

Congruence in Music and Movement Enhances the Perception of Sports Routine Quality

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Abstract

Most studies of music and sports relate to the ergogenic effect of synchronization between music and movement in repetitive sports activities. As in dance, music is clearly important for sports routines that involve choreography. This study performs an experiment involving a rhythmic gymnastics routine to investigate whether increasing the congruence between music and movement enhances the quality of sports routines from a musical perspective. In preparing the video stimulus, the original music accompaniment was replaced with a new composition to increase the congruence between music and movement using six musical parameters that parallel dance, including tempo, rhythm, phrasing, accent, direction and dynamic. Fifty-two undergraduate music majors participated in the study and evaluated two videos of the same routine, one with the original music and the other with the new music. The participants completed a two-part questionnaire: the first part evaluates the perceived congruence between music and movement in terms of the six parameters, and the second part evaluates the acrobatic qualities. The results show that the intended congruence and the acrobatic qualities were perceived as significantly improved in the routine with the new accompaniment.

Keywords: perceived congruence, sports routine, music and movement, choreomusicology, music and sports

Congruência na Música e no Movimento Aumenta a Percepção de Qualidade na Rotina Esportiva

Resumo

A maioria dos estudos de música e esportes está relacionada ao efeito ergogênico da sincronização entre música e movimento em atividades esportivas repetitivas. Como na dança, a música é claramente importante para rotinas esportivas que envolvem coreografias. Este estudo realiza um experimento envolvendo uma rotina de ginástica rítmica para investigar se o aumento da congruência entre música e movimento aumenta a qualidade das rotinas esportivas a partir de uma perspectiva musical. Ao preparar o estímulo de vídeo, o acompanhamento musical original foi substituído por uma nova composição para aumentar a congruência entre música e movimento, utilizando seis parâmetros musicais que acompanham a dança, incluindo compasso, ritmo, fraseado, acentuação, direção e dinâmica. Cinquenta e dois estudantes de música participaram do estudo e avaliaram dois vídeos da mesma rotina, um com a música original e outro com a nova música. Os participantes completaram um questionário de três partes: a primeira parte avalia a congruência percebida entre música e movimento em termos dos seis parâmetros, a segunda parte avalia as qualidades acrobáticas e a terceira parte avalia as qualidades atléticas. Os resultados mostram que a congruência pretendida foi percebida como significativamente melhorada na rotina com o novo acompanhamento, e tanto as qualidades acrobáticas quanto as esportivas também foram percebidas como significativamente melhoradas.

Palavras-chave: congruência percebida, rotina esportiva, música e movimento, coreomusicologia, música e esportes

Introduction

Matching music with other subjects has been studied and investigated in many fields using various approaches focused on a variety of levels and features. Thus, many studies have investigated music's congruence in diverse contexts, such as multimedia presentations, musical performance, dance and even sports. Although music appears to serve a secondary role in certain contexts, it is indispensable because it provides functions and different perceptions to viewers, where 'sound would thus almost inevitably activate visual and kinetic imagery' (EITAN & GRANOT, 2006). In addition, theoretical and

empirical studies (BOLIVAR, COHEN, & FENTRESS, 1994; IWAMIYA, 1994; LIPSCOMB & KENDALL, 1994; LEVITIN, GRAHN & LONDON, 2018) have investigated the interactions and perceptions of the congruence between audio-visual subjects and have found that the congruence between music and visual features seems to positively affect the visual perceptions of media productions (IWAMIYA, 2013). Prior studies have documented viewers' perceptions of expressive information generated by the gestures of instrumentalists (DAHL & FRIBERG, 2007; DAVIDSON, 1993; DAVIDSON, 1995; SHINOSAKO & OHGUSHI, 1996). In addition, studies have also shown that body movements can reflect musical structure (MACRITCHIE, BUCK, & BAILEY, 2013) and rhythm structure (PHILLIPS-SILVER & TRAINOR, 2007), revealing an intrinsic connection between a musician's gestures and musical sounds.

Moving from instrumentalist to other movement-music related enterprises, parallels between dance and music were established in the choreomusical analysis developed by HODGINS (1992), which has attracted much attention in the dance field. The relationship between musical scores and dance has led to voluminous discussions and disputes among various choreographers and composers regarding whether dancers should be constrained by music (FOGELSANGER & AFANADOR, 2006; JORDAN, 2011; MASON, 2012; WHITE, 2006). Studies paralleling dance and music are naturally related to research in music and sports, which has been investigated in various areas of study. In terms of scientific perspectives, scholars have examined how musical elements contribute psychologically, psychophysically and ergogenically to athletic performance in terms of motivation, stamina and energy (KARAGEORGHIS, TERRY, & LANE, 1999). Most of these studies have focused on sports that involve repetitive movements, such as running, cycling, bench press and so forth. From the most fundamental principle, the intrinsic character in music such as tempo and rhythm indirectly affects the physical function not only of human's respiration and heartbeat but also the consistency of movement in a particular sports activity.

However, certain routine-based sports – such as rhythmic gymnastics, figure skating, synchronized swimming, and martial arts – have a strong affinity with dance and aestheticism. Unlike sports with repetitive movements, music provides an indispensable supplement to sports routines in which performance quality takes into account the synchronization between movement (or choreography) and music (Federation Internationale de Gymnastics, 2017-2020; International Wushu Federation, 2005; International Skating Union, 2018). For example, in rhythmic gymnastics, the emphasis on music is self-evident. The rules of the sport explicitly state that a routine must be 'performed according to the tempo, rhythm, music character and accents' (Federation Internationale de Gymnastics, 2017-2020, section 4.1.4). Although music has been emphasized in the rules, poor musical interpretation in these routines has been noted and observed (Harman, Garbato & Forberg, 2009). However, it remains unknown whether this negligence results from a failure of musical understanding or whether it results from subjective interpretation, which is a common phenomenon in fields such as dance.

