertical and sagittal motion, speed change, and energy. Vertical motion is closely analogized with jumping movements and/or the throwing of the apparatus upwards. Referring to jumps in terms of height was discussed in Eitan [53:181], which found that 'spatial height and motion in the vertical axis were associated with pitch, loudness, and tempo, rather than with pitch alone'; thus, a 'spatial ascent may be evoked by pitch rise, crescendo, and accelerando' [49:226]. In the realm of sports routines, and figure skating in particular, Harman et al. [12] similarly discuss music and figure skating and address how skaters who relate 'energy' using the dynamics of music and

‘climactic moments should get special attention with accented moves’.

5. Conclusion

The current study reveals that the increased level of congruence in six selected parallel parameters between music and movement resulted in a better perception of sports quality in a rhythmic gymnastics routine. Given the same movements in both videos, except for motivation, sports qualities that include energy, stamina, confidence, excitement, and level of interest were rated significantly higher in the more congruent model of the video. The better rating of the qualities in this article also corresponds with the data from the same research project [17] on a significantly higher rating for acrobatic difficulties such as amplitude of jumps, smoothness of rotations, and the intensity of the apparatus. While many cross-modal studies examine the interaction of a particular parameter with subjects in the context of analogy or metaphoric conditions [61], this experiment examines the effect of parameters in their actual setting and emphasizes the significance of music in altering the visual perception of a movement. Like the relationship between dance and music, the purpose of this research also aims to provide a methodological solution in terms of the use of music, which is to eliminate problems of music interpretation and also the unnecessary compromise with unintended musical details that could hardly be removed from editing. It intends to support the approach of composing music after the routine is choreographed, rather than another way round, which is a common practice in many sports routines, though this was disputed in many research due to the subjectivity of aesthetics and interpretation, particularly in dance [69, 70]. Studies in recent years also examine the advancement of technology that enables different approaches of computerized integration between music and dance [71]. Although examining a larger pool of respondents with different expertise will verify the findings, individuals who come from a particular area of expertise may perceive differently due to preferences, media influences, and bias. While music or sound is considered a supplementary support in a sports routine, it affects, to a certain extent, the perception of viewers. This also explains why the criteria of music has been emphasized in the Code of Points for these routine-based sports activities. Given the differences in perception, choice, and influence of environment and cultural background, the fundamental scientific literature should not be neglected. It links music and movement-related disciplines to establish an optimal combination of the routine.

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