

Does jumping to the beat result in better ratings from gymnastics experts?

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ABSTRACT

How does auditory information influence the perception and evaluation of complex skills? Especially in technical compositional sports, such as gymnastics, the visual information perceived by the judges (and coaches) is the subject of an immediate evaluation. Various factors influence the judges' performances. The impact of auditory information on the evaluation of complex skills is predominantly unexplored. Therefore, the study aimed to investigate floor music's role in female gymnastics routines. Participants with different gymnastics expertise were asked to rate acrobatic series on the floor in three different audio-visual conditions (original, inter-beat, matched-beat). The current study results show that participants (irrespective of the group) rated acrobatic series in the matched-beat higher than in the original condition. In conclusion, it would be interesting to investigate if an effect on the participants' perception is given for other gymnastics skills (gymnastic jumps and leaps) or the overall (execution) score on the floor.

Keywords: Action perception; Auditory information; Floor routine; Evaluation; Acrobatic series.

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INTRODUCTION

Music is a constant companion for many people these days. It seems that music is taken for granted by many people, which may be related to the almost limitless music availability. This development has also influenced the connection between music and sports, particularly marked by the further development of technical equipment (Postuwka, 2006). This applies similarly for the Olympic Games, where the combination of music and movement has played an important role ever since, especially during the opening and closing ceremonies, for sporting events, and for the fitness industry, where "spinning" or "aerobics" would hardly be conceivable without music. The diversity of music use is made clear by its equally associated expectations (e.g., motivational, supportive, guiding purposes, therapeutic effect) (Greder, 1997). The investigations of the influence of music on movement or the connection of music and movement have an extended history, with music's influence on (motor) activity being the main focus so far (Postuwka, 2006). But how does music or auditory information influence the perception and evaluation of complex skills? Why is it important to know if and how the observers' perception is affected?

Especially in technical compositional sports, such as gymnastics, the visual information perceived by the judges (and coaches) is the subject of an immediate evaluation. Consequently, the judges' perceptual process is significant for the final ranking of the athletes (Ste-Marie, 1999). Various factors influence the judges' performances: i.e., gaze behaviour (Pizzera et al., 2018), viewing position (Plessner and Schallies, 2005), and motor experiences (Heinen et al., 2012). The impact of auditory information on the evaluation of complex skills is predominantly unexplored. The question yet arises how different components, especially music, influence experts' perception during the observation and evaluation of complex skills. Therefore, the following study aimed to investigate the role of floor music in female gymnastics routines.

In female gymnastics, floor music is a central factor in the composition of the floor exercise. It is known from music psychology that musical parameters such as tempo and volume have a direct physiological effect (Plahl, 2008). Listening to music triggers spontaneous neuronal activities of action planning and action initiation, fundamental for recognizing and learning actions (perception-action-system) (Plahl, 2008). In the perception process, perceived information is transferred to the possible execution of actions (Koelsch and Schröger, 2008). In addition, the perception of auditory information is impossible to fade out, so there is always conscious or unconscious information processing of auditory information (Eysenck and Keane, 2015).

The floor exercises' scoring rules also include the interaction of floor music and movements of the floor routine. If this is not sufficiently the case, deductions of 0.1 to 0.3 points may be made (FIG, 2009). A noticeable characteristic that music and movement may or may not match be the speed of movement with the music's tempo. Different tempi (bpm) are perceived dissimilarly. Tempi around 100 beats per minute (unit of tempo) are perceived as neither too fast nor too slow, i.e., as moderate. London (2004) provides an overview of the range of perceived tempi. Tempi of music that is between 80 and 120 bpm are called useful tempi. The perceived tempo depends on the mental information processing (Bruhn, 1998).

The fact that music is essential in sports and for perception and for the evaluation of complex skills in technical compositional sports is made clear by the study of Chiat et al. (2013). They investigated the perception of congruence between music and gymnastic skills in floor routines in rhythmic gymnastics. The authors asked 52 musicians to rate the choreography's quality of a routine in rhythmic gymnastics regarding the congruence between music and gymnastics skills from a musical perspective. The musicians had to evaluate videos with the same routine and choreography but different music. One video was accompanied by the gymnast's original music and the other by new music. The new music was re-composed based on the gymnasts'

choreographies, meant to analyse the gymnastics skills and choreography and construct the music elements to fit the routines exactly. The results show that more participants perceived a better congruence of skills and music in the video version with the new music.