This article presents an empirical investigation into the congruence of music and sports routines, which bear a close similarity to dance, particularly when they involve choreography. This study aimed to investigate how music enhances the visual perception in a rhythmic gymnastics routine by strengthening the congruence between music and body movements. The level of congruence was measured based on six aspects that are shared by both music and movement, including tempo, rhythm, phrasing, accent, direction and dynamics. While perceptions of individuals are vastly different based on their expertise, cultural and training background, this research aims firstly to investigate the perception of

respondents with musical background. This is due to the reason that in this context, music serves as the main entity that alters the visual perception of the routine.

Perceived Parallelism in Movement and Music

Perceived congruence in dance and music. As defined as kinaesthetic empathy, many research discuss that when watching dance, the visual stimulation of the kinesthetic images can be translated from the dancer to the audience (REASON and REYNOLD, 2010). Parallels between dance and music were established by Paul HODGINS (1992) in his concept of choreomusical analysis elucidated in the seminal book, *Relationships between score and choreography in twentieth century dance*. Hodgins (1992) proposed two categories in the relationship between music and dance: intrinsic and extrinsic. Parallels in the intrinsic categories that are shared by both subjects include rhythm, dynamics, structure, and qualitative and mimetic aspects and involve a more technical structure. These components are comparable to the extrinsic category, which consists of archetypal, emotional and narrative elements. These categorizations clearly underscore the synchronization and congruence situated between music and choreography, which is also closely associated with sports routines such as rhythmic gymnastics. HODGINS (1992, p. 39) argued that intrinsic relationships are a 'highly ostensible and idiomatic element' that are 'largely unprejudiced'. For example, rhythmic relates to ascent and meter, where a metric or syncopated parallel is struck with the corresponding movement. Another example is structure, which refers to the correspondence between motive (music) and figure (dance), on one hand, and phrase (music) and period (dance), on the other, in which both correspondences lead to larger structures in both entities. The composer Schuller (PISCHL & COHEN, 1963) commented that watching 'choreography which consistently ignores the metric [...] shapes of music [...] is like reading a book in which the printer has put all the commas and periods in the middle of sentences and clauses.'

While the parallels between dance and music are evident, many studies have investigated the match between music and choreography or dance movements. MITCHELL and GALLAHER (2001) show that participants recognize matches between music and dance that are congruent. These authors also show that viewers can recognize the intended match between two subjects, even when they are temporally separated. Perceived congruence was also studied by KRUMHANSL and SCHENCK (1997), where respondents were aware of the correspondence between music and dance in Balanchine's choreography of Mozart's *Divertimento*. From the dance perspective, it has been found that different musical genres affect the perceived tempo of a similar dance routine for respondents with dance and non-dance backgrounds (HODGINS, 1992: 4).

Synchronous music in sports. KARAGEORGHIS and TERRY (2009) categorized three types of music used in sports: asynchronous, synchronous and pre-task music. Synchronous music is used as a metronome to regulate a movement pattern, whereas asynchronous music serves as background accompaniment 'without conscious synchronization between movement patterns and musical tempo' (KARAGEORGHIS, Priest, Williams, Hirani, Lannon & Bates, 2010). Pre-task music is used to stimulate athletes for better performance. The synchronization experiments in these studies typically involve issues of tempo, rhythm, and speed with respect to athletes' movement patterns. Various studies have found that synchronous music thus makes a positive contribution to athletes and to athletic performance. In comparison to asynchronous music, synchronous music led to longer endurance in physical tasks (ANSHEL & MARISI, 1978), positive moods (HAYAKAWA,

MIKI, & TAKADA, 2000) and higher quality anaerobic endurance performance (SIMPSON & KARAGEORGHIS, 2006).

Congruence in Audio and Visual Elements

In addition to the musical and dance perspectives, issues related to perceived congruence between audio-visual aspects are also examined in film and multimedia studies, which equally and indirectly contributes to the current study. Congruence in this area may be the most fundamental to underscore the direct effects of combined audio and visual input from many perspectives, as the goal is always the end product to serve viewers. Psychomusicology studies have shown that musical soundtracks can influence meaning in film (BOLIVAR et al., 1994; LIPSCOMB, 1995 y, 2005; MARSHALL & COHEN, 1988). Moreover, perceived congruence between audio-visual objects is categorized in terms of formal congruence and semantic congruence (BOLIVAR et al., 1994; COHEN, 2001; IWAMIYA, 2002), while increased temporal congruence also leads to greater focus of visual attention in which the meaning of the music can be consequently ascribed (MARSHALL & COHEN, 1988). The term that was used in the field of film production was ‘Mickey Mousing’, which referred to the approach to synchronization of auditory and visual accents and temporal structure to create formal congruence. IWAMIYA, SUGANO, and KOUUDA (2000) found that formal congruence was created when musical accents (rhythmic structure) were synchronized with visual accents, which are represented by the discontinuous changes in a visual scene of a moving ball.

