PERCEIVED AESTHETIC FEATURES DIFFERENTIATING BETWEEN COMPLEX ARTISTIC DANCE SKILLS OF VARYING STYLE

Pia M. Vinken[1], Thomas Heinen[2]

[1] Institute of Sport Science, Georg-August-University Göttingen, Germany
[2] Faculty of Sport Science, Leipzig University, Germany

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Abstract

Research on (empirical) aesthetics investigates properties and features of objects, the resulting response-mechanisms to such objects in the observer, and the interplay between factors of the object and the observer in a given context. This study focuses on object-related factors, such as biological motion. The question is addressed of whether there are perceived aesthetic features differentiating between complex artistic skills ranked most and least aesthetic by experienced observers. Therefore, 18 participants with dance experience were asked to evaluate the perceived aesthetics of stick-figure video sequences of three different complex motor skills, namely dance jumps, poses, and turns. As a result, three specific aesthetic features are pointed out as aesthetic fundamentals in the perception and evaluation of aesthetic sports and performing arts: 1) an outwards direction away from the dancers longitudinal axis and body center, 2) a focus on external rotation of the limbs (turn-out), and 3) a (diagonal) spread of body movements creating the impression of elongating the dancer's body. In particular, aesthetic features that demand the performer's ability and challenge physical laws seem to be robust parameters when aiming to create aesthetic motion stimuli. Concluding, a skill-specificity for aesthetic features, as well as the need to differentiate between the interaction of different aesthetic features, is pointed out – aspects which seem especially apparent in biological motion stimuli.

Keywords: *artistic sports, performing arts, stick-figure video sequences, two-alternative forced choice task, motion perception.*

INTRODUCTION

One central aim of artistic sports as well as of performing arts is to create and perform biological motion in such a way that it evokes an aesthetically pleasing impression in the observer (Arkaev & Suchilin, 2009; Christensen & Calvo-Merino, 2013). It is thought that an aesthetically pleasing impression results from the interplay between the perceived motion (the *object*), the perceiving spectators (the *observers*), and the (socio-cultural) environment in which the performed motion is observed (the *context*; Jacobsen, 2006; Pearce, Zaidel, Vartanian, et al., 2016). Because aspects such as the observer and the context are regulated in artistic sports, the focus of this study is the object in terms of the perceived (biological) motion. In artistic sports, the mastery of complex skills is judged accoring to their difficulty and execution, whereas their ratio to the final score differs between disciplines

and is written in the Codes of Points (Čuk, Fink, & Leskošek, 2012; FIG, 2016). In performing arts, the mastery of complex skills is most often not judged explicitly, and there are rather implicit movement catalogs from which artists chose their skills (Burrows, 2010; Laban, 2011). However, in artistic sports as well as in performing arts, the impression which is created by mastering movements skillfully seems to be related to interdisciplinary motion aesthetics (Brielmann & Pelli, 2018). The central question yet arises, whether there are perceived aesthetic features differentiating between complex artistic skills ranked most and least aesthetic by experienced observers?

Current research on (empirical) aesthetics aims to investigate properties and features of aesthetic objects, the resulting response-mechanisms to such objects in the observer, and the interplay between factors of the object and the observer in a given context (Brielmann & Pelli, 2018; Chatterjee & Vartanian, 2014; Jacobsen, 2006; Leder & Nadal, 2014; Pearce, Zaidel, Vartanian, et al., 2016). Thereby, aesthetic features for non-biological and biological stimuli reveal varying attention in research on empirical aesthetics and follow different aims, measurements, and hypotheses.

When observing *non-biological objects* such as paintings or graphic patterns, stimulus-driven aesthetic features discussed in the literature are complexity, curvature, figure-ground contrast, the goodness of form, ideal habitat, symmetry, and the golden ratio (Brielmann & Pelli, 2018; Reber, Schwarz, & Winkielman, 2004; Tinio & Leder, 2009). Symmetric, average, and curved objects generally seem to be perceived as more aesthetic when compared to asymmetric and angular ones (Brielmann & Pelli, 2018). Furthermore, a high figure-ground contrast, the goodness of form (few forms arranged vertically), as well as symmetry, are discussed to affect processing fluency of objects positively and thus increasing their perceived aesthetics (Reber et al., 2004). However, there are still contradicting results, especially concerning the golden ratio, the complexity of, and the familiarization with the stimulus (Brielmann & Pelli, 2018; Tinio & Leder, 2009). For example, Tinio and Leder (2009) found that symmetry and complexity are reliable determinants when participants should indicate their perceived aesthetics of black and white patterns. Complex and symmetric patterns received the highest aesthetic rankings followed by simple and symmetric, complex and non-symmetric, and simple and non-symmetric patterns. However, if participants were familiarized with complex stimuli, they indicated higher aesthetic ratings to simple stimuli and vice versa (Tinio & Leder, 2009). It can be concluded that aesthetic features, like symmetry, familiarity, and object-specific aspects (e. g., the goodness of form) which support a stimulus' processing fluency, should be utilized when aiming to create aesthetic objects.

In this study, the focus is on object-driven factors of perceived biological motion aesthetics. It is acknowledged that perception and evaluation of motion aesthetics occur in the observer and thus can hardly be interpreted separately. The following aspects of the relationship between the object and the observer should be outlined: the observer's visual, sensory-motor, and conceptual expertise concerning the aesthetics of the perceived motion. Orgs and colleagues (2018) describe dance as social art form and communication between performer and spectator. The performer transmits information via the movement to the observer. However, if the transmitted information is understood, depends on both the performer's ability to transmit the information via his/her bodily movements, as well as the observer's own visual, sensory-motor, and conceptual expertise about such movements.

