Knowing dance or knowing how to dance? Sources of expertise in aesthetic appreciation of human movement.

Guido Orgs[1], Beatriz Calvo-Merino[2], Emily Cross[3]

[1] Department of Psychology, Goldsmiths, University of London, SE14 6NW, New Cross, London, UK.

[2] Department of Psychology, City, University of London, UK

[3] School of Psychology, Bangor University, LL57 2AS, Bangor, Wales, UK

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A brief history of dance aesthetics

The study of how humans appreciate art has a long history in psychology. The first empirical investigations into aesthetic cognition were conducted in the late 18th century by Gustav Theodor Fechner (Fechner, 1876). Fechner studied optimal proportions in paintings ("the golden ratio") arguing that a "bottom-up" scientific approach to aesthetics should aim to reveal general principles of human aesthetic judgement. Initially, the term 'aesthetics' was introduced by the philosopher Alexander Baumgarten. It is derived from the Greek word "aisthetikos" (I sense, I feel) and refers to "sensual" as opposed to "rational" cognition. Baumgarten believed that aesthetic judgements were entirely subjective and not accessible to empirical investigation (Hammermeister, 2002). Modern aesthetic science has primarily focussed on the visual arts and music (Berlyne, 1974; Shimamura & Palmer, 2012; Zajonc, 1968). Only few attempts have been made to develop a theory of aesthetic perception in the performing arts, and more specifically, dance. (Kreitler & Kreitler, 1972) argued that the aesthetic appeal of dance primary lies in "remoteness from the habitual". On this notion, dance movements are enjoyed because they are performed in such a way that people would not normally move. According to Gestalt Psychologist Rudolf Arnheim, aesthetic appreciations of dance should resemble the aesthetics of all other moving visual stimuli (Arnheim, 1974) and should depend on the gestalt laws of perceptual organisation, such as good continuation and symmetry. Importantly, he also emphasised the role of dynamic changes in movement speed and acceleration in movement aesthetics. In recent years, neuroaesthetics (Chatterjee & Vartanian, 2014; Pearce et al., 2016) have questioned such a purely visual approach to movement aesthetics. Even abstract visual art often makes references to human action and provides clues to the movements that were made by the artist to produce the artwork (Freedberg & Gallese, 2007; Sbriscia-Fioretti, Berchio, Freedberg, Gallese, & Umiltà, 2013; Ticini, Rachman, Pelletier, & Dubal, 2014) In the context of the performing arts, merely observing a dancer's movements evokes resonant brain activity in the brain of the spectator (Fadiga, Craighero, & Olivier, 2005) that is indeed related to the aesthetic pleasure derived from watching other people move (B. Calvo-Merino, Jola, Glaser, & Haggard, 2008; Jola, Abedian-Amiri, Kuppuswamy, Pollick, & Grosbras, 2012; Kirsch, Dawson, & Cross, 2015b).

Dance as a social art form

(Guido Orgs, Caspersen, & Haggard, 2016) have recently developed a neurocognitive model for studying human movement aesthetics that aims to combine different aspects of human movement in a single theoretical framework. The model emphasise communication between a performer and a spectator as a key feature of dance and perhaps all performing arts. In any social interaction, information is exchanged between at least two people. In the context of conversation, (Grice, 1991) argues that this exchange of information requires cooperation between the speaker and the listener. In dance, information is primarily, though not exclusively (Jola, Pollick, & Calvo-Merino, 2014), communicated through movement. Aesthetic appreciation of dance involves sharing ideas, feelings and intentions between performer and spectator via watching the performers' movements. Importantly exchange of information in dance is often ambiguous and open to multiple interpretations. The pleasure derived from watching dance thus depends on the spectator's ability to perceive and understand the performers' intentions and emotions on the one hand, and the performer's ability to effectively express these intentions and emotions on the other hand (Hanna, 1983).

We can distinguish three components of the communicative process during a dance performance (Guido Orgs et al., 2016). The *dancer* transmits information to the *spectator* via the *movement message*. In turn the spectator acknowledges message transmission and understanding, for example by clapping at the end of the performance, or may even alters the course of the performance, for example in participatory contexts.