Events of sound and movement that are intentionally or coincidentally produced in congruence might provide a model of optimal combination as in the McGurk effect (MCGURK & MCDONALD, 1976), which leads to the technique of ‘capture’ (FOGELSANGER & AFANADOR, 2006; PETRINI, MCALEER, & POLLICK, 2010). Despite McGurk’s study in the field of speech, the optimal combination effect appears in many aspects such as the bounce-inducing effect (GRASSI & CASCO, 2010), which was shown in an experiment in which two discs move toward one another, and when a sound is heard as the discs meet, a bounce-off effect will be perceived. However, the discs will only be understood as passing through one another if the scene is displayed in silence. The perceived effect of the visual stimuli that are affected by different auditory stimuli is called auditory capture.

Various musical parameters and listeners’ images of motion were investigated by EITAN and GRANOT (2006), where features of motion imagery were influenced significantly by most musical parameters. The results from this study indicate that rising pitch is associated with increasing distance and vice-versa. Thus, pitch contour relates to verticality, and crescendo is interpreted as approaching motion, where respondents provide descriptions such as ‘walk turning into run or as a walk terminated by a leap’ (*ibid.*: 237). Although much of the above research investigates the effects of individual musical parameters on visual subjects, the current study investigates the congruence of different features with the entire choreography of a routine.

Methods

Selecting Parameters. The six parameters that are used in this experiment was chosen based on significant studies traced in the field of sports and music, choreomusicology, and audio-visual congruence from the perspective of instrumentalist and multimedia.

Phrasing. In the field of dance, phrasing, which also consists as structure and motifs was established in one of the intrinsic categories in HODGINS (1992) choreomusical analysis. Phrasing also serves an important feature in contributing a 'sense' to a section, fragment, or particular sequence of movement in a work involve choreography. Looking it as a hierarchical perspective, the primary unit of cognitive processing in linguistic and musical passages is the phrase (CHIAPPE & SCHMUCKLER, 1997). Phrasing could evidently be perceived through bodily gesture in performance as revealed in many studies (WANDERLEY et al. 2005; JUCHNIEWICZ, 2008; MACRITCHIE et al. 2013).

Tempo and rhythm. These are the two parameters that shows the most fundamental relationship with human movement as evidently found as early as in infancy (ZENTNER & EEROLA, 2010). This relationship was also noted as early as the philosopher Plato where he stated that 'all the rhythm that we perceived are rhythms which originally resulted from human activity' (FRAISSE, 1982: 150). The association with movement certainly relates both parameters with dance and sports where both involves kinaesthetic movements. In dance, rhythm is similarly placed under the Hodgins' (1992) intrinsic category that explains accent, meters and also movement integration. While in sports, regardless of repetitive or routine based activities, the two parameters are certainly the most relevant entities and is the basis of many studies between music and sports (SZABO, SMALL & LEIGH, 1999; KARAGEORGHIS & TERRY, 2009; KARAGEORGHIS et al. 2010). As movement related, tempo directly serve an important parallels in the field of audio-visual perception as IWAMIYA (2014) defined it under semantic congruence where the musical tempo will influence the speed, brightness and crowdedness of the visual movement; fast musical tempo was found to match with fast visual object speed and vice versa.

Accent. This parameter serves as the fundamental relationship in formal congruence when an audio and visual subject presented at the same time. From a musical sound definition, accent is explained as moments of 'increased prominence, noticeability, or salience ascribed to a given sound event' (HURON & ROYAL, 1996: 489). In the current study, it includes accounts of 'salient moments' (LIPSCOMB, 2013), for example a point of jump, the climax of a turn, the catch or swing of the apparatus that emphasized by a particular musical accent represented by a pitch, chord, timbre, or effects. The accent in this context also refers to the McGurk effect and audio 'capture' as stated earlier (MCGURK & MCDONALD, 1976; FOGELSANGER & AFANADOR, 2006; PETRINI, MCALEER, & POLLICK, 2010). In this theory, a perceived effect will be generated or felt when a musical accent or sound is provided during a meeting point between two objects.

Dynamic. This appears as one of Hodgins' five intrinsic parallels which he explains as 'The volume of the musical gesture is matched by the size of the choreographic gesture (usually occurring as part of another choreomusical correspondent)'. This refers to small repetitive steps with melodic idea in softer dynamics and vice versa; and also examples of *crescendo* in which a series of steps towards a jump or other movements. As movement-related subjects, the correspondence between two entities was greatly experimented in the audio-visual field. Fundamentally, it could be traced with the study of SMITH AND SERA (1992) where children matched larger objects with larger sound. EITAN AND TUBUL (2010) studies also suggested that loudness is the most effective parameter in explaining spatio-kinetic association of music. KOHN AND EITAN (2009) experiment on bodily response to music also shows pitch rise (pitch direction), *crescendo* (dynamic) and *accelerando* (tempo) was associated with increase motion such as opening motion or motion forward, faster tempo, increase of muscular energy and vice versa.

Pitch Direction. Although pitch could be perceived differently with many other musical parameters (Eitan & Granot, 2006; Kohn and Eitan, 2009), the pitch direction here indicates the most fundamental ascent and descent of a melodic line; and also higher or lower pitch of the music in signifying raising or lowering body movement in the context of perceived physical movement and music of a sports routine. As reviewed in Eitan's article (2013), empirical findings thus suggests the mapping of pitch and height affect perception, cognition and action in various way, where listeners associates higher pitch sound with higher location regardless of the actual source location (CABRERA, FERGUSAN, TILLEY & MORIMOTO, 2005; PRATT, 1930; ROFFLER & BUTLER, 1968). In dance, Dalcroze's technique of visualizing musical parameters and his integration of dance and music was mentioned in Mason's article (2012), where pitch in music is parallel with 'position and direction of gesture in space'.