Furthermore, the authors argue, that movements with low motor familiarity in the observer might be less aesthetically pleasing than movements for which the observer has the corresponding motor

familiarity (Orgs, Calvo-Merino & Cross, 2018). An aspect that can be described as follows: Watching biological motion engages motor resonance in the observer and seems to be an embodied process (Christensen & Calvo-Merino, 2013; Cross, 2015). In light of the findings on processing fluency, outlined above, familiar motion stimuli can be processed more fluently in the observer, thus increasing perceived motion aesthetics (Orgs et al., 2018; Reber et al., 2004).

Nevertheless, observers equally enjoy such motion stimuli that exhibit a high level of skill, ability, and virtuosity of the performer and naïve dance observers aesthetically prefer movements they declare as not being reproducible for themselves. Consequently, motor familiarity alone cannot explain motion aesthetics because everybody can enjoy watching dance either because of motor familiarity or because of the spectacularity of the movement (Cross, 2015; Orgs et al., 2018). Furthermore, observers most enjoy such motion stimuli for which they possess physical, visual, and auditory experiences. Motion stimuli for which observers possess only auditory experience or no experience at all were enjoyed less (Kirsch, Dawson & Cross, 2015). It can be concluded that the observer's expertise, motor familiarity, and processes of an embodiment are related to observer's perceived motion aesthetics and should be controlled when aiming to focus on stimulus-driven features of motion aesthetics.

The same is true for contextual factors like, for example, ornamentation, (background) color, and (bodily) appearance of the performer (Calvo-Merino, Jola, Glaser & Haggard, 2008; Christensen & Calvo-Merino, 2013; Christensen, Nadal, Cela-Conde & Gomila, 2014). Consequently, in this study, original motion stimuli are transferred into stick-figure video sequences aiming to remove bias on personal and context information and to reduce original dance movements to their kinematic motion characteristics (cf., Findlay & Ste-Marie, 2004). By doing so, it is argued that aesthetic features of the object, namely aesthetically pleasing biological motion, can be adequately studied.

For *biological motion*, in general, and dance motion, in particular, aesthetic features discussed in current research are amplitude, balance time, complexity, direction, effort, horizontal and vertical orientation, smoothness, speed, symmetry, and synchronization (Christensen & Calvo-Merino, 2013; Daprati, Iosa, & Haggard, 2009; Orgs et al., 2018; Torrents, Castañer, Jofre, Morey, & Reverter, 2013). Those motion specific aesthetic features partly complement the features outlined for non-motion specific stimuli. There are several approaches to study and measure features of motion aesthetics. First, kinematic measures focusing on the physical properties of biological motion are implemented (Daprati et al., 2009; Torrents et al., 2013). Second, neuroscientific measures aiming to capture aspects of brain activity when watching aesthetic stimuli (Calvo-Merino et al., 2008; Cross, 2015; Kirsch et al., 2015). Third, affective and behavioral measures are used to indicate the observer's perception, evaluation, and experience to aesthetic stimuli. Affect, for example, is measured by indicating positive and negative valence to the stimuli presented (Christensen et al., 2014). Behavioral measures, for example, address concepts such as beauty, liking, and interest indicated via Likert-scales, semantic differentials, or forced-choice tasks (Calvo-Merino et al., 2008; Christensen et al., 2014; Cross, 2015; Daprati et al., 2009).

In general, findings on aesthetic features of biological motion stimuli indicate that smooth and predictable movements are aesthetically preferred when compared to complex, jerky, and asymmetrical movements (Orgs et al., 2018). An aspect, which may refer to the processing fluency of the stimuli (cf., Reber et al., 2004). Furthermore, naïve dance observers prefer more vertical limb

displacements compared to less vertical ones (Daprati et al., 2009). Additionally, fast turning speeds, large balance time, and large general amplitude of movement are related to higher perceived motion aesthetics compared to slow turning speeds, small balance time, and low amplitudes (Torrents et al., 2013).

Additionally, features that characterize the ability of the performer can be summarized. Such features are especially prominent in aesthetic sports and performing arts where the ability of the performer is expressed via skillful bodily movements, which are being embodied in both, the performer and the observer (Calvo-Merino et al., 2008; Christensen & Calvo-Merino, 2013; Cross, 2015; Kirsch et al., 2015). Contrary to non-biological stimuli, in aesthetic sports and performing arts, the object cannot be observed detached from the performing body. Therefore, aesthetic features which may be fundamental for non-biological stimuli may be *different* when it comes to biological stimuli and their perceived (motion) aesthetics. Different, first, concerning their general appearance and occurrence. And second, presumably also different concerning their impression while being performed and observed. It can be concluded that smooth movements which can be processed easily, focus on vertical orientation, and underline the performer's ability, should be utilized when aiming to create aesthetic motion stimuli.

The impression of aesthetic features in biological motion is often hard to capture by simply measuring parameters such as physical displacement of the limbs. Therefore, qualitative measures of biological motion are recommended (Thomas, Nelson, & Silverman, 2015). Calvo-Merino and colleagues (2008), for example, looked for physical descriptors within such dance movements that target "aesthetic" brain areas in naïve dance observers undergone functional magnetic resonance imaging (fMRI) measures while watching ballet and capoeira sequences. The authors argue that physical parameters such as horizontal and vertical displacement – actions that are especially necessary during jumping – may target aesthetically-relevant brain areas (e. g., occipital cortices and right premotor cortex; Calvo-Merino et al., 2008). However, it remains open which features within variations of such jumps are related to a jump's perceived aesthetics.

