

The Influence of Music on Judges' Evaluation of Complex Skills in Gymnastics

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ABSTRACT

In technical compositional sports, such as gymnastics, judges' decisions regarding deductions for errors in an athlete's execution of complex skills lead to the final evaluation of the exercise shown. Different variables can become important in the context of decisions in sports, and consequently, various factors influence the judges' performances. Therefore, the current study aims to investigate the influence of music on the evaluations of female gymnastics floor routines. Participants' task was to evaluate gymnastic series on the floor in three different conditions (audio-visual, beat-matched, and visual). The results show that the participants (22 judges and 22 laypeople) rated the executions of the gymnastic series in the beat-matched condition (unchanged video file and selected music) higher than in the audio-visual (unchanged video file and auditory information) and visual (unchanged video file and no auditory information) conditions. By the fact that performances in the beat-matched condition are rated the highest by the judges, one could conclude that it makes it worthwhile for the gymnasts to select their music so that the rhythmical structure coincides with the corresponding motor activity.

Keywords: auditory information, auditory perception, female gymnastics, floor routine, judging

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I. INTRODUCTION

Making decisions is everyday task humans are confronted with. In sports, decisions can make the difference between victory and defeat. Different variables can become important in the context of decisions in sports, such as who is asked to make a decision (coach, athlete, referee, or judge) and when (in a timeout, during a motor skill).

Decisions are to be ascribed to a particular significance in evaluating complex skills. In technical compositional sports, such as gymnastics, judges' decisions regarding deductions for errors in an athlete's execution of complex skills lead to the final evaluation of the exercise shown. The basis for the decisions is the visual information that the judges take in and process. Consequently, the judges' perception process is crucial for the ranking of the athletes (Findlay & Ste-Marie, 2004; Heiniger & Mercier, 2021; Ste-Marie, 1999). This means that the perceived information is, at the same time, the subject of an evaluation. The human perceptual system is understood as a multisensory system. Consequently, perception comprises different components (Bremner *et al.*, 2012). Sensory information taken in from the environment interacts with each other (Ernst & Bühlhoff, 2004; Goldstein & Brockmole, 2010).

Regarding what triggers the perception of information or stimuli in the brain, it is already known that the observation of movements, for example, activates the same regions in the brain as the actual execution of movements or even the imagination of movements (Rizzolatti & Craighero, 2004). The occurrences have already been proven for a long time concerning visual stimuli. Woods *et al.* (2014) were able to show in their study that the auditory perception of familiar sports sounds known to the participants can also trigger activation in the brain. Kennel *et al.* (2014) were also able to show that movement sounds can be used to distinguish whether the movement is one's own, that of a familiar person, or that of a stranger. The results support the assumption that perception and action are closely related.

Various studies have already demonstrated the assumption that perception and action interact. These include, for example, studies showing the influence of the perception of auditory information on motor controls. In their research on long jumping, Hildebrandt and Cañal-Bruland (2021) were able to show that concurrent, action-induced auditory feedback influences the coordination of complex, rhythmic motor tasks. Within two experiments, they investigated, on the one hand, if and which effects existing or missing auditory feedback has on gait, gaze behavior, and performance outcomes. On the other hand, they investigated the influence of simultaneous or delayed auditory feedback on the same three parameters as in the first experiment. Results show deteriorations in gait, gaze behavior, and performance outcome.

Back in 2006, Baudry and colleagues conducted a study in gymnastics in which they investigated the influence of concurrent auditory feedback. One group of gymnasts trained about 300 circles during a two-week training period on the pommel horse apparatus without receiving concurrent feedback. A second group trained with the same training volume but received concurrent auditory feedback. In a pre-test and a post-test, the segmental body alignment was measured. The experimental group showed an improvement in the body segmental alignment at post-test. The authors conclude that the gymnasts receive relevant kinesthetic information through auditory feedback, which they can use to improve their movement performance continuously. A follow-up test after a further two weeks, during which the participants in the experimental group did not receive any other concurrent auditory feedback, was used to check whether dependence on the feedback developed during the training phase. The results showed an improvement in the body segmental alignment even without the auditory feedback.