Selecting Visual Stimuli - Routine

The video recording of the routine was made at a school gymnasium. The coach and the gymnasts participated in this study, and the purpose of the research was explained to them beforehand. The fifteen-year-old gymnast has a background of 12 years of training and substantial experience participating in local and international competition and was a medalist at many competitions. From the various sets of routines that are performed by the gymnast, a routine with a ribbon apparatus that lasted for 90 seconds (a standard duration of rhythmic gymnastics routines) was chosen for this experiment, which was accompanied by music entitled 'The Swallow', composed by Dmitri Malikov. The piece is a classical piano and orchestral composition in triple time. As acrobatic movements are involved, the routine was performed five times with the aim of achieving an optimal performance. All the performances were video recorded. Out of the five performances, the best performance was selected by the coach and researchers to be employed in this experiment. As the coach explained, the musical accompaniment was edited by the coach, and the routine was choreographed based on the edited music. Therefore, the music-dance relationship is entirely based on the coach's interpretation. To avoid a biased opinion regarding the choice and quality of the video from a more musical perspective, notable ex-gymnasts were consulted, and it was agreed that this routine was considered to be highly synchronized in terms of music and movement amongst gymnasts.

Composing Music Stimuli

Traits from the original video. In interviews, the coach revealed that the routine was choreographed based on the selected and edited version to match the movements, which means that the music was not used as 'background music'. In the realm of dance and sports routine, the use of accompaniment can exist either in the form of background music or non-background music. Background music provides an ambience towards the dance or routine, and does not or with limited requirement of 'match' in terms of musical elements. While the rules and regulation in sports routine such as code of points (2017-2020) and International Skating Union (2018) emphasize the importance of 'match' between music and movement, the level of congruence between music and movement in many competitions are always found very minimal. As mentioned earlier in previous literature (HARMAN, GARBATO & FORBERG, 2009), reasons could be varied from poor musical understanding, or limitations to match the intended choreograph to the music. After analysing the original performance

(in Video 1, defined below), the movements were found to be choreographed with the music in a number of ways. First, the highlights of certain movements were based mainly on selected pitch in a melody, which has less significance in terms of structure, harmony or articulation, accents or any highlights in the music. Leaps were accompanied by chord ascents, but no significant musical figure matched the jumps and throws of the apparatus. Second, the beginning of an element was sometimes placed in the consequent of a phrase, and the movement would be completed at the antecedent of a phrase. For example, some of the 360 degree turns begin at the end of a phrase and end at the beginning of a musical phrase. Third, the initiation of an element was choreographed based on a melodic figure, which could be in the middle or at the end of the phrase. The purpose could be explained in that the congruence was intended largely based on a melodic figure or certain ‘pitch’. Another congruence could be observed in which the ribbon patterns that feature spirals, circles and snakes were matched with running-note figures of the piano.

New accompaniment. After determining the best-performed video recording, the video was edited using LogicPro 8 to remove the original musical accompaniment and to allow for the composition of a new musical accompaniment for this routine. Because the aim of this research is to investigate the congruence between music and movement of routine, a new musical accompaniment was composed focusing on the six parallels between music and movement, i.e., phrasing, rhythm, accent, dynamics, tempo and direction. The changes included the following: starting and ending dance steps; synchronizing a series of movements in which turns were synchronized with the beginning and ending of a musical phrase; a sequence of runs leading to jumps that were accompanied with an ascend in melodic contour and an accent to match the jump; and ribbon-throwing that was accompanied by an ascent and accented notes. Table 1 shows the detailed intended parallels.

To eliminate the effects of preference in musical style, the new musical accompaniment was written in the Western classical style using orchestral instruments, which was similar to the original musical style. However, instead of a triple, it was written in 4/4 meter. As with the original musical accompaniment, the new accompaniment was composed in a minor key with a tonal melodic idea, although it occasionally ends with a cadence in a *tierce de Picardie*.

Table 1: Description on the changes made in the new accompaniment

Musical and movements Parallels	Changes in New Accompaniment
Phrasing (long)	Synchronized the beginning and ending of a movement sequence based on the beginning of a series of steps; sequence of runs.
Phrasing (short-melodic figure)	Used to complete a full 360 turn, execution of apparatus, etc.
Tempo	A faster tempo is generated due to the amount of movements observed from the routine and the fast movement of the athlete. Tempo was elevated from 125 crotchets per minute to 143 crotchets per minute. The new accompaniment was changed to 4/4 meter from triple time.
Rhythm	Dance steps were aligned to either the melodic rhythm or the accompanied rhythm pattern. The same goes for a series of hand movements, including in strokes that were generated to execute ribbons patterns. Anacrusis was given before the entry of a turn that aligned with the beginning of the bar.

Accent	Musical accents derive from designated loud pitch or timbre such as timpani, crash cymbals; climax from a fragment were matched with movements such as jumps and swinging of the apparatus.
Dynamic	<i>Crescendi</i> were added to match steps leading to a jump and climax sections, and certain chords and accents were added to highlight series of jumps or gestures of the apparatus. Changes in dynamics were also added along with the melodic contour. The sequences of jumps were also matched with the intensification and abatement of dynamics along with the designated phrasing.
Pitch Direction	Rising intervals were used to match jumps, and falling intervals were synchronized with the descent of the jumps. The same goes for the throwing of the apparatus. Intervals in rotations were used to match the vertical reiteration of hand movements for the apparatus execution.