The Performer

The performer conveys information to the audience by making body movements. The limits of what can be communicated through movement are set by the physical constraints of the human body. The increase in movement repertoire through dance training thus increases the number and quality of messages that can be communicated. As in conversation, the number of possible messages that can be exchanged non-verbally via movement can be termed the movement vocabulary (Calvo-Merino, Chapter XX this volume). Dance styles are often characterised by fixed movement vocabularies, for example western ballet. The movement vocabulary of the performer is expanded through training by adding new movements that were not previously possible or may involve perfecting movements that are made every day. In either case, the range of physical and emotional expression is increased (Christensen & Calvo-Merino, 2013). This idea resembles Rudolf Laban's developments of specific exercises "to develop the body as an instrument of expression" (Laban & Ullmann, 2011). Importantly, this definition of the purpose of dance training is not exclusive to any particular dance style or technique, but only refers to a dancer's ability to effectively communicate intentions through movement. Becoming an effective transmitter of the message is thus an integral part of dance training, and perhaps all training in the performing arts.

The Movement Message

The movement message can be described in terms of its visual features, its action features and its social features. Visual, action and social features constitute the layers of the movement message and are associated with distinct neural processing mechanisms. Social features are derived from action features and action features are derived from visual features of the movement message. Yet aesthetic appreciation of dance can occur at all three levels, depending on the appreciation style and the expertise of the spectator.

Visual, action and social features of movement

Visual features comprise the spatial organisation of dance movements of one or more dancers and how these spatial features unfold over time. Many of the visual features present in a dance performance are not necessarily specific to dance but are shared by all visual displays. As a visual stimulus, dance can be conceptualised at least three levels of representation, the static postural level, the dynamic level and the structural level (Guido Orgs, Hagura, & Haggard, 2013). The static level comprises a set of body postures. Aesthetic perception of these static features will depend on the same principles that govern aesthetic perception of all visual stimuli. These include for example balance of composition and symmetry (Arnheim, 1974; McManus, 1980, 2005; McManus & Weatherby, 1997; Sammartino & Palmer, 2012) and posture geometry. For example, vertical ballet postures are preferred to more horizontal postures (Daprati, Iosa, & Haggard, 2009). Next, the dynamic level comprises movements, considered as transitions from one posture to another. Aesthetic evaluation at this level might depend on factors such as speed, movement direction and effort (Christensen & Calvo-Merino, 2013; Laban & Ullmann, 2011). For example, movements with a smooth, predictable movement path are preferred to jerky movement paths with changes of movement direction between every posture (Guido Orgs, Hagura, et al., 2013). Other dynamic parameters of movement aesthetics include the speed at which turns are performed, movement amplitude and the presence of jumps (B. Calvo-Merino et al., 2008; Torrents, CastaÃ±er, Jofre, Morey, & Reverter, 2013). For groups of dancers, dynamic visual features will further include movement symmetry and synchrony between dancers (Brick & Boker, 2011; Vicary, Sperling, Von Zimmermann, Richardson, & Orgs, forthcoming). Finally, at a structural level, individual movements can be arranged into longer phrases, following compositional rules (Opacic, Stevens, & Tillmann, 2009; Guido Orgs, Hagura, et al., 2013; Schiffer & Schubotz, 2011). Sequential symmetry is frequently used in the composition of dynamic art works such as music (Koelsch, Rohrmeier, Torrecuso, & Jentschke, 2013; Kuhn & Dienes, 2005; Rohrmeier, Zuidema, Wiggins, & Scharff, 2015) and poetry (Jiang et al., 2012). In choreography, similar rules can be applied to arrange movement elements into longer sequences.

Action features include goals and intentions of the observed movement. Action features are inferred and predicted from movement kinematics (Giese & Poggio, 2003; J. M. Kilner & Lemon, 2013; Obhi & Sebanz, 2011; Sartori, Becchio, & Castiello, 2011). For example, observers readily predict jumping height from a few steps that precede the jump (Ramenzoni, Riley, Davis, Shockley, & Armstrong, 2008) or use kinematic cues to detect deception (Sebanz & Shiffrar, 2009) Action features are thus perceptually inferred from visual features.