In addition to the fact that auditory information can affect motor control, it could be shown in gymnastics that motor experience, in turn, can affect the perception and evaluation of motor skills (Heinen *et al.*, 2012; Pizzera *et al.*, 2018). For the present study, the evaluation of motor skills is of particular importance. The reason for its particular importance is, as described above that in technical compositional sports such as gymnastics, the judges' movement perception and the underlying perceptual processes are crucial for the athletes' ranking (Findlay & Ste-Marie, 2004; Heiniger & Mercier, 2021; Ste-Marie, 1999).

Besides the fact that one's own motor experience (Heinen *et al.*, 2012; Pizzera, 2012) influences movement perception and evaluation, various studies have highlighted other influencing factors, i.e., gaze behavior (Pizzera *et al.*, 2018), viewing position (Plessner & Schallies, 2005), competitors' order (Joustra *et al.*, 2020), national bias (Leskošek *et al.*, 2012) and sequential bias (Damisch *et al.*, 2006). In a study regarding the influence of the judges' perspective on the evaluation of the cross on rings, Plessner and Schallies (2005) could show that the angle of view influences the evaluation. Forty participants (20 judges and 20 laypeople) had the task of evaluating the element *the cross* on the rings on 36 photos (12 different executions from 3 different perspectives) regarding the deviating angle from the optimal execution (according to FIG). The results show that the judges outperformed the laypeople in evaluating the complex skill. Furthermore, the judges were significantly influenced by the angle of view. The error rate increased with increasing deviation from the front sight on the element.

Joustra *et al.* (2020) were able to show in their study that the order in which the female gymnasts presented their routines influenced the scores. The results show that those female gymnasts who performed later received, on average, higher execution scores for their routine than those who performed earlier. Knowing that several factors influence the perception of motor skills or the execution of complex skills and consequently the evaluation of the judges, it is clear how demanding the task is for judges and how meaningful it is that they do their work conscientiously (Findlay & Ste-Marie, 2004; Heiniger & Mercier, 2021). Since the perception of the judges also decides the ranking of the athletes (Ste-Marie, 1999), the importance of the influencing factors/bias and the knowledge about them is very high.

The results of previous studies in gymnastics suggest that especially visual information has an impact on the perception and evaluation of complex skills. In different contexts, however, the influence of auditory information on perception has also been addressed. Especially in the context of anticipation (Allerdissen *et al.*, 2017; Cañal-Bruland *et al.*, 2018; Sors *et al.*, 2018), motor control (Kennel *et al.*, 2015; Pizzeria & Hohmann, 2015), agent discrimination (Kennel *et al.*, 2014; Kennel, Pizzeria *et al.*, 2014), gait behavior (Hildebrandt & Cañal-Bruland, 2021), the results of different studies could show that auditory information also plays an important role. However, the subject of the studies has mainly been movement sounds, or the sounds produced when, for example, a ball hits the playing equipment.

In gymnastics, it could be shown that visual and auditory information interact when observing and evaluating complex movements, which was reflected in a higher quality of perception of complex skills (measured by correct decisions) (Veit & Heinen, 2019). In female gymnastics, the auditory information perceived during the observation of complex skills on the apparatus floor is the musical support of the choreography. Therefore, floor music is a crucial factor in the composition of the floor routine. The scoring rules for the floor include deductions if there is no excellent fit of movement and the floor music. If the gymnast does not fulfill the criteria, the deductions can be between 0.1 and 0.3 points (FIG, 2020).

Chiat and colleagues (2013) studied on the influence of music in rhythmic gymnastics. For this purpose, they gave 52 musicians the task of evaluating the choreography in terms of the congruence of the motor skills and the music. They fulfilled this task in two different conditions. On the one hand, the motor skills were presented with the original music and, on the other hand, with newly composed music that exactly matched the motor skills. The results show that the ratings differ significantly.

Based on the current studies, upcoming questions exist. An investigation of the influence of music on the perception and evaluation of complex skills on the floor in female gymnastics could offer an added value. Additionally, Veit and colleagues (2021) have already investigated the role of music in female gymnastics on the floor for the acrobatic series. The participant's task was to rate acrobatic series in three conditions (original, inter-beat, matched-beat). The results show that the acrobatic series are significantly

higher rated in the matched-beat condition than in the original condition.