Other, rather qualitative aesthetic features discussed in dance are the flexibility of the performer, extensively stretched feet, and external rotations (*turn-out*) of the hip, knee, and ankle joint (Christensen & Calvo-Merino, 2013). Authors argue that such features challenge the range of motion of the human body and create the impression of elongating the performer's body and range of motion in space. Besides, such features may be related to fertility and courtship behavior.

Christensen and colleagues (2014) combined quantitative and qualitative measures of motion aesthetics in classical ballet stimuli. Quantitative (e.g., number of pirouettes) and qualitative parameters (e. g., movement dynamics as well as Laban score; Laban, 2011) were assessed. Parameters such as movement path, movement quantity, and Laban score predicted aesthetic ratings of inexperienced dance observers. Expressed in terms of motion aesthetics, those parameters appear in soft, expansive, and horizontal movements executed in an indulging, flexible, and gently fluent way (Christensen et al., 2014). As a result, combinations of quantitative and qualitative measures seem to capture the holistic manner of perceived biological motion aesthetics, by combining physical parameters and their induced impression in the observer via the performer's ability.

Taken together, context and the observer's expertise should be controlled when aiming to focus on stimulus-driven features of perceived motion aesthetics. Furthermore, in particular, in this study, a qualitative approach capturing the holistic manner of biological motion aesthetics

should be emphasized, aiming to find prototypical aesthetic features within biological motion stimuli (Castañer, Torrents, Morey, & Jofre, 2014; Mack, Hennig, & Heinen, 2018). Previous research indicates that smooth movements that can be processed easily, focus on vertical orientation, and underline the performer's ability, are promising parameters of perceived motion aesthetics. It is therefore assumed that such parameters represent interdisciplinary aesthetic features, which differentiate between complex artistic skills, namely dance jumps, poses, and turns of varying style.

METHODS

Participants (N = 18) with dance experience in classical, modern, and/or jazz dance were recruited to take part in this study. Participants (16 females, 2 males) were 29 ± 11 years old, and they reported to have an average of 16 ± 12 years of dancing experience with 6 ± 5 training hours per week. Their task was to evaluate the perceived motion aesthetics of stick-figure video sequences of three different artistic skills, namely variations of dance jumps, poses, and turns.

Additionally, N = 9 experienced female dancers (mean age: 29 ± 3 years) were recruited as an additional group in order to generate video stimuli (stimuli group). They were asked to perform variations of dance jumps, poses, and turns. Dancers reported having substantial experience in different dance styles, such as classical dance, modern dance, or jazz dance (Chi, 2006). Their average dancing experience was 21 ± 8 years with 4 ± 1 hours per week of regular practice.

All participants voluntarily joined this study and gave informed consent about participation. The study was conducted according to the guidelines of the local University's ethics committee.

Each dancer of the stimuli group separately arrived at the gymnasium and was informed about the general purpose of the study, as well as the process of video stimuli generation. She gave her informed consent to voluntary participate in this study and completed a short questionnaire about her dance experience. She was allowed an individual warm-up and practice phase. Video stimuli generation for the three artistic skills, namely dance jumps, poses, and turns, occurred randomly for each dancer. First, the dancer was instructed about the motion prerequisites of the dance skill performed initially (cf., Tab. 1). Then, she individually practiced the skill and its variations while being allowed to ask questions about movement variations, prerequisites, and the process of video stimuli generation. Afterward, the dancer was asked to perform at least four variations of the first dance skill. When finishing this, she was asked whether she was satisfied with her performance or wanted to do another variation. Finally, when at least four variations of the first dance skill were successfully performed and captured, the aforementioned process was repeated for the two remaining dance skills. When the dancer performed at least four variations of each of the three dance skills, she was debriefed.

Dance skill variations were performed in a capture area of 5 x 5 meters while being videotaped utilizing six video cameras operating at 60 Hz (640 x 480 pixels). In total, 47 jumps, 43 poses, and 45 turns were recorded. The 135 recorded video sequences were subjected to a silhouette-based computer-based algorithm to extract movement kinematics from the video sequences *(iPi Motion Capture* ^{TM}, iPi Soft, Russia). The video footage of all six cameras was used to calculate a 3D volume model of a human body consisting of head, trunk, two upper and lower arms, two hands, two thighs and shanks, two feet, as well as the appropriate joints, namely, neck, shoulders, elbows and wrists, spine, hips, knees, and ankles.

From the extracted movement kinematics, stick-figure video sequences were generated. This had the advantage of

reducing the original video footage to its kinematic motion information, and to control for potential contextual and bodily biases (Findlay & Ste-Marie 2004). From the captured dance skills, stick-figure video sequences of 28 jumps, 30 poses, and 19 turns could be generated with excellent movement quality. Within the performed dance skills, there were equal variations between dancers of, for example, a *pirouette en dehors* occurring in classical ballet with the left foot in a *sur le coup de pied* position. From those equal variations, one stick-figure video sequence was randomly selected to achieve a sufficient variety of stimuli dance skills. In general, ten video sequences of each dance skill were selected for stimuli presentation and evaluation, thus representing a sufficient variety of different dance jumps, dance poses, and dance turns. At the end of the aforementioned steps, there were thirty stick-figure video sequences of dance skill variations, namely ten jumps, ten poses, and ten turns.