Movement also communicates social features. Emotions such as joy, sadness and anger can be accurately discriminated from the abstract movements of one arm only and are associated with distinct kinematic parameters (Pollick, Paterson, Bruderlin, & Sanford, 2001; Sawada, Suda, & Ishii, 2003; Van Dyck, Vansteenkiste, Lenoir, Lesaffre, & Leman, 2014). Emotion can be also recognized in dance (Christensen, Nadal, Cela-Conde, & Gomila, 2014; Christensen, Pollick, Lambrechts, & Gomila, 2016). Static body postures and visually impoverished point-light displays of a person moving provide reliable cues for specific emotions (Atkinson, Tunstall, & Dittrich, 2007). In point-light displays, a human figure is reduced to a set of dots, typically positioned across joints. The configural motion of these dots gives a vivid impression of a person moving, in the absence of any available information about body shape. Interestingly, high intensity emotions are more easily identified from bodily as compared to facial expressions (Aviezer, Trope, & Todorov, 2012). Moreover, observers readily distinguish between cooperative or competitive action goals based on movement kinematics (Obhi & Sebanz, 2011; Sacheli, Candidi, Pavone, Tidoni, & Aglioti, 2012; Sacheli, Tidoni, Pavone, Aglioti, & Candidi, 2013).

The social features of dance may play an important role in communicating social signals to other performers and spectators. For example, dancing in synchrony increases group affiliation (Reddish, Fischer, & Bulbulia, 2013; Tarr, Launay, Cohen, & Dunbar, 2015; von Zimmermann, Vicary, Sperling, Orgs, & Richardson, in review) and memory for other group members (Woolhouse, Tidhar, & Cross, 2016). (Hagen & Bryant, 2003) argue that dance and music fulfill evolutionary function in ‘coalition signalling’. Groups of performers moving in skilfull synchrony signal to spectators that they are close affiliated to each other and work together efficiently. In a recent study, (Vicary et al., forthcoming) directly measured the effect of movement synchrony on aesthetic perception of dance in live contemporary dance performances. In line with an evolutionary function of communicating social signals between groups of spectators and groups of performers, (Vicary et al., forthcoming) indeed show that continuous rating of enjoyment are predicted by changes in movement synchrony among a group of dance performers. Importantly, *how* performers coordinated their movements was a better predictor of aesthetic judgements than *how much* the performers moved. These findings therefore support a layering of movement features. Visual and action features are the building blocks of the social features of dance.

The Spectator

Visual, action and social features are processed by the spectator’s brain. Aesthetic appreciation and aesthetic judgement thus require understanding of the psychological and brain mechanisms that process these different features of the movement message. One important constraint of communicating this information is the spectator’s expertise with the movement that is being watched. In the case of dance, we can distinguish at least three sources of expertise. Firstly, the spectator’s visual expertise with the observed movement. Visual familiarity depends on how often the same or similar movements have been observed before. It also depends on experience with watching specific dance styles and vocabularies. For example, a regular spectator of ballroom dance will gain substantial visual experience with a specific set of partner dances such as the Viennese waltz, but will gain very little visual experience in watching other dances that are not part of this specific set, for example Indian Kathak. The second source of expertise is unique to aesthetic perception of bodies and human movement and relates to the motor familiarity with the observed movement. For example, a HipHop dancer who participates in a battle will not only have previously seen the movements that the other dancers are performing, but will also be able to perform the same or similar movements. The ability perform observed actions alters how these actions are perceived and engages a distinct set of brain regions as we will see in the next section of this chapter. Finally, the spectator’s aesthetic response to a dance performance will depend on knowledge about how the specific dance piece was created. For example, a dance piece that involves a specific series of fixed steps and a narrative will be judged not only based on the current performance that the spectator is watching, but also on other performances of the same piece that the spectator may have seen before. These specific realisations of choreographic score by a different cast or staged by a different choreographer may vary considerably. As an example, many classical pieces of western ballet (e. g. Swan Lake) exist in many different versions by different choreographers and performed by different dance companies. Frequent spectators may therefore have very specific expectations as to how a performance ‘should look like’. In contrast, a dance piece that is primarily composed of improvised movement does not easily allow for such comparisons. Dance making is a complex process and can involve a multitude of techniques, tools and compositional approaches (see http://motionbank.org for a few examples from contemporary choreography). Novices to dance may not be aware of these varied approaches to dance making and choreography, and in contrast to much of visual art (Tinio, 2013), it is not possible to reconstruct the creative process of dance making by watching a performance of the choreographic work. Identical movements may be either preconceived and form part a fixed series of steps, or they may be improvised or performance-specific and never be performed in the exact same way again.