The current study aims to extend the investigation results by Veit *et al.* (2021) for another component (gymnastic series) of floor routine in female gymnastics. It was hypothesized that the participants rate the complex skills higher when the movement speed fits with the music's tempi than if the music's beats do not match (Chiat *et al.*, 2013). Additionally, it was expected that the laypeople and experts would be influenced differently since the laypeople do not know about the scoring rules and consequently do not attribute a special role to the music.

II. MATERIAL AND METHODS

A. Participants

The participants' number 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). Overall $N = 44$ participants attended the study ($M_{age} = 25.75 (\pm 7 \text{ years})$, 11 male and 33 female participants). The participants were separated into two groups based on their previous experiences in gymnastics. One group was composed of people with visual experiences and expertise in gymnastics. The second group was composed of people with no expertise in gymnastics: group 1 – visual experts ($n_1 = 22$ judges), group 2 – no expertise in gymnastics ($n_2 = 22$ laypeople). The judges possessed at least the first level license of German judges education and five years of experience. The laypeople had no experience watching or evaluating gymnastics.

Only individuals who did not have hearing disorders or impaired vision were allowed to participate in the study. Before the participants started to take part in the study, they were informed about the task within the study. Data collection began after participants confirmed the declaration of consent. The study was conducted within the ethical guidelines of the local ethical committee.

B. Measures

1) Stimuli generation

For data collection, twelve videos of different elite gymnasts in high-level competitions (Olympic Games and World Championships) were selected in which the gymnasts performed similar gymnastic series. The leaps shown were switch leap, switch leap with 180° turn, 360° turn, or to ring position. The selected leaps are frequently shown in a gymnastic series at the national and international levels.

The videos were modified into a black and white format to eliminate different color information between different videos (Eliot *et al.*, 2007; Goldschmied *et al.*, 2020). Furthermore, it is expected to allow or help the participant to focus on the relevant information more accurately. In addition to the original black and white video sequence, two other versions were created. On the one hand, the music was removed (visual condition), and on the other hand, the original floor music was replaced by a piece of selected music (beat-matched condition). The gymnast's movement speed determined the chosen music.

To determine the movement speed to choose a track which fit with the performance, the frame rate of the gymnastic series was established. The feet' contact with the floor while performing the gymnastic series produces the frame rate. Furthermore, the frame rate matches a composition's speed as beats per minute (bpm).

After determining the movements' speed, a different beat-matched version was generated. Finally, the original video sequences (black and white) were assembled with a selected track part that fits the performance (beat-matched condition).

At the end of stimuli generation, every video sequence existed in three different versions, constituting the three experimental conditions.

2) Experimental conditions and task

The stimuli generation resulted in the three experimental conditions as described above (1) audio-visual condition (unchanged video file and auditory information), 2) beat-matched condition (unchanged video file and selected music), and 3) visual condition (unchanged video file and no auditory information). Consequently, 36 video sequences arose out of twelve videos (twelve videos in three different conditions). The 36 video sequences were presented in a randomized order.

The participant's task was to watch the video sequences of the gymnastic (leap) series on the floor on a computer screen. After watching the video sequence, they had to evaluate the quality of the series' execution on an analog rating scale. The scale values correspond with the introductions for evaluating technical norms of the German Gymnastics Federation. Participants' evaluations were recorded through the online questionnaire as described below.

The main focus was on the participants' evaluation. Each video sequence could be rated with a minimum of 1 and a maximum of 6. Out of the evaluation of each video sequence, average scores for the three experimental conditions and groups were calculated.

In total, participating in the study took 15 minutes.

3) Questionnaire

An online questionnaire was used to collect data. This included general (socio-demographic questions such as age and gender) and a specific part. The specific part started with the question about the activity in gymnastics, either no activity in gymnastics or as a judge. The question divides the further course temporarily into two parts. Suppose the participant has no experience in gymnastics. In that case, he/she is directly directed to the explanation of the experimental task, and then the third section, the evaluation of the video sequences, starts. Those participants who are active as judges in gymnastics had to answer further questions about their license, the level at which they judge, their experience in years, and whether they have motor experience in gymnastics. After the specific questions were answered, the judges were also directed to the explanation of the experimental task and, to the third section, the evaluation of the video sequences.