Artistic dance skills were evaluated using a two-alternative forced-choice task (2AFC; Palmer, Schloss, & Sammartino, 2013), whereas jumps, poses, and turns were evaluated separately and in randomized order. For each 2AFC task, two stick-figure video sequences labeled "A" and "B", were presented next to each other. Thereby, A was presented on the left side of the screen and shown first, while B was presented on the right side of the screen and presented second. Both video sequences were presented in the original speed on a 2.5 x 1.8-meter projection screen. After the presentation, participants had to indicate which of the two stick-figure video sequences, A (left) or B (right), they perceived as more aesthetic. They were asked to indicate their decision for A or B on a questionnaire sheet by ticking either A or B for the corresponding forced-choice task. This procedure was repeated until each, for example, jump sequence was compared to each of the other jump sequences resulting in 45 comparisons for the dance jump's 2AFC task. When the forced-choice task of the first dance skill, was completed, the same course of action was repeated for the two remaining artistic dance skills. In sum, this procedure resulted in 3 x 45 = 135 forced choices for each participant resulting in a total number of 2.430 choices for all participants.

Each participant was invited separately to a laboratory room at the local university. He/she was informed about the general purpose of the study, signed an informed consent form, and completed a short questionnaire about his/her dance experience. Before data collection, the experimenter introduced the evaluation procedure, and the participant was shown exemplary stick-figure video sequences for calibration purposes. The two-alternative forced-choice task (2AFC) was done for each of the three dance skills separately, while jumps, poses, and turns were presented in random order. After the evaluation of the first dance skill, participants were allowed to take a short break. Then, the same procedure was repeated for the remaining two dance skills. There was no time pressure, but the participant was instructed to indicate his/her evaluation spontaneously. After data collection, he/she was debriefed.

Each participant's decision was scored as 1 when the participant perceived this sequence as more aesthetic, while the compared sequence received a score of 0 in this forced choice. This was done for each comparison of each participant. Afterward, the participant's scores of each stick-figure video sequence were summed up. This procedure provided a ranking order of stick-figure video sequences ranging from most aesthetic (rank 1) to least aesthetic (rank 10), and was done separately for the three dance skills, namely dance jump, pose, and turn. Participants' summed rankings of the video sequences evaluated most and least aesthetic were compared using Wilcoxon signed-rank test to ensure their statistical distinctness. In order to explore aesthetic features differentiating between complex

artistic skills of varying style, a qualitative description of video sequences was conducted (Thomas et al., 2015): First, the perceived content in the video sequences evaluated most and least aesthetic was described. Second, differences and similarities within the two sequences were contrasted, aggregated, and ordered concerning kinematic (Watkins, 2014) and contextual (Castañer et al., 2014; Laban, 2011; Mack et al., 2018) parameters.

Table 1
List of prerequisites, instructions, and variations for the three artistic skills, namely dance jump, pose, and turn.

	Prerequisites	Instructions	Variations
Jump	Stand upright with feet hip-width apart and arms on the side of the body - jump from the left leg with a 45° turn to land on the right leg - come back to the upright stance with feet hip-width apart and arms positioned on the side of the body	Show variations of this jump by individually varying - movement of legs, arms, trunk, and whole body - accentuation and complexity	- jump height - jump width - involvement of arms - involvement of legs - involvement of trunk and head - accentuation of different movement phases (preparation phase, jump phase, landing and resolution phase)
Pose	Stand upright with feet hip-width apart and arms on the side of the body - use the left leg as standing leg and exhibit a one-legged pose - come back to the upright stance with feet hip-width apart and arms positioned on the side of the body	Show variations of this pose by individually varying - movement of legs, arms, trunk, and whole body - accentuation and complexity	- involvement of arms - involvement of legs - involvement of trunk and head - accentuation of different movement phases (standing phase, moving phase, (off-) balance phase, resolution phase)
Turn	Stand upright with feet hip-width apart and arms on the side of the body - do a 450° turn to the left with your right leg as standing leg - come back to the upright stance with feet hip-width apart and arms positioned on the side of the body	Show variations of this turn by individually varying - movement of legs, arms, trunk, and whole body - accentuation and complexity	- involvement of arms - involvement of legs - involvement of trunk and head - accentuation of different movement phases (preparation phase, turning phase, resolution phase)

RESULTS

Figure 1 shows picture sequences of the three dance skills evaluated most (rank 1) and least (rank 10) aesthetic. For dance jumps, the skill variation evaluated most aesthetic received a score of 122, while the skill variation evaluated least aesthetic received a score of 16 ($Z = -3.72$, $p < .05$). For dance poses, the skill variation evaluated most aesthetic received a score of 123, and the skill variation evaluated least aesthetic received a score of 39 ($Z = -3.36$, $p < .05$). For dance turns, the skill variation

evaluated most aesthetic received a score of 124, whereas the skill variation evaluated least aesthetic received a score of 27 ($Z = -3.55$, $p < .05$).

The dance jump evaluated most aesthetic starts from an upright stance and begins with a preparation phase in which the left leg is flexed to approximately 90° (one-legged *grand plié*) while the right leg and both arms are directed to the front lower-left corner for a preparation movement. From there, both arms are raised above the head to a *third position* while both legs are bend, rotated external (turned out), and abducted one after the other. At the highest point of the jump, both arms are above the head in a *third position*, and both legs reach their maximum height, external rotation, and simultaneous flexion. The landing phase is characterized by bending the right leg, while both arms and the left leg are lowered, heading towards the front lower-right corner. From this position, the dancer erects into the upright stance.

The dance jump evaluated least aesthetic starts from an upright stance and begins with a preparation phase in which the left leg is bent a little while the right leg is abducted heading to the future landing spot. Thereby, the left arm is lifted to shoulder height with a flexed elbow joint and the right arm is lifted to navel height and almost straightened. At the highest point of the jump, both legs are abducted to the lower-right side (right leg) and lower-left side (left leg) and show a little flexion in the knee joint. The right leg is rotated externally (turned out), and the left leg is rotated internally (turned in). The right arm is lifted to navel height and nearly straighten while the left arm is lifted to shoulder height with flexion of approximately 90° in the elbow joint. The landing phase is characterized by bending the right landing leg while the left leg is bent and positioned next to the right one. Both arms are moved towards the trunk while swinging first to the right and then to the left. This comes along with a swing of the trunk until the movement is slowed down fully. From this position, the dancer erects into the upright stance.

