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Kinematic parameters that influence the aesthetic perception of beauty in contemporary dance

Carlota Torrents[1], Marta Castañer[1], Toni Jofre[2], Gaspar Morey[2], Ferran Reverter[3]
[1] National Institute of Physical Education of Catalunya (INEFC), Universitat de Lleida, E-25192 Lleida, Spain; e-mail: carlotat@inefc.es; [2] Laboratory for the Functional Analysis of Shoes, INESCOP, Inca, Spain; [3] Faculty of Biology, University of Barcelona, Barcelona, Spain
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Abstract. Some experiments have stablished that certain kinematic parameters can influence the subjective aesthetic perception of the dance audience. Neave, McCarty, Freynik, Caplan, Hönekopp, and Fink (2010, *Biology Letters* **7** 221–224) reported eleven movement parameters in non-expert male dancers, showing a significant positive correlation with perceived dance quality. We aim to identify some of the kinematic parameters of expert dancers' movements that influence the subjective aesthetic perception of observers in relation to specific skills of contemporary dance. Four experienced contemporary dancers performed three repetitions of four dance-related motor skills. Motion was captured by a VICON-MX system. The resulting 48 animations were viewed by 108 observers. The observers judged beauty using a semantic differential. The data were then subjected to multiple factor analysis. The results suggested that there were strong associations between higher beauty scores and certain kinematic parameters, especially those related to amplitude of movement.

Keywords: aesthetic experience, motion-capture, motor skills, modern dance

1 Introduction

Dance is the artistic expression of human movement, the art form that exists simultaneously in time and space. Like the spatial features of a photograph or the temporal aspects of a musical composition (Bhatara et al 2011), the spatial and temporal features of a dancer's movement can induce a psychological state in the observer that is usually termed *aesthetic experience* (Calvo-Merino et al 2008). The specific nature of this experience will depend on the sensory perception of the person who observes a work of art, reads a piece of literature, or sees a play.

In art psychology some authors propose the existence of a 'general factor' of aesthetic judgement (Eysenck 1940) which is influenced by different elements of the artwork, as well as by the artistic experience of the observer (Eysenck 1972; Marty et al 2005; Winston and Cupchik 1992). Objectivist theories treat beauty as an attribute of stimuli (Jacobsen and Hofel 2002; Jacobsen et al 2004). Conversely, subjectivist theories maintain that beauty depends on the observer and is largely a matter of attitudes, such as individual taste and preference, expectations, emotions, culture, or familiarity (Höfel and Jacobsen 2007). Similar to other art forms, dance seeks to provoke aesthetic experiences in the observer, not only when watching a whole choreography or performance but also with each single movement. However, only a few studies have sought to identify factors that influence the subjective aesthetic perception of dance.

Most research on aesthetic perception has focused on fixed images. When viewing such images the aesthetic experience will depend on the observer (emotional state, familiarity with the stimulus, knowledge, experience), the context, and on compositional aspects of the relationships among parts, or between these parts and the whole, on the symmetry, balance, visual complexity, grouping, and order (Leder et al 2004). Dance, however, is a dynamic and ephemeral visual form of art, and many other factors may influence its aesthetic perception— for example, the body attitude and physical characteristics of the dancer, the scenography, the plot or narrative of the work, and the music, etc.

So as to simplify our approach to dance, our analysis is limited to the study of its core motor elements. In an earlier study of the kinematics of dance movements Calvo-Merino et al (2008) similarly removed the narrative, costume, and musical elements in order to analyse the neural mechanisms that were related to the aesthetic appraisal of dance stimuli. Other research in the field has shown that the human eye is extremely sensitive to biological movement, and also that it is possible to identify the gender, identity, or even the emotion of performers solely on the basis of point constellations (Clarke et al 2005; Cutting and Kozlowski 1977; Dittrich et al 1996; Pollick et al 2005). Dapatri et al (2007) observed that, based on kinematic information, healthy individuals can recognise a given gesture as their own, even in the absence of morphological cues. Specifically in dance, Neave et al (2010) used 3-D motion-capture avatars to identify specific movement components within dance that may influence its perceived quality. Their study involved 19 male non-expert dancers who danced for 30 s to the same basic drum rhythm observed by 39 females. The authors identified eleven movement parameters that showed a significant positive correlation with perceived dance quality, and three movement measures were key predictors: the variability and amplitude of movements of the neck and trunk, and speed of movements of the right knee. In a similar line, Brown et al (2005) also used 3-D motion-capture technology to study the link between dance quality and genetic and/or phenotypic quality, avoiding the effect of the dancer's appearance. These authors selected 40 dance animations involving 20 people and asked 155 young adults to judge them on a 90 mm visual analogue scale, anchored by "bad dancer" and "good dancer". Strong positive correlations between body symmetry and dancing ability were found, more so among men than women. However, to our knowledge, no previous studies have identified specific movement parameters that may influence perceived dance aesthetics in a specific type of dance by testing expert dancers.