Brain mechanisms relevant for movement aesthetics

Neuroaesthetics aims to link aesthetic perception to brain structure and function (Chatterjee & Vartanian, 2014; Zeki & Lamb, 1994). The neural mechanisms of aesthetic perception of dance are tightened to the neural correlates of perceiving others' movement. These involve a wide range of brain areas including the visual cortex, but also motor, premotor and parietal brain areas (Grosbras, Beaton, & Eickhoff, 2012; Guido Orgs et al., 2015). Neuroscientific research has identified specialised, yet overlapping processing pathways for perception of (a) static visual bodies (b) human movement kinematics and (c) inferring intentions and emotions from other people's actions.

'Visual' areas for body and movement aesthetic perception

The human brain has dedicated areas for processing all kinds of moving stimuli, including both animate objects such as bodies, but also inanimate objects and abstract shapes (Semir Zeki, 1998) argues that these mechanisms are also important for the aesthetics for (non-biological) motion. Specifically, some patterns of motion are particularly powerful in activating visual motion areas such as V5/MT+. (Zeki & Stutters, 2012) show that the preference for specific patterns of motion for abstract visual stimuli scales with the activation of motion-sensitive brain areas. Patterns include concentric motion of dots emanating from a central viewpoint and smooth, flocking motion of groups of dots across the screen. Preferred patterns of motion are associated with greater activity in motion sensitive brain area V5/MT+. Although this experiment was conducted using simple white dots moving on a black background, and did not contain any displays of the human body, similar principles of grouping dancers on stage are applied in choreography and are likely to contribute to the visual appeal of watching dance.

A number of brain areas have been shown to be important for neural processing of both static and dynamic features of human action. These include the Extra-striate Body Area (EBA) and Fusiform Body Area (FBA) (Guido Orgs et al., 2015; Orlov, Makin, & Zohary, 2010; Urgesi, Calvo-Merino, Haggard, & Aglioti, 2007). Whereas EBA primarily responds to body parts (Downing & Peelen, 2011; Vangeneugden, Peelen, Tadin, & Battelli, 2014), visual body representations in FBA are supposedly more configural and more closely related to the subjective percept (Bernstein, Oron, Sadeh, & Yovel, 2014; Ewbank et al., 2011; Guido Orgs et al., 2015; Taylor & Downing, 2011). Moreover, activity in these body-specific areas is modulated by whether actions are neutral or display emotions (de Gelder, de Borst, &

Watson, 2015; Pichon, de Gelder, & Grèzes, 2012). Specifically, angry body postures produce greater neural responses, presumably due to their evolutionary relevance for survival.

EBA and the ventral premotor cortex indeed contribute to aesthetic preferences for body postures (B. Calvo-Merino, Urgesi, Orgs, Aglioti, & Haggard, 2010). In this study, pairs of body postures were presented while transcranial magnetic stimulation (TMS) was applied over both brain areas. For each pair, observers judged which body posture they preferred. Relative preferences were compared to an aesthetic baseline judgement for each body posture. Stimulating both EBA and ventral premotor cortex independently altered aesthetic preferences relative to baseline. Participants' aesthetic judgements were more consistent with their baseline ratings when EBA was stimulated relative to ventral premotor cortex. In contrast to the study by Zeki and Stutters (2012) this pattern of results suggests that there is no simple linear relationship between the activity in one of these areas and aesthetic judgements. In Calvo-Merino's study, stimulating across both sites did not simply increase or decrease liking for these body stimuli. Instead participants' preferences were less aesthetically sensitive, suggesting a more complex relationship between motor resonanceand aesthetic judgements. This was the first study that employed TMS to modify aesthetic preference and therefore showing a causal relationship between aesthetic judgement and processing of visual and action features in these areas.