Previous studies on perception and evaluation of complex skills and on the influencing factors of judging performance, except the study mentioned above, have focused on visual aspects (gaze behaviour, Pizzera et al. (2018), viewing position, Plessner & Schallies (2005)) or on the influence of one's motor experience (Heinen et al., 2012; Pizzera, 2012).

Besides these factors (gaze behaviour, visual and motor experiences) mentioned above, Joustra et al. (2020) have shown an effect of the order in which the female gymnasts performed on the execution score of the gymnasts' exercises. The gymnasts who started later received a higher score. An effect on male gymnasts' performance scores could not be shown. They included all European and World Championships and Olympic Games' apparatus finals that took place between 2009 and 2017 (nine European Championships, seven World Championships, and two Olympic Games) in their analysis. A study by Bruine de Bruin (2006) revealed a significant effect: those figure skaters who entered later were rated higher than those who performed earlier.

Additionally, different studies show that the auditory information supports the visual information in the perception process during movement control (Heinen et al., 2014, Kennel et al., 2015), movement evaluation, and anticipation (Sors et al., 2018, Veit and Heinen, 2019). Veit and Heinen (2019) asked different groups (i.e., current gymnasts, former gymnasts, judges/coaches, and laypeople) to observe and evaluate complex gymnastics skills. The participants had to evaluate straight back somersaults' duration in three different conditions (visual, audio-visual, and auditory condition). The results show that the participants made the most correct decisions in the audio-visual condition. It seemed that visual and auditory information interact and support each other.

The results of previous studies suggest that different sensory information have an impact on the perception of complex skills. The main focus of research on gymnastics experts' perception processes has been on the influence of visual information. In various contexts, the auditory information gained more attention in the past (e.g., agent identification, anticipation). That the natural sounds of movement in gymnastics influence the perception of complex skills has already been investigated (Veit, 2020). As a result of contacting the floor during acrobatic series, the thumbing sound is mostly not perceptible for judges in female gymnastics during a competition, because of the simultaneous music playing. However, it is primarily unexplored what role music plays in the perception and evaluation of complex skills, especially in gymnastics. The question yet arises how music influences observers' perception during the observation and evaluation of complex skills. Therefore, the study aimed to investigate the floor music's role in female gymnastics routines in the evaluation of complex skills in gymnastics.

It was hypothesized that music (matching the movements) influences the observer's (irrespective of the group - experts and laypeople) perception and thereby, the evaluation of complex skills (Eysenck and Keane, 2015). It was additionally expected that laypeople and experts could be influenced similarly, because this is based on the perceptual processes that cause the influence (Plahl, 2008). As the judges are also dependent on perceiving the music, because it is part of the evaluation, they cannot "fade out" the music. Furthermore, it was hypothesized that if the tempi of the music match with the speed of movement, the participants rate the complex skills with a higher score than if the tempi do not match (Chiat et al., 2013).

MATERIAL AND METHODS

Participants

In total $N = 30$ participants took part in this study (age range: 18-37 years, five male and 25 female participants). The number of participants (minimum 28 participants) was derived from a power analysis when expecting a medium effect (Cohen's $f = 0.25$, type-I-error probability = 5%, type-II-error probability = 20%) (Cohen, 1998). The participants were categorized into two groups, depending on their (motor and visual) experiences and expertise in gymnastics: group 1 - neither motor nor visual expertise with the experimental task ($n_1 = 15$ laypeople), group 2 - vast visual experience (visual expertise) with the motor task ($n_2 = 15$ experts). The laypeople never did gymnastics before and/or had no experiences watching gymnastics. The experts had essential expertise (minimum of five years) to observe and judge gymnastics skills in general.

To have reference values as a baseline for the acrobatic series, three high-level judges (A-level license, which is the fourth of five levels in the German judges' education) were asked to judge the experimental stimuli in the original condition.

Participants were excluded if they stated any hearing disorders and any visual impairments. The participants were also informed about the general aim (auditory and visual perception of complex skills) and the study's specific procedure. Before data collection they gave their informed consent. The study was conducted in line with the ethical guidelines of the local ethics committee.