Some dance styles, such as dancesport, folklore, or classical ballet, have very defined and closed rules, but this is not the case of contemporary dance. The latter are free styles of dance in which choreographers use emotions, concepts, or moods to design their own steps and choreographies. This freedom enhances the search for new ways of movement and there are no defined steps or skills (Castañer et al 2009; Torrents et al 2012). However, the identification of certain general characteristics that influence the aesthetic experience of observing these movements could be helpful in the creative process of composition or for designing dance teaching programmes.

In light of the above, the aim of the current study was to identify the kinematic parameters of expert dancers' movements that influence the subjective aesthetic perception of non-expert observers in relation to specific skills of contemporary dance. 3-D motion-capture technology was used to obtain the kinematic parameters and to create avatars.

2 Methods

2.1 *Participants*

Four contemporary dancers with more than 5 years of professional practice (two males: age 31 ± 9.9 years, height 171.5 ± 4.95 cm, weight 68.9 ± 3.5 kg; and two females: age 28 ± 12.7 years, height 164.5 ± 6.36 cm, weight 55.45 ± 5.3 kg) volunteered to participate in the study by performing the chosen motor skills. In addition, 108 first-year students (77 males, 31 females, age 19.46 ± 1.96 years) from the Physical Activity and Sport Sciences degree offered by the National Institute of Physical Education of Catalunya (Universitat de Lleida) volunteered to participate as non-expert observers of the avatars. None of the students had any experience of contemporary dance.

2.2 *Procedure*

The four dancers performed three repetitions of four contemporary dance motor skills in a space measuring ($3 \times 4 \times 2.5$) m. This capture volume was previously calibrated for the 3-D motion-capture system, working with 10 cameras (125 Hz) for 3-D reconstruction, plus one conventional video camera (PAL standard) for reference.

Prior to image capture, the dancers were given time to warm up. 38 retroreflective markers (14 mm diameter) were then attached to the dancers' bodies at defined locations according to the VICON Full Body PlugInGait marker set. Participants wore tight clothing to facilitate accurate information from the markers. When markers were attached on the clothes, the latter were fixed to the skin with double-sided tape underneath the marker location. The skills to be performed were explained to the dancers, who were allowed to practise them until they felt confident. The skills involved were a turn, a jump, a balance, and a displacement skill (see figure 1 for descriptions and images). Each skill was repeated in three different movement qualities, according to Laban's criterion of muscular tension of effort used in contemporary dance (dancers were familiarised with this language): strong, light, and moderate (Laban 1971).
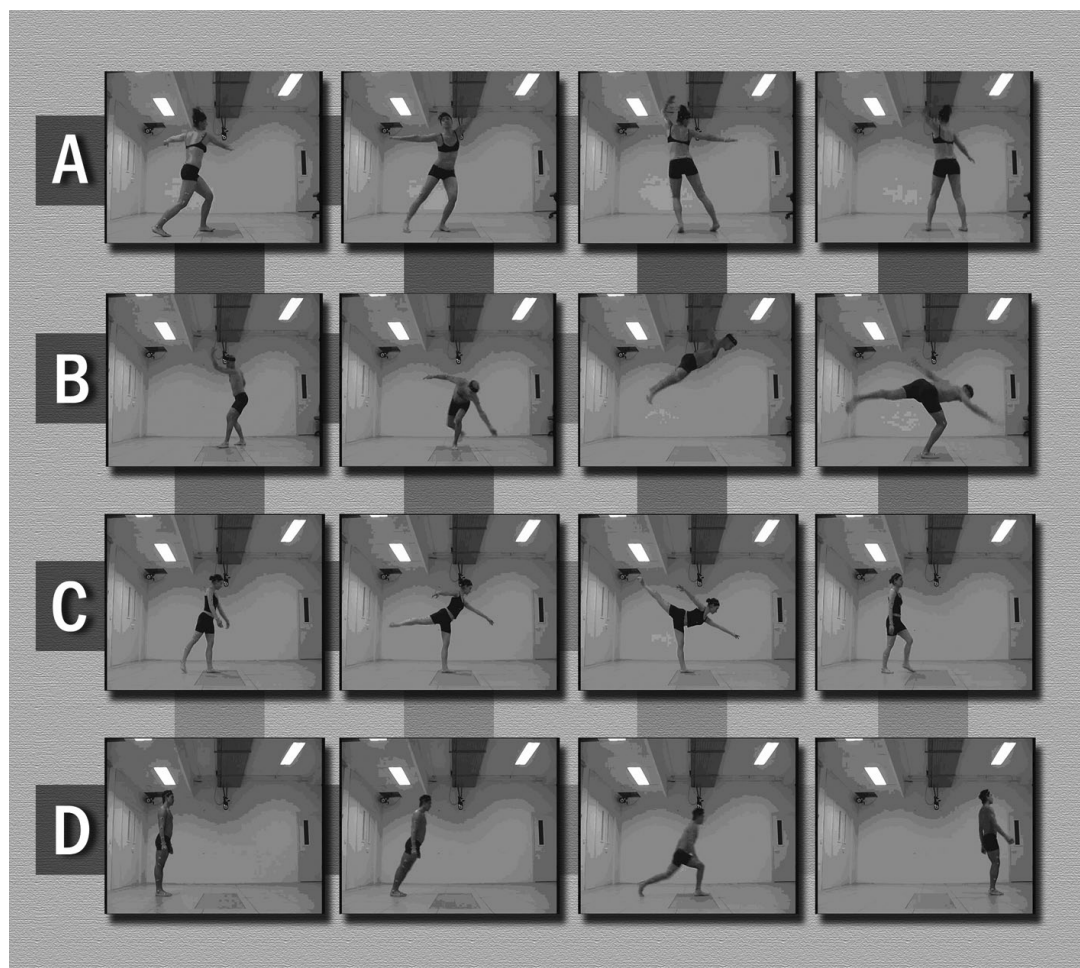