A third questionnaire section followed the general and specific questions. Here, the videos were presented with an analog scale. The participants used the analog scale to record their decisions.

A fourth section was used to acknowledge and debrief the participants.

C. Procedure

The study was divided into three phases. First, the participant was asked to provide socio-demographic data about themselves, beginning with a welcome email and the opening of the associated link leading to the questionnaire and the video sequences. Next, the participant was asked to provide socio-demographic data about themselves. Furthermore, expertise in the field of gymnastics was requested. After the participant answered the questions, the procedure of the investigation, the evaluation criteria, and the experimental task was explained. In order to get used to the experimental task and adjust to the elements, four orientation videos were presented first. The participant was also given the opportunity to try out the analog scale.

After the orientation videos, data collection started. For example, after the participant watched the video of a gymnastic series, the participant rated the quality of the execution on the analog scale. After they give the rating, he/she can move to the next video by pressing the "next" button. A total of 36 video sequences had to be rated.

The fourth phase included a debriefing and acknowledging participation in the study. Furthermore, the participant had the opportunity to request the study results by mail.

In total, participation in the study took an average of 15 minutes.

D. Analysis

The level of significance was set at 5% for all results. First, the assumptions to conduct analyses of variance were checked (normality, sphericity, and homogeneity of variance).

To test the hypotheses, a 2 (*group*: laypeople vs. judges) \times 3 (*condition*: 1) audio-visual vs. beat-matched vs. visual) analysis of variance (ANOVA) with repeated measures was conducted. The average of the evaluation scores was included as the dependent variable. The group was treated as a between-subject factor, and the condition was treated as a within-subject factor. Bonferroni corrected post hoc tests were calculated.

III. RESULTS

The current study aims to extend the investigation results by Veit *et al.* (2021) for another component (gymnastic series) of floor routine in female gymnastics. It was hypothesized that the participants rate the complex skills higher when the movement speed fits with the music's tempi than if the music's beats do not match (Chiat *et al.*, 2013). Additionally, it was expected that the laypeople and experts would be influenced differently since the laypeople do not know about the scoring rules and consequently do not attribute a special role to the music.

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The results show a main effect of condition ($F(2,84) = 13.856$, $p < .01$, Cohen's $f = .57$) and no main effect of group ($F(1,42) = 3.581$, $p = .06$, Cohen's $f = .29$). There was a significant interaction effect of condition and group ($F(2,84) = 4.720$, $p = .01$, Cohen's $f = .33$). Overall, the judges tended to rate the video sequences higher (but not significantly) than the laypeople expect in the visual condition.

The post hoc tests show that the gymnastic series was significantly higher rated in the beat-matched condition than in the audio-visual and visual conditions and in the audio-visual condition higher than in the visual condition.

Fig. 1 shows the average and standard deviations of the participants' rating scores across the different conditions.

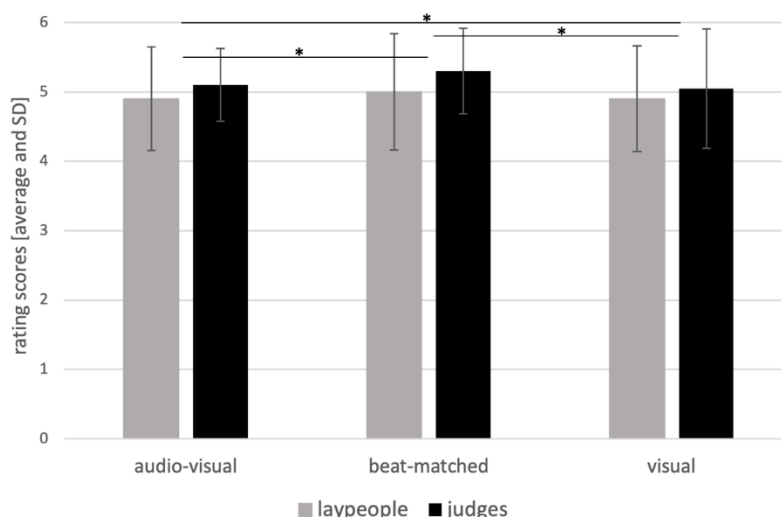


Fig. 1. Means and standard deviation of the participants' scores within the different conditions.
Note. * indicates a significant effect.