Measures

Stimuli generation

The study's experimental task was to observe and to evaluate an acrobatic series on the floor. Namely a round-off, followed by a back handspring and a straight back somersault. Combining these three gymnastics elements represents a common acrobatic series on the floor (Arkaev & Suchilin, 2004). In the German elite program of gymnastics, the series is provided for age groups up to 10 years to perform it on the floor (similar in the USA) (DTB, 2018, USA Gymnastics, 2018). It is desirable to maximize the flight duration and optimize the straight back somersault's angular momentum, which requires a high performance of the round-off and the back handspring as preparatory elements (Prassas et al., 2006).

Prior to data acquisition, eight female gymnastics experts, who performed the experimental task in their floor routine, were filmed during the competition on a standard gymnastics spring floor. Their acrobatics series was videotaped with a Full-HD digital video camera (50 Hz). The camera was placed approximately orthogonal to the execution direction.

The software iMovie edited the recorded video sequences to scale the size of the gymnasts nearly to the same body size (taking into consideration that it still looks "*normal*"), to determine a uniform length of the video sequences, and to turn the video sequence into a black-and-white video-clip. This was done to reduce irrelevant and distracting features and information (e.g., personal characteristics, leotard colour, etc.) to make it easier for the participants to concentrate on the movement information. In addition, the original sequence of the floor music was added to the video clip to have a clear auditory sound.

Besides the original video sequence, two additional versions were generated using the software iMovie (version 10.1.14) and Logic Pro X (version 10.6.1). For these versions, the original video clips were assembled with selected parts of music. In one condition, the beat of the selected music does not match with the feet' or hands' contacts, but lies exactly between these floor contacts, named the "*inter-beat*" condition.

In the other condition, the beat of the chosen music fits exactly in the feet' and hands' contacts with the floor during the acrobatic series. The condition is named the "*matched-beat*" condition. To find out which track fits with which performance, the frame rate of the acrobatic series was determined. The frame rate arises out of the feet and hands contacts with the floor while performing the acrobatic series, namely the contacts from the leap of the round-off to the leap of the straight back somersault. The frame rate also corresponds with the tempo, thus beats per minute (bpm), of a composition. For example, the performances possess a frame rate of 85 bpm to 105 bpm. The beats per minute's range complies with the perceived moderate to moderate fast tempi (London, 2004). Simultaneously, the moderate or moderate fast tempi constitute the preferred tempo for perceived rhythm (Fraise, 1982).

At the end of the processing procedure, every video sequence was available in three divergent versions, which were used for the three different experimental conditions.

Experimental task and conditions

The participants' experimental task was to observe and evaluate video sequences of the acrobatic series on the floor. Video sequences were presented on a 27-inch computer screen. The video sequences' auditory information was played back via a Sony MDR-XB950AP headphone (Sony Corporation, Tokyo, Japan).

After observing a video sequence, the participants had to evaluate the quality of the acrobatic series' execution. They registered their evaluation decisions on an analogue rating scale from 0 to 100 on a tablet computer. The scale values of the rating scale correspond with the introductions for evaluating technical norms of the German Gymnastics Federation (DTB, 2019). In total, participating in the study took 15 minutes.

Three conditions arose out of the stimuli generation described above: 1) baseline (unchanged video file and auditory information), 2) "*inter-beat*" auditory information of the floor music (beat) is located incongruent to the floor contacts, and 3) "*matched-beat*" auditory information of the floor music (beat) and the floor contacts are located exactly on top of each other. The eight videos in three different conditions resulted in 24 video sequences that had to be evaluated. They were presented in a randomized order.

The centre of interest was the participants' evaluation of each video sequence. For each video sequence, average scores for all experimental groups and conditions were calculated. The evaluation score arose out of the analogue scale from 0 to 100, which means that a video sequence could be rated with a maximum of 100 and a minimum of 0. Participants' evaluations were recorded through an online questionnaire by using a tablet computer.

Questionnaire

The data was collected using an online questionnaire. It started with a general part, which included socio-demographic questions (age and gender), followed by a specific part. The specific part queried the participants' specific experiences in gymnastics. Besides the current activity in gymnastics (as a judge/none of the presented activities), every participant had to answer the question if he/she ever was able to perform the acrobatic series included in the study (round-off, back handspring, and straight back somersault). The answer to the current activity splits the following questionnaire into two parts. The experts (judges) were asked to give information about their license level, number of judging hours, competitions level, and if the acrobatic series is an integral part of their judging sessions. After asking participants about their ability to perform the acrobatic series, the laypeople were directly redirected to the third part of the questionnaire, the evaluation of the experimental stimuli.