Figure 1. Skills performed by the dancers. (A) *Tour en dehors* or turn performed with the right leg extended to the side of the body and elevating the left arm; (B) Skater's jump or *brisé volé en arrière en tournant*: a jump combined with a turn that tries to reach the parallel full body extension facing the floor; (C) *Arabesque penchée* or stability skill elevating the right leg, bending the body forward, and describing a straight line with the arms and with the right leg and left arm; (D) Forward fall: a displacement leaning forward and catch stepping forward.

A total of 48 trials were filmed with 10 cameras pertaining to the 3-D motion analysis system (VICON MX, Oxford, UK). This system provided the position in space and time of each defined body segment: head, arms, forearms, hands, thorax, pelvis, legs, lower legs, and feet. In this way joint motion could be calculated. On the basis of all this information 39 parameters (see table 1) that the authors—experts in dance—thought might influence aesthetic perception were calculated by custom-written MATLAB (Mathworks, Natick, MA, USA) routines. Several of the parameters could be calculated for more than one skill, while others were specific to a given skill.

Table 1. Motion parameters calculated from the 3-D data.

Parameter	Skill	Abbreviation
1. Difference (%) between turning velocities (around the vertical axis of the room) of head and pelvis	Turn	$\Delta\omega z\_P\text{-}H$
2. Difference (%) between vertical turning velocities (around the vertical axis of the room) of head and thorax	Turn	$\Delta\omega z\_T\text{-}H$
3. Maximum turning velocity of the pelvis (around the vertical axis of the room)	Turn	$MAX\omega z\_P$
4. Mean and standard deviation (SD) of the head angle (expressed relative to pelvis orientation: around anteroposterior axis, around transversal axis, around the vertical axis of the room)	Turn	$\alpha x\_H, SD\alpha x\_H$ $\alpha y\_H, SD\alpha y\_H$ $\alpha z\_H, SD\alpha z\_H$
5. Mean, SD, and maximum of the thorax angle (around the vertical axis of the room)	Turn	
6. Mean, SD, and maximum of the pelvis angle (around the vertical axis of the room)	Turn	
7. Coefficient of variation (CV) of the pelvis angular acceleration (around the vertical axis of the room—6 Hz low-pass filter)	Turn	
8. CV of the pelvis angular acceleration (around the vertical axis of the room—12 Hz low-pass filter)	Turn	
9. CV of the pelvis angular acceleration (around the vertical axis of the room—20 Hz low-pass filter)	Turn	
10. Integral of the fast Fourier transform (FFT) of the position of the centre of mass (CM) (viewing perspective: near–far, right–left, down–up) in the interval from the first value above 0 to 2.5 Hz. Slow vibration	Turn Arabesque Forward fall	SlowVibx_CM SlowViby_CM SlowVibz_CM
11. Integral of the FFT of the position of the CM (viewing perspective: near–far, right–left, down–up) in the interval 2.5–5 Hz. Middle vibration	Turn Arabesque Forward fall	MidVibx_CM MidViby_CM MidVibz_CM
12. Integral of the FFT of the position of the CM (viewing perspective: near–far, right–left, down–up) for frequencies >5 Hz. Fast vibration	Turn Arabesque Forward fall	FastVibx_CM FastViby_CM FastVibz_CM
13. Integral of the FFT of the position of the centre of the pelvis (viewing perspective: near–far, right–left, down–up) in the interval from the first value above 0 to 2.5 Hz	Turn Arabesque Forward fall	SlowVibx_P SlowViby_P SlowVibz_P
14. Integral of the FFT of the position of the centre of the pelvis (viewing perspective: near–far, right–left, down–up) in the interval 2.5–5 Hz	Turn Arabesque Forward fall	MidVibx_P MidViby_P MidVibz_P
15. Integral of the FFT of the position of the centre of the pelvis (viewing perspective: near–far, right–left, down–up) for frequencies >5 Hz	Turn Arabesque Forward fall	FastVibx_P FastViby_P FastVibz_P