Aside from EBA and FBA, research using point-light walkers shows that the STS is causally involved in recognizing human movement (Blake & Shiffrar, 2007; Puce & Perrett, 2003; Vangeneugden et al., 2014). Similar to movement processing in EBA/FBA, activity in pSTS distinguishes between different emotions, suggesting an increased response of pSTS to expressive as compared to non-expressive movement (Grèzes, Adenis, Pouga, & Armony, 2013; Pichon et al., 2012). Further support for the role of STS in processing emotion comes from a recent study by Grèzes and colleagues (2014). These authors demonstrated structural connections between STS and the amygdala, one of the primary subcortical brain structures implicated in emotional processing (Grèzes, Valabrègue, Gholipour, & Chevallier, 2014). The STS is also associated with multisensory integration. Chen and colleagues (2009) suggest a close association between musical rhythm perception and movement coordination within the superior temporal gyrus, and identify this region as an important node for facilitating auditory–motor interaction in the context of rhythm (Chen, Penhune, & Zatorre, 2009). A recent study that coupled sensorimotor dance training with pre- and post-training fMRI measures to investigate how dance learning shapes observers' aesthetic preferences sheds further light on the role of this brain region in aesthetics. In this study, (Kirsch et al., 2015b) found that a portion of the left STS showed greater engagement when participants watched movements they had not only observed but also practiced. Crucially, learning to perform these movements also increased aesthetic preference for these movements, relative to pre-training. Increased engagement of STS following training might reflect a binding of auditory, visual, and motor experience to produce a more pleasurable and emotional experience for the perceiver.

'Motor' areas for body and movement aesthetic perception

Several brain areas traditionally associated with motor rather than perceptual functions are sensitive to observing other people's actions. Both premotor and motor areas are part of the classically defined human mirror neuron system (MNS). The MNS shows similar responses when observing and executing specific motor actions (Gazzola & Keysers, 2009; Rizzolatti & Sinigaglia, 2010). Such internal 'motor resonance' (Fadiga et al., 2005) fulfills a number of important functions and contributes to action understanding, action prediction and imitation learning (Keysers & Gazzola, 2014; James M. Kilner, Friston, & Frith, 2007). Recent studies have suggested it may also participate during the aesthetic appreciation of dance (B. Calvo-Merino et al., 2008; Jola & Grosbras, 2013; Kirsch et al., 2015b).

Motor brain areas support action perception, for example when the movement stimulus is incomplete, lacking in information of bodily shape (Schütz-Bosbach & Prinz, 2007) or movement dynamics (Stevens, Fonlupt, Shiffrar, & Decety, 2000; Guido Orgs et al., 2015). Vivid perceptions of movement can result from watching purely static sequences of body postures (Guido Orgs, Bestmann, Schuur, & Haggard, 2011; Guido Orgs & Haggard, 2011; Guido Orgs, Kirsch, & Haggard, 2013). In a recent imaging study, (Guido Orgs et al., 2015) showed that this reconstruction indeed involves primary and supplementary motor areas. Moreover, seeing such apparent biological motion was associated with increased functional connectivity between these motor areas and FBA. Motor resonance therefore does not only help to extract action features from the visual movement stimulus itself, but reconstructs visual features based on existing motor representations of the observed movement.

Recent studies suggest a role of motor and premotor areas in aesthetic perception beyond dance. According to an embodied simulation account of aesthetics (Freedberg & Gallese, 2007; Sbriscia-Fioretti et al., 2013; Ticini et al., 2014; Umilta', Berchio, Sestito, Freedberg, & Gallese, 2012). The simulation of actions, emotions and corporeal sensations provoked by a particular art form brings about an aesthetic experience. By allowing embodiment of the actions depicted on a canvas sensorimotor brain regions contribute to the aesthetic evaluation of a given artwork and underpin a spectator's empathic response towards visual and performative art.