The third part of the questionnaire was one analogue scale for each trial (in total 24 video sequences in randomized order) during the evaluation of the experimental stimuli.

Procedures

The study was structured in four phases. The first phase serves as a pretext to extract a baseline out of the original video sequences' evaluation values. The pretext was conducted by three expert judges (A-level license).

In the second phase, the data collection started. In total, the study lasted about 15 minutes per participant. The participant arrived at the laboratory and was informed about the procedure, and the study's general aim. Then the participant filled out the first two parts of the questionnaire (socio-demographics and specific current or past gymnastics experiences as a coach, or gymnast, and as a judge) on a tablet computer. Afterwards, the participant received a short introduction about the evaluation criteria for the acrobatic series. Three videos with ascending execution quality were shown to familiarize the technical norms and get used to the experimental task. Finally, the participant had time to ask emerged questions.

Following the orientation-videos, the third phase comprising the data collection started. After watching one video sequence, the participant evaluated the execution quality on an analogue scale on the tablet computer. He/she had ten seconds to mark their evaluation before the next video sequence started. The participant was informed that if he/she needed more time for evaluation, he/she could pause the playback with the space bar. In orientation towards the competition conditions, they were allowed to watch the sequences once. Every participant had to evaluate 24 video sequences that lasted up to 7 minutes and 25 seconds in total.

The fourth phase included a debriefing and appreciation for participating in the study.

Analysis

The level of significance was set at 5% for all results. Before main hypotheses were tested, it was determined whether the data met the assumptions for analysis of variance. The results of the Shapiro-Wilk test and the Mauchly test revealed that the data could be considered to be normally distributed and that the assumption of sphericity was not violated.

To test the main hypotheses, a 2 (*group*: 1) laypeople, 2) experts) x 3 (*condition*: 1) original, 2) inter-beat, 3) matched-beat) analysis of variance (ANOVA with repeated measures) was conducted. The average of the evaluation scores was used as dependent variable. The group was treated as between-subject factor, and the condition was treated as within-subject factor.

RESULTS

It was hypothesized that music (matching the movements) influences the observer's (irrespective of the group - experts and laypeople) perception and thereby, the evaluation of complex skills (Eysenck and Keane, 2015). It was additionally expected that laypeople and experts could be influenced similarly because this is based on the perceptual processes that cause the influence (Plahl, 2008). As the judges are also dependent on perceiving the music, they cannot "fade out" the music because it is part of the evaluation. Furthermore, it was hypothesized that if the music's tempi match with the speed of movement, the participants rate the complex skills with a higher score than if the tempi do not match (Chiat et al., 2013).

An analysis of variance (ANOVA) with repeated measures was calculated to test the hypotheses. As a dependent variable, the average of the evaluation scores was included. The ANOVA results show a main effect of condition ($F(2,58) = 4.077, p = .022$, Cohen's $f = 0.38$), no main effect of group ($F(1,28) = .474, p = .497$, Cohen's $f = 0.13$). There was no interaction effect of group and condition. The results suggest different evaluation scores across the conditions. The post hoc tests demonstrate that the participants rated the acrobatic series in the "matched-beat" condition significantly higher than in the original condition. Additionally, there was neither a significant difference between the original condition and "inter-beat" condition, nor the "matched-beat" condition and "inter-beat" condition. Interestingly, a detailed inspection of the groups' evaluation scores within the conditions shows that the laypeople's scores do not significantly differ from the experts' evaluation scores.

Figure 1 shows the means and standard errors of the participants' scores in the different conditions.