Table 1 (continued).

Parameter	Skill	Abbreviation
16. Duration of the single limb stance	Arabesque	DURATION
17. Right-leg angle relative to the vertical in the plane of view	Arabesque	α_rLEG
18. Left-leg angle relative to the vertical in the plane of view	Arabesque	α_lLEG
19. Right-arm angle relative to the vertical in the plane of view	Arabesque	α_rARM
20. Left-arm angle relative to the vertical in the plane of view	Arabesque	α_lARM
21. Angle between right leg and right arm in the plane of view	Arabesque	$\alpha\_rLEG\text{-}rARM$
22. Angle between left leg and left arm in the plane of view	Arabesque	$\alpha\_lLEG\text{-}lARM$
23. Angle of the right arm to the plane of view	Arabesque	α_rARM
24. Angle of the left arm to the plane of view	Arabesque	α_lARM
25. Angle of the right leg to the plane of view	Arabesque	α_rLEG
26. Angle of the left leg to the plane of view	Arabesque	α_lLEG
27. Area of the polygon joining ankles and wrists, projected on the frontal plane of the pelvis at the instant of take-off (normalised to the square of body height)	Skater's jump	A_TO
28. Area of the polygon joining ankles and wrists, projected on the frontal plane of the pelvis at the instant of maximum height of the CM (normalised to the square of body height)	Skater's jump	A_hMAX
29. Area of the polygon joining ankles and wrists, projected on the frontal plane of the pelvis at the instant of touch down (normalised to the square of body height)	Skater's jump	A_TD
30. Vertical amplitude of the CM motion	Skater's jump Forward fall	AMPz_CM
31. Maximum achieved height of the CM	Skater's jump	hMAX_CM
32. Maximum vertical inclination of the line joining 7th cervical vertebra (C7) with the right heel at the instant of maximum height of the CM	Skater's jump	INCLMAX
33. Root mean square (RMS) of the angle between thorax and pelvis during flight (Euler rotations, pelvis around thorax in the sequence mediolateral, anteroposterior, vertical)	Skater's jump	$\alpha x\_P\text{-}T$ $\alpha y\_P\text{-}T$ $\alpha z\_P\text{-}T$
34. RMS of the angle between pelvis and right leg during flight (Euler rotations, leg around pelvis in the sequence mediolateral, anteroposterior, vertical)	Skater's jump	$\alpha x\_rLEG\text{-}P$ $\alpha y\_rLEG\text{-}P$ $\alpha z\_rLEG\text{-}P$
35. RMS of the angle between pelvis and left leg during flight (Euler rotations, leg around pelvis in the sequence mediolateral, anteroposterior, vertical)	Skater's jump	$\alpha x\_lLEG\text{-}P$ $\alpha y\_lLEG\text{-}P$ $\alpha z\_lLEG\text{-}P$
36. Maximal trunk forward leaning prior to forwarding the foot	Forward fall	α_TRUNK
37. Angle defined by the line joining the midpoint between both ankles with the sacrum and the sacrum with C7 at maximal forward leaning	Forward fall	$\alpha\_C7\text{-}ANKLE$
38. Forward step length	Forward fall	l_STEP
39. Symmetry of the anteroposterior velocity/time curve of the CM (vertical symmetry axis at the absolute minimum)	Forward fall	$SYM\_\omega AP$