The dance pose evaluated most aesthetic starts from an upright stance. Weight is shifted to the left leg as the standing leg while the right leg is moved to the back lower-left corner. Thereby, the left leg is flexed to approximately 90° (one-legged *grand plié*) while rotated external (turned out). Both arms are raised into an elongation of the trunk, which is aligned with the elongated right leg. When the standing leg reaches its greatest flexion, the right leg is elongated to the back lower-left corner in line with head, trunk, as well as both arms, which point to the front upper-right corner. From this position, the left leg starts to straighten while the right leg, as well as both arms, are moved back to the ending position, namely the upright stance.

The dance pose evaluated least aesthetic starts from the upright stance. Weight is shifted to the left leg as the standing leg. Following, the right leg is lifted to approximately knee height to the front while the left arm is moved to a *preparatory position*. The right arm is held next to the body and rotated laterally. Then, the right leg is rotated externally, then internally, and then again externally at the hip and knee joint, while being bent in the knee and hip joint and moved from the front to the side (comparable to the *rond de jambe en l'air en dehors* in classical ballet). Simultaneously, the left arm is moved from the *preparatory*, over the *first*, to the *third position*, and then lowered back next to the body. The right arm is rotated internally, then externally, and finally moved back next to the body in the shoulder and elbow joint. This occurs simultaneously to the external and internal rotation at the hip and knee joint while moving the right leg. Finally, the right leg, as well as both arms, are moved back to the ending position, namely the upright stance.

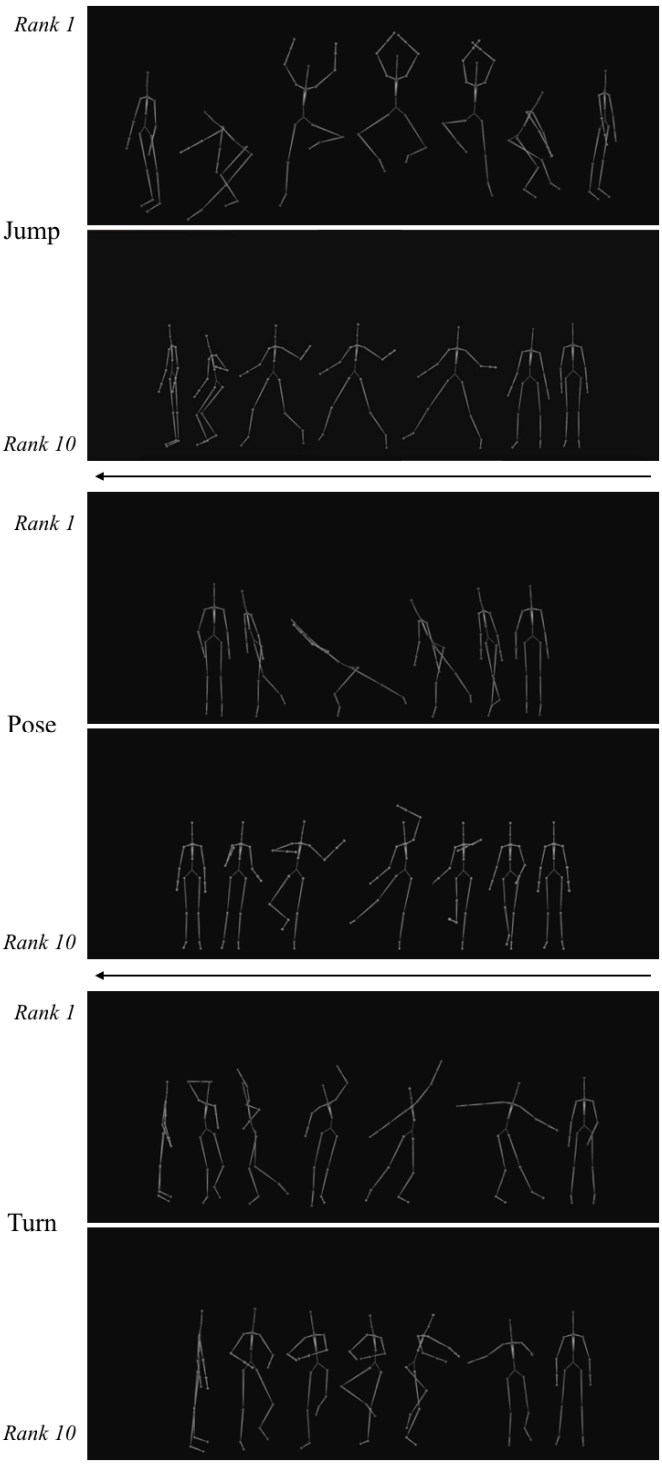

Figure 1. Picture sequences of the jump, pose, and turn stick-figure video sequences ranked most (rank 1) and least (rank 10) aesthetic. Arrows indicate the movement direction.

The dance turn evaluated most aesthetic starts from the upright stance by shifting weight to the right leg while the left leg is moved to the lower left side. Thereby, the elongated right arm is abducted and raised to the upper-right side while the elongated left arm is raised to the lower-left side. During the first 270° of the turn, both arms are held in this position, while the left leg is abducted, pointing to the lower-left side. During the last 180° of the turn, the left leg is adducted from the lower left side next to the standing leg. This leg is straightened in such a way that both legs are finally positioned parallel to each other. Simultaneously, both arms are rotated

internally, then externally, then again internally, and back next to the body in both shoulder and elbow joints. Thereby, both arms are moved next to the body – the right arm from the upper-right side and the left arm from the lower-left side. Finally, when the turn is executed, the dancer finishes in an upright stance.