Participants

Fifty-two undergraduate music students, aged between 20 and 23, participated in evaluating the two videos. The purpose of the study was explained to the participants, and they were asked to watch each video followed by completing a questionnaire. All the participants have a background in Western classical music of at least ten years. To avoid an irrational primacy effect and biased interpretation of either video, 26 participants watched and evaluated the video accompanied by the original music that was used by the gymnast followed by the video with the new accompaniment. Then, another 26 participants watched and evaluated the video with the new accompaniment first. The videos were projected in a lecture room, and the participants watched and evaluated in groups.

Procedure of Evaluation

Preparation of video. Two videos were prepared to be evaluated by the respondents, one containing the original musical accompaniment that was used by the gymnast, and the second video containing the new composition. To prepare both videos, the audio in the original video was removed. The first video (Video 1) was edited with the original soundtrack that was used by the gymnast, and the second video (Video 2) was edited with the new accompaniment. In this manner, we sought to ensure that the environments of the sonic quality of both videos were similar. For example, noises in the gymnasium were picked up at the time when the routine was originally recorded because the musical accompaniment was played through a sound system in which the quality of the sound in the video is rather poor. As a result of the editing process, the synchronization of the gymnast's movements and music duration of the first video was checked and compared such that it was similar to the original.

Questionnaire. Demographic questions included the participants' age and years of music training. The purpose of the evaluation was explained, and the participants were expected to provide an evaluation after each video. The questionnaire was categorized into two groups; the first and main category asked respondents to rate the level of congruence between the music and movements, including phrasing, tempo, rhythm, accent, dynamic, pitch direction and overall ratings. This category was followed by questions about the acrobatic quality in the performance of the rhythmic gymnastics routine, as referred to in

the Code of Points (2017-2020) from the International Gymnastics Federation (FIG). The questions included references to the perceived level of acrobatic quality between the music and the execution of the apparatus-ribbon (intensity), rotation (smoothness) and jumps and/or leaps (amplitude). All three aspects are categorized under the ‘difficulty’ section in the Code of Points. The rating was in the form of a five-point Likert scale (e.g., 1 = poor and 5 = excellent). Each experimental session lasted approximately 30 minutes.

Results

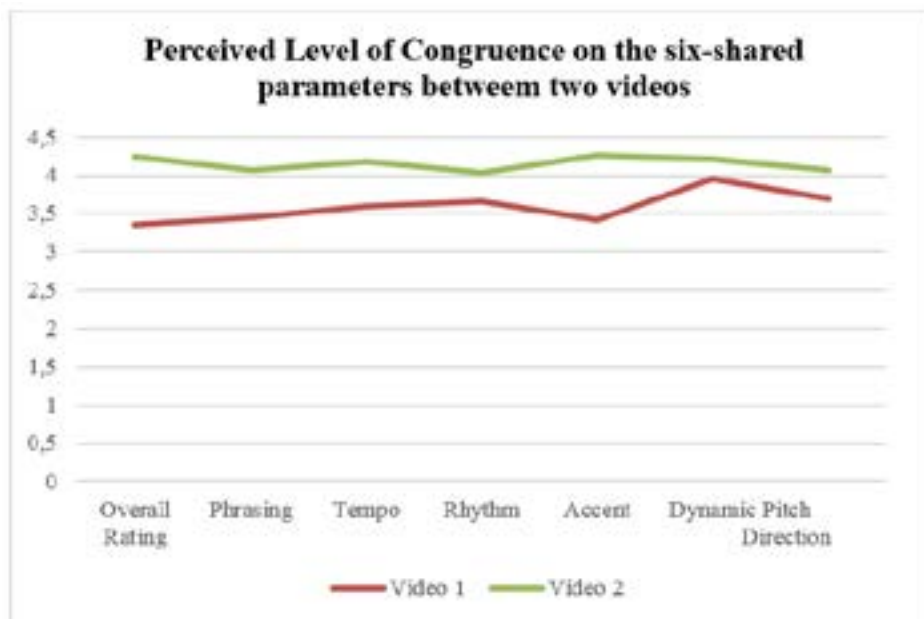
Perceived Level of Congruence. The comparison of the ratings was analysed using a paired-sample t-test, and a threshold of $p < 0.05$ was used to examine the statistical significance with a confidence level of 95%. Table 2 and Figure 1 reports the Mean (M) and Standard Deviation (SD) ratings of the participants, and the results show a significant difference between both videos in terms of the level of congruence for six parameters, including phrasing ($t = 4.004$; $p = 0.000$), tempo ($t = 3.415$; $p = 0.001$), rhythm ($t = 2.060$; $p = 0.044$), accent ($t = 5.224$; $p = 0.000$), dynamic ($t = 2.302$; $p = 0.025$), pitch direction ($t = 2.657$; $p = 0.010$) and the overall rating ($t(52) = 4.284$; $p = 0.000$). Further, Cohen’s effect size values were also calculated for overall congruence ($d = 1.05$; large effect size), phrasing ($d = 0.76$; moderate effect size) and accent ($d = 0.96$; large effect size); tempo ($d = 0.64$; moderate effect size); rhythm ($d = 0.40$; small effect size); dynamic ($d = 0.30$; small effect size) and pitch direction ($d = 0.42$; small effect size) [The effect size were based on the criteria of Cohen (1992): 0.20 = small; 0.50 = moderate; and 0.80 = large]. In general, the results reveal that the video with the new accompaniment received a higher rating for the six parameters.