2.3 Stimulus construction

Other studies have utilised only the markers to represent human motion (Clarke et al 2005; Cutting and Kozlowski 1977; Dittrich et al 1996; Pollick et al 2005). Given the complexity of some of the studied tasks (especially when turning), in order to ease perception by providing more visual cues it was decided to create the avatars by drawing lines joining the tracked markers attached to the body depicting the different segments: head, thorax, upper arm, lower arm, hand, pelvis, thigh, leg, foot. The reporting tool Polygon (VICON MX, Oxford, UK) was used to create video clips showing the animated stick avatars (see figure 2) from a fixed perspective.
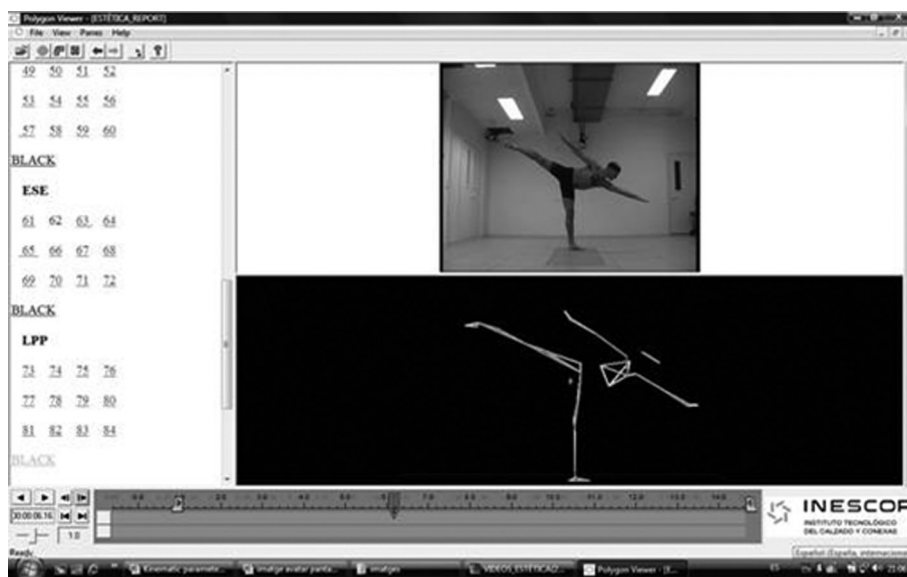

Figure 2. Screen from the Polygon software showing the image of the performance of an arabesque and the corresponding animated stick avatar.

The students observed all 48 animations in one session. Observers were asked to rate each dance movement using a 7-point semantic differential anchored by ugly and beautiful (Osgood et al 1957). This approach is based on the findings of Marty et al (2003), which suggest that there is a general factor of beauty that can be judged by using a simple and unified criterion. These authors compared the appraisal of beauty using the categories 'beautiful–ugly' with an appraisal based on the categories 'interesting–not interesting', 'pleasant–not pleasant', and 'original–common'. Their results suggested the existence of a general factor of aesthetic experience, and they therefore proposed reducing aesthetic judgement to simple questions, such as those used in the present study.

The animations were presented grouped into skills, but in a random order as regards the dancer or the quality of the movement. Each animation was shown three times in order to have enough time to appreciate it, after which a black screen was presented for 5 s.

The experiments were carried out in accordance with the relevant institutional and national regulations and legislation.

2.4 Data analysis

The biomechanical parameters were crossed with the subjective judgements of the observers. Data were analysed using FactoMineR software,[1] a package designed for multivariate exploratory data analysis, and in this case a multiple factor analysis (MFA) was conducted (Escofier and Pagès 1994).

[1] The FactoMineR software was developed and is maintained by F Husson, J Josse, and S Lê from Agrocampus Rennes, and by J Mazet, http://factominer.free.fr/index.html

MFA is dedicated to the simultaneous exploration of multiway data sets where the same individuals are described by several groups of variables. The assets of MFA appear when integrating both numerical and categorical groups of variables, and when supplementary groups of data need to be added in the analysis (for more information on this issue see Husson et al 2007 or Lê et al 2008).

The core of MFA is a Principal Components Analysis (PCA) applied to the whole set of variables in which each group of variables is weighted, rendering possible the analysis of different points of view by taking them equally into account. Resulting graphical outputs for the first two principal components (PC1 and PC2) are used.

The goal of MFA is to integrate different groups of variables describing the same observations. In order to do so, the first step is to make these groups of variables comparable. To compare groups of variables, each group is normalised by dividing all its elements by a quantity called its first singular value which is the matrix equivalent of the standard deviation (SD). Practically, this step is implemented by performing a PCA on each group of variables. The first singular value is the square root of the first eigenvalue of the PCA. After normalisation, the data tables are concatenated into a data table which is submitted to PCA. The corresponding graphical displays: individual factor map and correlation circle, are read as for PCA.