The dance turn evaluated least aesthetic starts from the upright stance and begins with a preparatory phase in which the dancer moves from the upright stance into her preparatory position. Here, weight is shifted to the slightly flexed right leg, while the left leg points to the lower-left side, and the arms are lifted, abducted, and elongated to shoulder height and parallel to the floor. From this position, the left leg is moved to the lower-back side, while the left arm is moved at shoulder height to the front. Then, the right leg is first flexed and then straightened to lift the left leg, which is flexed at the hip and knee joint, positioning the left foot next to the right knee. Thereby, both slightly flexed arms are moved into a *first position* with hands at navel height, while head and trunk are slightly curved forward. This position is hold until the turn is fulfilled and resolved into the ending position, namely the upright stance.

When contrasting the main movement phases of the different dance skills evaluated most and least aesthetic, the following aspects become apparent: jump height of the most aesthetic jump is larger compared to the least aesthetic jump, whereas jump width is comparable. Furthermore, the most aesthetic jump shows an elevation of both arms above shoulder height and both legs to approximately hip height. Compared to the least aesthetic jump, this elevation is much more prominent and may underline the impression of achieved jump height, additionally.

The most aesthetic dance pose is characterized by one single accentuation. In contrast, the least aesthetic pose shows several accentuations. The single, and thus emphasized accentuation of the most aesthetic pose is characterized by a diagonal spread implementing the elongation of the non-supporting leg and parallel arms, thus creating an impression of elongating the dancer's body. Furthermore, the flexion in the supporting leg, in combination with the shift along the corresponding *diametrale* (cf., Laban, 2011), creates an off-balance that needs to be compensated by the dancer's ability and flexibility. In contrast, the least aesthetic pose is characterized by flexed arms and a flexed non-supporting leg. Furthermore, the limbs are moved while the supporting leg functions as a stable base, thus creating the impression of balance, which does not need to be compensated due to the accentuations of the arms and the non-supporting leg.

The most aesthetic dance turn creates the impression of being directed *outwards*, which is achieved first, by spreading the arms diagonal to the upper-right (right arm) and lower-left (left arm) corners, away from the dancer's longitudinal axis and body center. Second, this diagonal spread is underlined by the abduction of the elongated non-supporting left leg to the lower-left corner, away from the dancer's longitudinal axis and body center, too. In contrast, the least aesthetic dance turn creates the impression of being directed *inwards.* This is achieved first, by simultaneously and parallel moving both arms to a *first position.* Second, the non-supporting leg is lifted to a *passé position* towards the dancer's longitudinal axis and body center. Furthermore, the dancer's trunk in the most aesthetic turn is upright, thus underlining the impression of being directed outwards. In contrast, the curved trunk of the dancer in the least aesthetic turn emphasizes the impression of being directed inwards.

DISCUSSION

This study aimed to address the question of whether there are perceived aesthetic features differentiating between complex artistic skills ranked most and least aesthetic by experienced observers. From the results the following three aspects could be derived: 1.) Dance skills that implement body positions directed outwards and away from the dancer's longitudinal axis and body center are perceived as more aesthetic. 2.) An external rotation (*turn-out*), especially in the hip, knee, and ankle joint, is related to higher aesthetic rankings. 3.) Diagonal body positions with extended limbs, which create the impression of elongating the dancer's body and spread, receive higher aesthetic rankings compared to body positions, which implement several diagonal accentuations of flexed limbs.

The results of this study are in line with previous findings on aesthetic features of biological motion aesthetics (Calvo-Merino et al., 2008; Christensen & Calvo-Merino, 2013; Christensen et al., 2014). It is thus argued that outwards direction, external rotation (*turn-out*), and spread seem to be aesthetic fundamentals in the perception and evaluation of aesthetic sports and performing arts. However, and from a mechanical point of view, the aforementioned body positions are somewhat contrary to the economy of the skill's physical motion. For instance, spreading the arms outwards when performing a turn increases the dancer's moment of inertia, thus reducing angular velocity (cf., Watkins, 2014). A similar aspect is apparent in the jump and the pose. During the jump, both legs are elevated and flexed at the hip and knee joints. This produces a counter-movement, which is directed against the initial vertical direction of the movement. During the pose, the *diametral* spread of the whole body shifts the dancer's center of mass away from the initial area of support of the left standing foot (cf., Watkins, 2014). Both mentioned aspects demand a dancer's ability and may impress the observer, thus affecting his/her evaluation of perceived motion aesthetics.

Furthermore, the qualitative description of artistic dance skills ranked most aesthetic is compatible with the results of previous research by Christensen et al. (2014). Especially such aesthetic features which demand the performer's ability and challenge physical laws seem to be robust parameters when aiming to create aesthetic motion stimuli. Additionally, the results of this study underline a skill-specificity for aesthetic features and their interaction that results in a pleasing impression in the observer. While symmetry, outwards direction, external rotation (*turn-out*), and spread are apparent in the most aesthetic jump, symmetry is not apparent in the most aesthetic pose. Still, outwards direction, external rotation (*turn-out*), and spread are. Interestingly, symmetry is apparent in the least aesthetic dance turn, which is directed inwards and lacks external rotation (*turn-out*), as well as spread.