Table 2: T-Test for the Perceived Level of Congruence on the six-shared parameters

	Video 1		Video 2		<i>t</i>	<i>sig-t</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
<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 *

Figure 1: T-Test for the Perceived Level of Congruence on the six-shared parameters



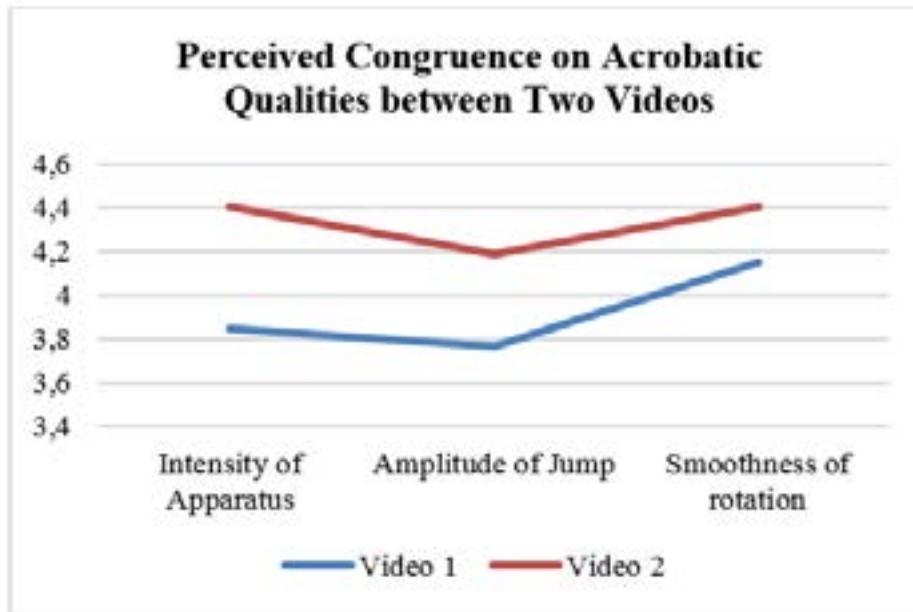
Perceived Acrobatic Qualities. The three acrobatic qualities were significantly different in the two videos and included intensity of throw-catch apparatus ($t = 5.51$; $p = 0.000$), amplitude of jumps ($t = 2.94$; $p = 0.005$), and smoothness of rotation ($t = 2.44$; $p = 0.018$) (Table 3 and Figure 2). The intensity ($d = 0.81$) yields a large effect while amplitude ($d = 0.48$) and smoothness ($d = 0.36$) yield a small effect. The higher quality of the intensity of the apparatus throw-catch execution might be directly affected by higher levels of congruence of accents between music and movement. The complete phrasing that enveloped a melodic figure and the patterns that accompany each 360 degree rotation thus both support a higher rating for the smoothness of rotation.

Table 3: T-Test for Perceived Congruence on Acrobatic Qualities

	Video 1		Video 2		<i>t</i>	<i>sig-t</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Intensity of Apparatus (throw and Catch)	3.85	0.794	4.40	0.660	5.51	0.000*
Amplitude of jumps	3.77	0.912	4.19	0.856	2.94	0.005*
Smoothness of rotation	4.15	0.690	4.42	0.819	2.44	0.018*

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

Figure 2 Perceived congruence on acrobatic qualities between two videos



Discussion

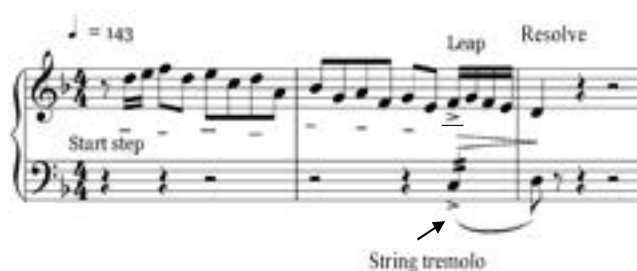
Perceived Congruence for the Six Parameters in Sports Routines. The intended increment of congruence for the six parameters that are shared by music and movement – or dance as derived from Hodgins' (1992) choreomusical analysis – was significantly perceived by the respondents in this experiment. The identification of the higher level of congruence in this experiment, with the overall significance in all parameters at $p = 0.00$, reinforced observers' perceived congruence between music and dance (KRUMHANSL & SCHENCK, 1997; MITCHELL & GALLAHER, 2001) and in the audio-visual condition, as in multimedia (BOLIVAR et al., 1994; IWAMIYA, 2013; MARSHALL & COHEN, 1988). The result that present a significantly higher level of visual perception for phrasing ($p = 0.00$), tempo ($p = 0.044$), and dynamics ($p = 0.025$) also supports the parallel of inferred musical structure or parameters from instrumentalists' gestures that are perceived by the audience, including phrasing (MACRITCHIE et al., 2013; WANDERLEY, VINES, MIDDLETON, MCKAY, & HATCH, 2005), tempo and dynamics (y et al., 2013). Although in the context of sports routine, that is different from the audio-visual perspective such as animation and film related aspects, this experiment similarly involved a viewing setting in which a performance was presented in a video format. However, considering issues related to interpretation or skill, there is a slight degree of variance in these studies because the music and sound are produced solely by the instrumentalists, in contrast to the gymnasts or dancers who 'dance' with and to the music.