3 Results

3.1 *Tour en dehors (turn)*

Figure 3 shows the individual factor map for the avatar analysis of the turn skill (accounting for 49.01% of the total variability). There was a clear division of the trials into two groups. The three trials of participant 4 represented a compact group, while the trials of participants 1 and 2 formed another group; participant 3 presented more heterogeneous results. Figure 3 also includes the correlation circle of the most determinant kinematic parameters and the possible values of the beauty appraisal (1–7). For PC1 (27.79% of the total variability) the original variable maximum turning velocity (MAXωz_P) was strongly associated with the highest scores and with the second and third trial of participant 3 (trials performed with moderate and strong effort). For PC2 (21.22% of the total variability), the original variables most strongly associated with these scores and trials were the slow and middle fast vibration of the centre of mass (CM) in the vertical plane, (SlowVibz_CM, MidVibz_CM), the slow vibration of the CM in the horizontal plane (SlowViby_CM), and the slow vibration of the
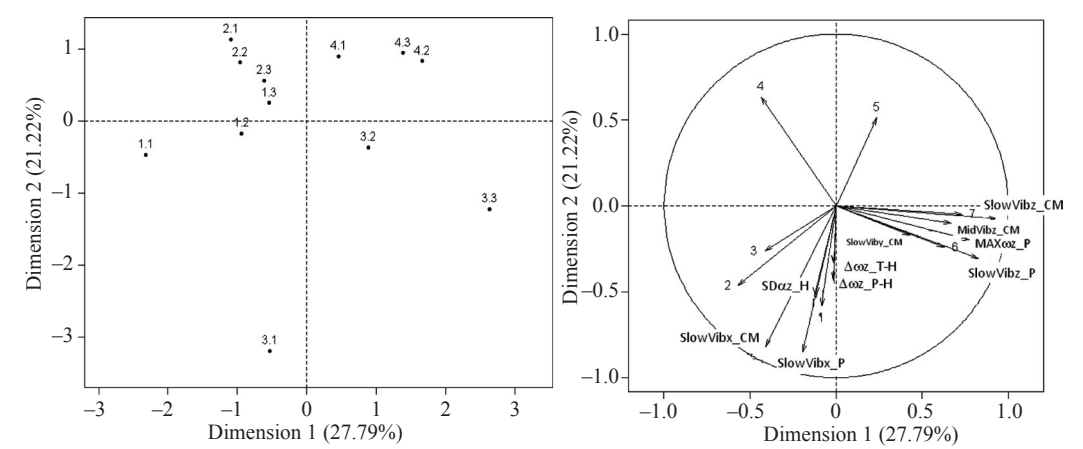

Figure 3. Individual factor map for the analysis of the turn skill (left), along with the correlation circle of all the kinematic parameters and the possible beauty appraisal values (right). The variables are projected onto the factor map and are represented as vectors. The closer to unity the vector magnitude is, the better is the projection.

pelvis in the vertical plane (SlowVibz_P). The differences between vertical turning velocities of head and thorax ($\Delta\omega z$_T-H) and of head and pelvis ($\Delta\omega z$_P-H), as well as the SD of the head angle around vertical axis (SDαz_H) of PC1, the variables SlowVibx_CM, SlowVibx_P of PC2, and the first trial of participant 3 were associated with the lowest scores (1, 2, 3). Variables such as the thorax, or the pelvic angle, or the pelvis angular acceleration don't seem to affect the aesthetic appraisal of this skill.