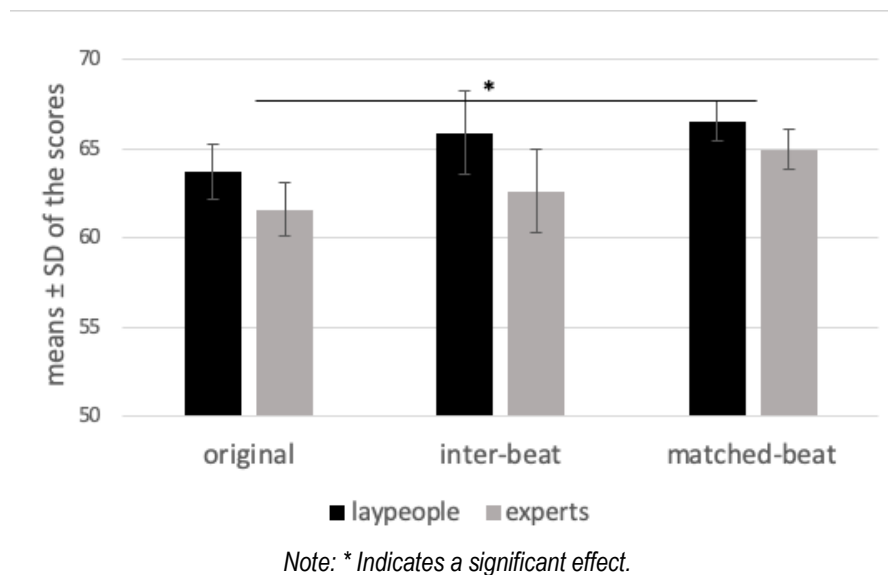


Figure1. Means and standard errors of the participants' scores within the different conditions.

DISCUSSION

The study aimed to investigate the role of auditory information of female floor routines during the observation and evaluation of complex skills in gymnastics. The participants had to evaluate 24 video sequences of the acrobatic series on the floor in three different conditions. The participants differed in their expertise in gymnastics (laypeople with no experience in gymnastics, experts with vast visual experiences in gymnastics).

The results show that participants rate the acrobatic series differently across the three conditions. It seems that participants could be influenced in their evaluations by the auditory information, i.e., when the music's tempo matched the speed of movement. Following music psychology assumptions, musical parameters such as tempo and volume have a direct physiological effect (Plahl, 2008). One could speculate that the physiological impact could lead to an increasing score in the participants' evaluation.

This assumption of music psychology would support the observations and findings of Chiat et al. (2013) and the current results. However, the difference is that it seems to be sufficient that only the music's tempo

matches the speed of movement instead of re-composing new music based on the shown gymnastic skills. In previous studies, the expert-novice comparison was often used. The results show that the groups do not differ significantly in their ratings. It should be highlighted that the direction (giving better ratings) in which they might be influenced is the same. This could be explained by human beings' perceptual processes (Eysenck and Keane, 2015).

The results shown mean for the judges' function that he/she is "*caught*" up in his/her task because the floor music has also to be considered in the evaluation of the floor routine (FIG, 2009). For this reason, they cannot "*hide*" it, unless the tasks in the judging panel are distributed so that one person is exclusively responsible for judging the fit of choreography and the others are responsible for judging the technical execution and correct performance of movement and difficulty of the elements without hearing the floor music. Furthermore, the fading out of auditory information purely from the perceptual processes is only possible after intensive and continuous training of this (Eysenck and Keane, 2015).

There are several limitations of the study, whereas two aspects should be highlighted. Even though the videos were presented grayscale, several gymnasts' characteristics are still recognizable, leading probably to an influence. It may be that the unusual presentation in grayscale, which are rare stimuli in the current era, influenced the experts in general, even if none of the participants expressed this at the end.

Second, the motor task was an acrobatic series on the floor, namely round-off, back handspring followed by a straight back somersault. The acrobatic series aims a correct technical execution of gymnastic skills and maximizes the flight phase in a backward somersault. The study results suggest that the acrobatic series' musical support through adapted floor music will result in higher scores (of execution). It would be interesting to explore if the same observation can be made for other gymnastics skills when the movements have different movement goals.

CONCLUSION

Following the current results, one could conclude that the fit of the floor music and the movements, especially the fit of the tempi of music and the speed of movement, influences the participants' perception, reflected in significantly better ratings. Therefore, a sensitization for gymnasts (to choose the floor music carefully) and for judges could be beneficial.

Further investigations would be necessary to determine if there could be an influence on the overall score of the floor routines in female gymnastics. The routines are composed of different contents, and the acrobatic series is only one of them. Therefore, it would be interesting to investigate if the effect on the participants' perception is given for other gymnastics skills (gymnastic jumps and leaps) or the overall (execution) score. A subsequent investigation may be to ask judges to evaluate gymnastic jumps and leaps on the floor or judge a whole floor routine to determine if music's tempo or rhythm influences the judges' perception. Additionally, it would be interesting to investigate, if a similar effect could be found in other technical compositional sports.

AUTHOR CONTRIBUTIONS

Frederike Veit. Collected data, conceived and designed the analyses, performed the analysis, wrote the paper. Lisa Riedel. paper editing. Damian Jeraj. paper editing.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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