IV. DISCUSSION

Based on the current investigations' results, the study aimed to investigate the influence of music on the perception and evaluation of complex skills on the floor in female gymnastics. Furthermore, the aim was to extend the results of the study by Veit *et al.* (2021) for another component of floor routine for the gymnastic series in female gymnastics. The participants' task was to evaluate 36 video sequences of gymnastic series on the floor in three experimental conditions (audio-visual, beat-matched, and visual condition).

The results show that the judges' ratings of the gymnastic series differ across the experimental conditions. In contrast to the laypeople, the music seems to influence the judges in their evaluations. This could be the case because they are encouraged by the scoring guidelines to pay attention to the fit of music and movement. On the other hand, laypeople do not know about the importance of fit.

The results show that the music influences the participants also the judges. The judges score the execution in the beat-matched condition higher than in the audio-visual and visual conditions. The visual condition was rated the lowest. Since the judges are also instructed to evaluate the fit of music and movement according to the scoring rules, it is not surprising that the movement executions with music are rated better than without music. This probably seems somewhat unfamiliar to the judges, which is then reflected in the lower rating. The fact that the judges rated executions in the beat-matched condition the highest could make it worthwhile for the gymnasts to select their music specifically. It is important to say, concerning the results of Veit *et al.* 2021, that the movement speed in acrobatic series and the gymnastic combinations of different leaps differs.

Consequently, a music cut would offer itself, taking this into account. Furthermore, the fact that it is further impossible to fade out auditory information is always conscious or unconscious processing of auditory information supports the added value (Eysenck & Keane, 2015). Furthermore, the judges are instructed to pay attention to the fit of music and movement.

It was possible to extend the results of Veit *et al.* (2021) for another component of the floor routine. The influence of music matched to the movement speed could be shown for the two main parts of the floor routine, so the recommendation can be made for gymnasts to pay attention to this in their choice of music.

When providing such a recommendation, it is crucial to address the study's limitations. Two aspects should be highlighted. Firstly, it should be mentioned that the gymnastic series were not always filmed from the same perspective, so the video sequences differed slightly in this aspect. However, this is also the case in competitions since the different gymnasts also use different spatial paths to perform their gymnastic series.

Second, although the video sequences were converted to a black-and-white format, other factors were still apparent to the participants. These include, for example, the type of competition (Olympic Games or World Championships) and which gymnast was presented. Since all were high-level athletes, the gymnasts were recognized. The participants were influenced by the fact of knowing the gymnast and her "level" (e.g., reputation bias, Findlay & Ste-Marie, 2004).

The study results suggest that the musical support through beat-matched tracks as the floor music results in higher scores for the execution of the gymnastic series. It would be interesting to know if the results would also show up in the evaluation of entire floor routines and if they could be transferred to other technical compositional sports (such as figure skating and rhythmic gymnastics). Additionally, it would

have had an added value to ask in the questionnaire about the music preference of the participants.

V. CONCLUSION

Based on the current study results (and the results of Veit *et al.*, 2021), one could conclude that if (the bpm of) the floor music fits with the speed of movement of the complex skills, the executions are higher rated. Consequently, it could be beneficial for gymnasts to choose their music carefully and to pay attention to their music cuts. Furthermore, it would be useful to make the judges aware of the different factors influencing the perception and evaluation of complex movements during their education.

It would be interesting to find out if the influence of matching music would also be reflected in the overall score. However, since an effect could already be shown in the evaluation of the acrobatic series and gymnastic series, an impact on the overall evaluation can also be suspected. Additionally, it would be interesting to determine if the results could be transferred to other technical compositional sports such as figure skating and rhythmic gymnastics.

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CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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