However, findings on the aesthetic feature symmetry discussed as an *aesthetic fundamental* (Brielmann & Pelli, 2018; Jacobsen, 2006; Tinio & Leder, 2009) in non-biological motion stimuli could not be confirmed. It seems as if symmetric body positions and their perceived motion aesthetics are skill-specific. While the dance jump ranked most aesthetic shows a clear top-down and left-right symmetry, such symmetry is neither apparent in the dance pose, nor the dance turn ranked most aesthetic. Interestingly, the dance turn ranked least aesthetic shows symmetry in the arm positioning. This finding may indicate a skill-specificity of aesthetic features and thus seems partly controversial to the aesthetic perception and evaluation of, for example, paintings and graphic patterns (Jacobsen, 2006; Tinio & Leder, 2009).

Similarly, object-driven factors affecting processing fluency of biological motion stimuli seem skill-specific, too. The dance pose and turn ranked most aesthetic

focus on one accentuation, whereas the dance pose and turn ranked least aesthetic show several accentuations. An aspect that may affect processing fluency in such a way, that single accentuations in a given time can be processed more fluently, thus affecting aesthetic motion perception (cf., Orgs et al., 2018; Reber et al., 2004). However, when comparing the dance jumps ranked most and least aesthetic, it is argued that the dance jump ranked least aesthetic should be processable more fluently compared to the dance jump ranked most aesthetic. In the least aesthetic jump, accentuation, implementation of limbs, and dancer's displacement are less apparent and should result in more fluent processing. However, observers seem to prefer object-driven factors that challenge their processing fluency when evaluating motion aesthetics of dance jumps. It is thus stated that the perception and evaluation of perceived biological motion aesthetics partly follow different routes compared to the perception and evaluation of non-biological (motion) aesthetics. Aspects of embodied perception and cognition may explain such differences (Christensen & Calvo-Merino, 2013; Cross, 2015). However, investigating such aspects was not the primary aim of this study but could be addressed in subsequent research.

It is acknowledged that there are several limitations of this study, and the following two aspects should be highlighted: First, dance skills and movement variations of this study were generated concerning the ability and variability of the dancers of the stimuli group. Future studies may shed light on whether manipulation of, for example, the amount of outwards direction, external rotation (*turn-out*), or spread causes changes in the evaluation of perceived motion aesthetics in the observer. Second, behavioral measures were implemented by asking experienced observers to indicate perceived aesthetics in a forced-choice task. How observers with different visual, sensory-motor, and contextual experience to the presented stimuli evaluate motion aesthetics should be investigated further. The same is true for combining or contrasting behavioral measures with, for example, affective measures or modifiable motion stimuli. One could argue that behavior and affect are targeted to a stronger degree in experimental settings when participants could manipulate physical and body-related parameters in an analog fashion by themselves (cf., Troje, 2002).

Concerning practical implications, the following is inferred: when aiming to create and perform aesthetically pleasing complex whole-body movements in aesthetic sports or performing art, three aesthetic features should be implemented when experienced observers are addressed. First, body movements which are directed outwards away from the performer's longitudinal axis and body center. Second, body movements that implement an external rotation of the limbs (*turn-out*), for example, of the hip, knee, and ankle joints. Third, body movements which create the impression of elongating the performer's body by focusing on a (diagonal) spread, for example, by creating long lines between extended feet, legs, trunk, arms, and hands. Knowledge about those aesthetic features may support coaches, choreographers, and performers aiming to create aesthetic motion stimuli. Additionally, the results of this study underline the importance of highlighting such aesthetic features in the Code of Points as it is already done, for example, in women's artistic floor gymnastics (cf., artistry and expressiveness as well as artistic harmony and feminine grace; FIG, 2016). By doing so, potential biases (cf., Findlay & Ste-Marie, 2004) can be resolved in such a way that highlighting and honoring fundamental aesthetic features may have the potential to reduce allegedly subjective aesthetic judgments. Finally, the need to further investigate similarities and differences between biological and non-biological (motion) stimuli and their processing behavior within the observer is

acknowledged. The results of this study, including previous research, indicate that aesthetic features are skill-specific and different between biological and non-biological stimuli.

CONCLUSION

In this study, it is argued that the perception and evaluation of motion aesthetics is a complex phenomenon depending on the interplay between the object which is perceived from the observer(s) in a given context. Consequently, this interplay of factors affecting perceived motion aesthetics should be investigated and interpreted holistically. Three specific object-driven aesthetic features can be highlighted that distinguish between motion stimuli ranked most and least aesthetic: 1) an outwards direction of the movement, 2) an external rotation (*turn-out*) of the limbs, and 3) a (diagonal) spread. Although factors of the observer and the context were controlled in this study, it is argued that the object-driven aesthetic features pointed out here are transferable to observers with different sensory-motor and contextual experiences as well as to different contexts. Future studies may shed light on the different amounts of object-, observer-, and context-dependent parameters of perceived motion aesthetics, thus aiming to understand the processes of creating, choreographing, and performing pleasing motion aesthetics holistically.

REFERENCES

Arkaev, L., & Suchilin, N. (2009). *Gymnastics: how to create champions*. Aachen: Meyer & Meyer.

Brielmann, A. A., & Pelli, D. G. (2018). Aesthetics. *Current Biology, 28*(16), 859-863. https://doi.org/10.1016/j.cub.2018.06.004

Burrows, J. (2010). *A choreographer's handbook*. Taylor & Francis.