3.2 *Skater's jump*

The results for the jump task showed a clear association between the highest scores (6–7) and the amplitude and inclination parameters of PC1 (44.33% of the total variability) and the angle between pelvis and right leg during flight in the horizontal plane (αy_rLEG-P) of PC2 (24.58% of the total variability). The lowest scores were associated with the angle between pelvis and left leg during flight in the vertical plane (αz_lLEG-P; PC2). The individual factor map also clearly grouped the trials of each participant, regardless of the quality of the movement. All three trials of participant 1 were associated with the highest scores; whilst the lowest scores were associated with participant 2 and the first trial of participant 4 (performed with light effort; see figure 4). Similar results were obtained when taking into account the mean appraisal values obtained from the observers for each trial. The highest scores were associated with inclination and amplitude (PC1), and with αy_rLEG-P and the same variable but in the frontal plane (αx_rLEG-P; PC2). Variables such as the area projected by the dancer on the frontal plane in the different moments of the jump or the angle between thorax and pelvis don't seem to affect the aesthetic appraisal of this skill.
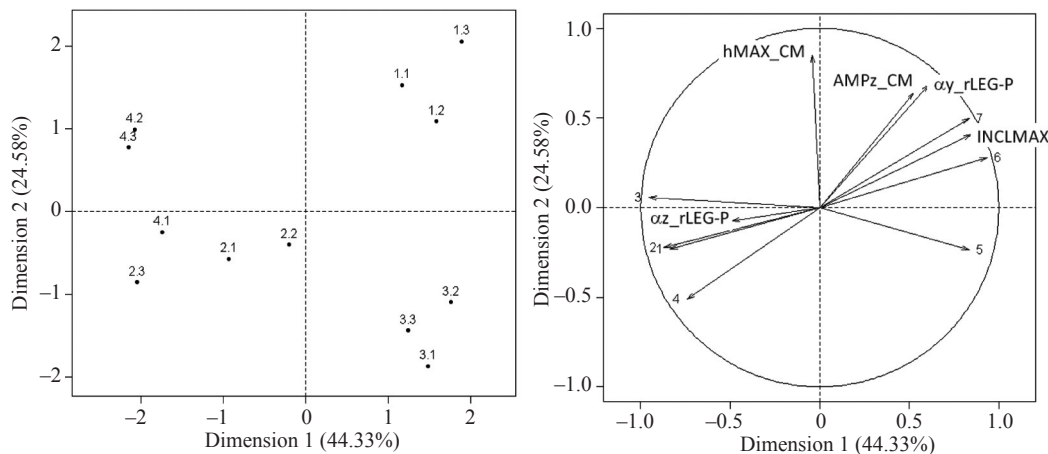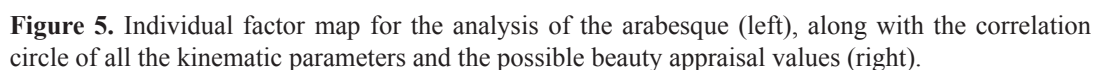

Figure 4. Individual factor map for the analysis of the skater's jump (left), along with the correlation circle of all the kinematic parameters and the possible beauty appraisal values (right).

3.3 *Arabesque*

Trials of the stability skill (arabesque) were also grouped depending on the performer. The three trials of participants 1, 2, and 3 represented three different compact groups. Participant 4 presented more heterogeneous results. Figure 5 shows the scores graphs. The highest scores (5–7) were associated with the kinematic parameters angles of the left leg and of the left arm to the plane of view (α_lLEG, α_lARM), the duration of the single limb stance (DURATION), and the angle between left leg and left arm in the plane of view (α_lLEG, lARM), and also with the right leg angle relative to the vertical in the plane of view (α_rLEG) of PC1 (24.71% of the total variability). PC2 (22.46% of the total variability) was associated with the middle fast and the fast vibration of the CM in the frontal plane (MidVibx_CM, FastVibx_CM). The highest scores corresponded to the first trial of participant 2 (performed with light effort) and the third trial of participant 4 (performed with strong effort). The lowest scores were

Figure 5. Individual factor map for the analysis of the arabesque (left), along with the correlation circle of all the kinematic parameters and the possible beauty appraisal values (right).

associated with the slow vibration of the pelvis in the vertical plane and with the middle fast and fast vibration of the pelvis in the frontal plane (SlowVibz_P, MidVibx_P, FastVibx_P; PC2), as well as with the second trial of participant 3 (performed with moderate effort). Very similar results were obtained when analysing mean appraisal scores. Variables such as the left leg angle, the right and left arm angle to the vertical in the plane of view, the angle of the right arm or right and left leg to the plane of view don't seem to affect the aesthetic appraisal of this skill.

3.4 *Forward fall (displacement)*

The MFA of the displacement skill showed a clear inverse association between lowest scores and amplitude and the maximal forward leaning of the trunk prior to forwarding the foot (α_TRUNK; PC1: 36.78% of the total variability). These parameters were also associated with the mean scores. The maximal forward leaning of the line joining ankles and neck (α_C7-ANKLE; PC1) was associated with the highest score, as were some original parameters of PC2, although these were not associated with the mean score. The length of the forward step (l_STEP) or the vertical amplitude of the motion of the centre of masses (AMPz_CM) did not seem to affect the aesthetic appraisal of this skill.