The intended match between parameters and movements that increases the level of congruence in the routine also corroborates previous studies. For example, phrasings in music, motives, or figures are matched closely with the beginning and end of a movement sequence, either short or long. This matching associates with perceived gestures in instrumentalists found in y et al. (2005), in which performers' movements not only occurred noticeably at the beginning and ends of phrases but also related to the rhythmic structures of the phrases within the music. Phrasing or temporal structures in music can be reliably represented in bodily motion (VINES, KRUMHANSL, WANDERLEY, & LEVITIN, 2006). In the dance context, the length of phrasing also contributes to the stratification and/or

hierarchical structure ranging from units, to cells, to sections (Jordan, 2011), which reflect the motifs, groupings of notes, and figures in the musical structure.

Tempo and rhythm are certainly closely related because a designated rhythmic structure is strongly affected by the existing tempo. As a result of the rapid movement that characterizes most rhythmic gymnastics routines (except for certain choreographed routines using the ball apparatus), this relationship similarly arose in the routine in this study. From the action-packed choreography, a faster tempo from a crotchet beat of 125 beats per minute to 143 beats per minute was used, and the results were that the musical tempo was rated as having more congruence with the routine. The density that contributes from the faster music and accented chordal passages with trills, arpeggios, and running notes figures in the routine echoed the findings in IWAMIYA (2013: 149) on perceived congruence between auditory and visual elements in multimedia, which noted that musical tempo affected not only speed but also brightness and crowdedness. However, the perceived change in tempo also affects and depends on other parameters, particularly rhythm, melodic contour (direction), dynamics, and phrasing. EITAN AND GRANOT (2006) posit that interactions between musical parameters cannot wholly predict music-motion mapping, such that 'both loudness and pitch and tempo significantly interact in conveying distance change' (EITAN, 2013, p. 180). This also affirms that the change of dynamic in video 2 was significantly perceived such as *crescendi* in series of steps, together with the intensification and abatement within a phrase to match a sequence of movement or rotation in the routine. In addition, pitch direction adjusted in video 2 in matching the ascent and descent of jump also contributed to the better congruence, which will further elaborated in the following acrobatic quality.

The strengthening of the congruence in rhythm with the intended matching of movements and steps in Video 2 was also borne out in the ratings (Example 1). In the field of dance, rhythm is one of the most obvious parameters that is emphasized by many choreographers, particularly Balanchine. Balanchine stressed rhythm and musical pulse, which has been emphatically noted by many scholars (HODGINS, 1992; JORDAN, 2011; KRUMHANSL & SHENCK, 1997; MASON, 2012), and he believed that the two parameters formed the foundation of his choreography.



Notes: a) – : indicating the steps of the gymnast according to the rhythm.

b) The leap from the series of steps match with an accent (by the main melody and the accompaniment)

Example 1: Step is matched with the designated musical rhythm and pulse (simplified version from full score).

The enhancement of accent in Video 2 that contributed a better congruence between movement and music in matching figures such as peak of jumps, swing or catch of apparatus thus corresponding to the description in LIPSCOMB (2005: 38) 'point of emphasis' in the field of aural and visual sensory in the field of multimedia. Further, the matching of accent

towards point of movement also serves to parallel with the theory of audio capture that leads to bounce-inducing effect (GRASSI & CASCO, 2010) although the various effect of a particular jump or swing could be examined in future studies. However, the intended accent thus provide a better ‘amplitude’ and ‘intensity’ in the acrobatic qualities which will be discussed in the following section.

Perceived Congruence in Enhancing Acrobatic Qualities. The interpretation of music in the code of points was definitely more precise from the revised regulations (2017-2020). New statements such as dance step combination must follow ‘according to the tempo, rhythm, musical character and accents’ (refer to 4.1.4) and ‘The movements of the body as well as the apparatus must correlate precisely with the musical accents, and the musical phrases; both the body and apparatus movements should emphasize the tempo/pace of the music’ (refer to 4.2.1), thus confirming the importance of congruence between music and movement. In this experiment, the increased congruence were not only identified but also found to enhance the perceived acrobatic quality. Even to a non-trained athlete, throwing and catching the apparatus is one of the most prominent elements in a rhythmic gymnastics routine. To increase the intensification of the apparatus elements, all six occurrences of swing-throw ribbon executions were matched with accents that were generated from the melodic idea as well as the climax within or at the end of a phrase or figure (Example 2). Accents were also enhanced with cymbal crashes or timpani to amplify the peak of the swinging of the ribbon. The condition similarly applies to the amplitude of jumps in which the accents that were derived from the peak of a melodic figure were used to demonstrate its significance. Providing an accent for these acrobatic movements illustrates how Lipscomb enumerated the definition of accents as ‘point[s] of emphasis’ within the aural and visual sensory fields (LIPSCOMB, 2005: 38), which are thus parallel to the perceived acrobatic moments. The matching accents between music and these movement elements are thus corroborated with prior research, particularly in terms of formal congruence, in which synchronized accents between audio and visual elements enhance perceived congruence (IWAMIYA, 2013: 145).

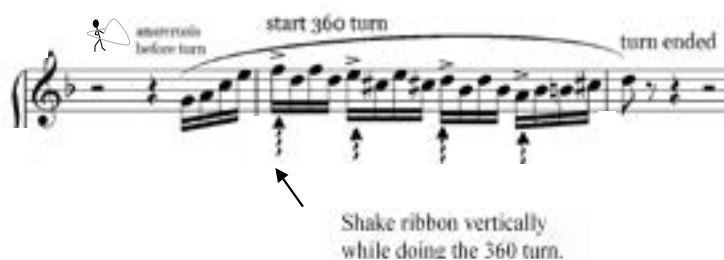
The image displays two musical staves with various annotations. The top staff is in treble clef and the bottom staff is in bass clef. Annotations include: 'Start phrase' with an arrow pointing to the beginning; 'Swing-throw on the ribbon' with an 'x' above a note; 'Jumps and catch ribbon' with an 'x' above a note; 'Jump' with an 'x' above a note; 'Resolve' with a curved arrow; 'X Cymbal crash - Jump/ swing up' with an 'x' below a note; and 'Timpani: landing and steps' with an arrow pointing to a note in the bass staff. The second staff has annotations: 'Swing-throw off (up) the ribbon' with an arrow; 'climax cymbal crash' with an 'x' above a note; 'catch ribbon' with an 'x' above a note; and '(Body turn 360 degree for two times before catching the ribbon)' with an arrow pointing to a note in the bass staff. The word 'timpani' is written below the bass staff.