Calvo-Merino, B., Jola, C., Glaser, D. E., & Haggard, P. (2008). Towards a sensorimotor aesthetics of performing art. *Consciousness and Cognition, 17*, 911-922. https://doi.org/10.1016/j.concog.2007.11.003

Castañer, M., Torrents, C., Morey, G., & Jofre, T. (2014). Appraising choreographic creativity, aesthetics, and the complexity of motor responses in dance. In O. Camerino, M. Castañer, & M. T. Anguera (Eds.), *Mixed methods in the movement sciences* (pp. 146-175). London: Routledge. https://doi.org/10.4324/9780203132326

Chatterjee, A., & Vartanian, O. (2014). Neuroaesthetics. *Trends in Cognitive Sciences, 18*(7), 370–375. https://doi.org/10.1016/j.tics.2014.03.003

Chi, M. T. H. (2006). Two approaches to the study of experts' characteristics. In K. A. Ericsson, N. Charness, P. Feltovich, & R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 21-30). Cambridge University Press. https://doi.org/10.1017/CBO9780511816796.002

Christensen, J. F., & Calvo-Merino, B. (2013). Dance as a subject for empirical aesthetics. *Psychology of Aesthetics, Creativity, and the Arts, 7*(1), 76-88. https://doi.org/10.1037/a0031827

Christensen, J. F., Nadal, M., Cela-Conde, C. M., & Gomila, A. (2014). A norming study and library of 203 dance movements. *Perception, 43*, 178-206. https://doi.org/10.1068/p7581

Cross, E. (2015). Beautiful embodiment: the shaping of aesthetic preference by personal experience. In J. P. Huston, M. Nadal, F. Mora, L. F. Agnati, C. Jose Cela Conde (Eds.), *Art, aesthetics, and the brain* (pp. 189-208). Oxford University Press.

Čuk, I., Fink, H., & Leskošek, B. (2012). Modeling the final score in artistic gymnastics by different weights of difficulty and execution. *Science of Gymnastics Journal, 4*(1), 73-82.

Daprati, E., Iosa, M., & Haggard, P. (2009). A dance to the music of time: aesthetically-relevant changes in body posture in performing art. *PLoS ONE, 4*(3), 1-11. https://doi.org/10.1371/journal.pone.0005023

FIG (2016). 2017 – 2020 *Code of points – women's artistic gymnastics*. Fédération Internationale de Gymnastique. http://www.fig-gymnastics.com/publicdir/rules/files/en_WAG%20CoP%202017-2020.pdf

Findlay, L. C., & Ste-Marie, D. M. (2004). A reputation bias in figure skating judging. *Journal of Sport and Exercise Psychology, 26*, 154-166. https://doi.org/10.1123/jsep.26.1.154

Jacobsen, T. (2006). Bridging the arts and sciences. A framework for the psychology of aesthetics. *Leonardo, 39*(2), 155-162. https://doi.org/10.1162/leon.2006.39.2.155

Kirsch, L. P., Dawson, K., & Cross, E. S. (2015). Dance experience sculpts aesthetic perception and related brain circuits. *Annals of the New York Academy of Sciences, 1337*, 130-139. https://doi.org/10.1111/nyas.12634

Laban, R. (2011). *The mastery of movement*. Dance Books Ltd.

Leder, H., & Nadal, M. (2014). Ten years of a model of aesthetic appreciation and aesthetic judgments: the aesthetic episode - Developments and challenges in empirical aesthetics. *British Journal of Psychology, 105*, 443-464. https://doi.org/10.1111/bjop.12084

Mack, M., Hennig, L., & Heinen, T. (2018). Movement prototypes in the performance of the handspring on vault. *Science of Gymnastics Journal, 10*(2), 245-257.

Orgs, G., Calvo-Merino, B., & Cross, E. (2018). Knowing dance or knowing how to dance? Sources of expertise in aesthetic appreciation of human movement. In B. Bläsing, M. Puttke, & T. Schack (Eds.). *The neurocognition of dance* (pp. 238-256). London: Routledge. https://doi.org/10.4324/9781315726410

Palmer, S. E., Schloss, K. B., & Sammartino, J. (2013). Visual aesthetics and human preference. *Annual Review of Psychology, 64*, 77-107. https://doi.org/10.1146/annurev-psych-120710-100504

Pearce, M. T., Zaidel, D. W., Vartanian, O., Skov, M., Leder, H., Chatterjee, A., & Nadal, M. (2016). Neuroaesthetics: the cognitive neuroscience of aesthetic experience. *Perspectives on Psychological Science, 11*(2), 265-279. https://doi.org/10.1177/1745691615621274

Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: is beauty in the perceiver's processing experience? *Personality and Social Psychology Review, 8*(4), 364-382. https://doi.org/10.1207/s15327957pspr0804_3

Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2015). *Research methods in physical activity*. Champaign, IL: Human Kinetics.

Tinio, P. P. L., & Leder, H. (2009). Just how stable are stable aesthetic features? Symmetry, complexity, and the jaws of massive familiarization. *Acta Psychologica, 130*, 241-250. https://doi.org/10.1016/j.actpsy.2009.01.001

Torrents, C., Castañer, M., Jofre, T., Morey, G., & Reverter, F. (2013). Kinematic parameters that influence the aesthetic perception of beauty in contemporary dance. *Perception, 42*, 447-458. https://doi.org/10.1068/p7117

Troje, N. F. (2002). Decomposing biological motion: a framework for analysis and synthesis of human gait patterns. *Journal of Vision, 2*, 371-387. https://doi.org/10.1167/2.5.2

Watkins, J. (2014). *Fundamental biomechanics of sport and exercise.* London: Routledge.

Corresponding author:

Pia M. Vinken
Institute of Sport Science,
Georg-August-University Göttingen,
Sprangerweg 2, 37075 Göttingen,
Germany
Email: pia.vinken@sport.uni-goettingen.de