4 Discussion

According to the results obtained from the individual factor maps, the perception of beauty is clearly influenced by the style of each dancer, rather than by the quality of movement that he/she sought to achieve. Individual factor maps clearly grouped the trials of each participant regardless of the quality of each trial. Although the effort qualities described by Laban are likely to affect the aesthetic perception of a sequence of movements, this aspect might be too subtle to modify the appraisal of isolated actions. Judging avatars ensures that observers appraise the beauty of the movement rather than the image or attractiveness of the dancers (Brown et al 2005). Subsequent studies with more dancers should be needed in order to generalise these results.

Strong associations were found between higher appraisal scores and certain kinematic parameters, especially those related to the amplitude of movement. The amplitude of movement was also one of the key predictors for perceiving dance quality reported by Neave et al (2010). In their study, it referred to the movement of the trunk and neck when observing free dance, but this nonetheless supports the hypothesis that the amplitude of movement is a highly relevant parameter for the perception of beauty.

As regards turns, the turning velocity (calculated as the maximum angular velocity of the pelvis around the vertical axis) seemed to be the most relevant parameter. Fluctuations or a swaying movement seemed to be associated with better scores when they occurred in the plane of view (down–up and right–left), with worse scores being awarded when they occurred in depth (near–far) and when they were below 2.5 Hz; this was probably because they were regarded as instability movements. Posture stability is often measured by analysing the mediolateral and anteroposterior sway (Hatzitaki et al 2004; Lafond et al 2004). Consequently, motion instability should be associated with the Fourier transform results in one of the horizontal axes.

The beauty of the jump skill seems to be associated with amplitude, inclination, and the rotation between the pelvis and right leg around the transverse and anteroposterior axes. Interestingly, the height of the jump appears to be quite independent of the scores, probably because observers placed greater emphasis on the amplitude of movement (considering that there is a lowering of the CM prior to jumping), or because the impression of height depends more on the amplitude (difference between maximum and minimum height of the CM) than on the final height achieved by the CM. This is an interesting result that should be taken into account during the process of learning to jump or in the creative process of a given choreography, since it appears that prior movements can affect the impression of the audience.

The beauty in executing an arabesque was associated with the time that the dancer took to perform it, probably because maintaining the position is a sign of mastery in balance. It was also associated with the amplitude of movement, in this case evaluated according to the angle of the legs and the perpendicular of the support leg (left leg) to the floor. Amplitude was also the most important characteristic when judging the beauty of the displacement skill, where it was related to the maximum achieved inclination at the beginning of the movement and to the vertical motion amplitude of the CM.

A number of limitations of this study should be considered. First, the avatars were not scaled and therefore contained information about the morphological characteristics of dancers that could influence the subjective appreciation of beauty. Moreover, some information that could be relevant has been removed in the avatars, for example hand gestures. Further research is now required to confirm these results by manipulating specific variables of relevance. For instance, dancers could perform jumps with different heights, or balances with different amplitudes. Avatar's motion could also be systematically altered to manipulate in very controlled manner the variables of interest.

Overall the results suggest that non-expert observers are influenced by the most basic characteristics of dance skills, such as turning speed, the time for which balance is maintained, or the amplitude of movement.

Sport students are probably influenced by their background when judging beauty in dance. Subsequent studies will therefore need to focus on detecting differences among expert observers as regards which kinematic parameters are most relevant to the aesthetic judgement of contemporary dance. This could eventually lead to a discussion what is more important in beauty, the attribute of stimuli, or the attitude of the observer (Höfel and Jacobsen 2007; Jacobsen et al 2004). Calvo-Merino et al (2010) consider that an observer's aesthetic experience is presumably grounded in the responses of his/her neural sensory motor and affective circuits to the expressive actions of the dancer's body. They also suggest that it is dependent on the viewer's previous sensorimotor experience (Calvo-Merino et al 2005). Therefore, expert observers are likely to be influenced by aspects other than purely aesthetic ones or personal feelings, aspects that are determined by the perceiver's concepts and expertise, style, codes, history, and traditions of the art form (Augustin and Leder 2006, Leder et al 2004; Morris 2008). Thus, although the kinematic parameters analysed in this research will be especially

relevant in the process of teaching and learning dance, other artistic elements related to the style or meaning of the dance will have a determining influence when judging the beauty or artistic relevance of a given choreography.

5 Conclusions

The present findings suggest that, when observing isolated specific contemporary dance skills, the perception of beauty is especially affected by some kinematic parameters. In this case, the individual style of a dancer was also more important than the effort made in performing the skills.

The overall results suggest that non-expert observers are influenced by the most basic characteristics of dance skills, such as the speed of turning or the amplitude of movement. Subsequent studies should therefore seek to detect differences among expert observers as regards which kinematic parameters are most relevant to the aesthetic judgement of modern dance.

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