Example 2: Accent and cymbal crash to indicate the swing-throw of the apparatus (simplified version from full score).

However, it should be emphasized that the current study was evaluated after respondents watched the entire routine, and the individual parameters were not examined in terms of a particular excerpt of the routine because we aimed to ensure that the evaluation would yield a more faithful response with regard to how a common spectator would watch a video clip. As EITAN and GRANOT (2006) argued persistently, each kinetic feature could be evoked by several musical parameters. The melodic accent did not act solely as a single parameter in providing the congruence. Other factors that support the congruence include a rising interval together with a slight crescendo supporting the increase of the interval. Delivering a curving contour, the closing of the jumps were also followed by the accompaniment of the abatement that was formed by the melodic figure. The rising intervals in the melody for all the jumps and throws and catches of ribbon in this experiment that were used to match the vertical motion also support how Monahan and CARTERETTE (1985: 2) associated accents as ‘pitch level’ or ‘the absolute value of pitch changes’. In providing the momentum that leads to a jump, the designated rhythm that synchronized the steps before the jump also enhanced the amplitude of each jump. As the jump elements in this routine were always generated from an acceleration of walking to running leading to the jump, this matches the description in EITAN AND GRANOT (2006: 237) of their experiment in which the participants described ‘the motion accompanied by crescendo as a walk turning into run, or as a walk terminated by a leap’, despite an expected approaching motion and increase in velocity. In addition, the higher rate of perception in phrasing parallels the initiation and resolve in a jump or series of jump sequences also parallels the intensity contours suggested and studied by music theorists. The combination of musical parameters thus justified the curve of musical intensification and abatement – which is not defined by a specific parameter but by its ‘global growth contour’ – and is a combined activity with diverse parameters (KURTH, 1991).

The perceived intensity and amplitude of the apparatus and jumps could be similarly associated with the theory of ‘audio capture’ that produced the ‘bounce-inducing’ effect (GRASSI & CASCO, 2010) that is discussed above. Although this notion applies to a music-motion experiment, the ‘bounce’ effect is generated by the synchronization between the jump, throw or catch of the apparatus, and the musical accents indirectly increase the perceived level of intensity and amplitude. In addition, it indirectly increased the perceived ‘energy’ of the athlete.

The intrinsic parallel given to all four 360 degree rotations is the phrase structure of a melodic figure to initiate and then to resolve each execution. In this experiment, the smoothness of the rotation in Video 2 relies more on the one-bar phrase that completes the 360 rotation (Example 3), where the analysis reveals that the congruence between music and movement in the rotations in Video 1 was obscured as it followed the pitch in the melodic idea rather than in the structure of the music.



Example 3: The initiation and resolve of the 360 turn parallel with the phrase of a melodic figure (simplified version from full score).

Conclusion

This experiment reveals that an increased level of congruence between music and sports routines could enhance a better visual perception on sports routines in selected parallel parameters between music and movement, including phrasing, tempo, rhythm, accent, dynamics and direction. Under the same circumstances, the quality of acrobatic elements, such as the amplitude of jumps, smoothness of rotations and the intensity of apparatus use were all significantly increased as the level of congruence rose. The congruence examined in this study also further supports studies of the relationship between music and movement-related subjects from various directions as in dance (KRUMHANSL & SCHENCK, 1997; MITCHELL & GALLAHER, 2001), in film (BOLIVAR et al., 1994; LIPSCOMB, 1992; LIPSCOMB & TOLCHINSKY, 2005; MARSHALL & COHEN, 1988; WATKINS, 2018), in music performance and gesture (DAVIDSON, 1993; MACRITCHIE et al., 2013; LEMAN, MAES, NIJS & VAN DYCK, 2018) and in psychomusicology (EITAN & GRANOT, 2006; GRASSI & CASCO, 2010; IWAMIYA, 1994, TAN, PFORDRESHER, HARRÉ, 2017). While the parameters have been examined individually in most studies, our study sought to examine these issues in the actual form of the event to acquire the perception of the moment when the event was projected as a completed mode. The purpose of this experiment also suggest a methodological solution for the use of music in sports routines, and it reduces the limitations and the unnecessary compromises to musical details that are not particularly intended for those with less musical background. Although the routines that are considered may be from the field of sports, subjectivity regarding aesthetics and artistry are inevitably similar to the field of dance. Therefore, the approach in this study that drew on concepts from music, choreography, and sports routine (choreo-sports-musicology) could further be explored with various effects by integrating audio-visual elements. A perfect audio-visual integration in these choreographical subjects may not be feasible, but the established scientific literature should not be neglected when considering the effects produced when music and movement are used simultaneously in any subject. However, extended research is required to examine this perception with a larger audience sample that includes different backgrounds because experts, novice or audiences without any training in music and movement-related activities may have different perceptions of these same phenomena.

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