When considering further the role of the MNS in aesthetic evaluation, research investigating dance has contributed a number of important insights (Christensen & Calvo-Merino, 2013; Cross & Ticini, 2012; Jola, Ehrenberg, & Reynolds, 2012; Guido Orgs et al., 2016). (B. Calvo-Merino et al., 2008) were the first to use human neuroscience tools to investigate brain processes underlying an observer's aesthetic experience of watching dance. They built on previous work using static images or limited body movement by investigating the relationship between activity within sensorimotor cortices while watching dance and giving aesthetic judgments. Functional MRI scans of non-dancers' brains were recorded while they viewed ballet and capoeira movements performed by professional dancers. Later, the same participants were invited back into the laboratory to rate each video stimulus on five aesthetic dimensions: complexity of the action, how interesting it was, whether it looked tense or relaxed, weak or powerful, and how much the participant liked or disliked the movement. The study found greater activation in bilateral occipital cortices and in the right premotor cortex while participants watched dance movements they later assigned high liking ratings to (as an average group mean), in comparison to dance movements that received low average liking ratings. It is of note that no other dimension of aesthetics other than liking was associated with differential neural responses during dance observation. The authors concluded that visual and sensorimotor areas play a role in an automatic aesthetic response to dance, in terms of how much spectators enjoy watching a movement (see further details on Calvo-Merino's chapter, this volume). Furthermore, Cross and colleagues (2011) demonstrated stronger engagement of parietal portions of the MNS when dance-naïve observers watched dance movements they rated as both highly enjoyable to watch, and extremely difficult to reproduce (Cross, Kirsch, Ticini, & Schütz-Bosbach, 2011). These findings emphasise the importance of action features in aesthetic appreciation of dance. Preferring movements that cannot be performed implies that the spectator performs aesthetic judgements in relation to his/her own motor repertoire. The spectator's experience of dance thus depends on prior knowledge and experience with both action and visual features of the movement message.

Aesthetics, Expertise and Brain Plasticity

The neural mechanisms of perceiving and understanding other people's actions are not fixed but depend on prior experience with the movements that are being observed (Beatriz Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006; Gardner, Goulden, & Cross, 2015; Kirsch & Cross, 2015; G. Orgs, Dombrowski, Heil, & Jansen-Osmann, 2008). In the case of dance this prior experience can take on at least three forms which constitute the spectator's expertise. Firstly, they will depend on the viewer's visual experience, for example whether a specific movement vocabulary has been seen before or is entirely new to the viewer; visual expertise is expertise with the visual features of a movement. Secondly, brain mechanisms of motor simulation and action recognition will be shaped by the viewer's own motor repertoire. Actions that can be performed by the spectator will be processed differently than actions that cannot be performed by the spectator. We will call this form of expertise action expertise as it relates to expertise with the action features of the movement message. Finally, aesthetic appreciation of a dance performance will depend on the spectator's conceptual expertise, hat is knowledge about dance making and its cultural history (Bullot & Reber, 2013; Leder & Nadal, 2014).

Perceptual familiarity

Aesthetic perception will depend on whether postures, movements and sequential structure are visually familiar to the spectator. The influence of perceptual familiarity on aesthetic judgement is well documented in the "mere exposure effect" (Bornstein, 1989; Zajonc, 1968). Mere exposure increases the efficiency and speed of cognitive processing. Processing fluency theory states that the experience of cognitive fluency is pleasant; familiar stimuli should thus be preferred to unfamiliar stimuli (Reber, Schwarz, & Winkielman, 2004). Movements that have been watched frequently should thus be preferred to movements that have been seen less frequently (Guido Orgs, Hagura, et al., 2013)

The influence of perceptual familiarity on the spectator can explain why people prefer specific movement styles. This argument is particularly strong if a movement style relies on a relatively restricted movement vocabulary, as in classical ballet. This is because a restricted movement vocabulary will usually imply more repetitions of the same or similar movements, thereby increasing their perceptual familiarity. Initially unpopular dance styles may gain widespread recognition over time, the more often the artistic works are being staged and experienced. One example is Stravinsky's "Rite of Spring" first staged by the Ballets Russes in 1913, which was rejected by the public when it premiered, but is now regarded as a masterpiece (Berg, 1988). Interestingly, such long-term changes in aesthetic appreciation also apply to specific visual features of dance movement. For example, ballet postures have become more extreme over the course of many years (Daprati et al., 2009). Changes in perceptual familiarity can thus partially explain long-term "Zeitgeist" effects in aesthetic appreciation (Carbon, 2010). Using transcranial magnetic stimulation during live dance performances (Jola, Abedian-Amiri, et al., 2012; Jola & Grosbras, 2013) showed that visual experience with a movement vocabulary such as ballet increases cortico-spinal excitability (see Jola's Chapter in this volume).

Perceptual familiarity does not only influence aesthetic appreciation for the exact same movements, but also for similar movements with a similar arrangement or structure: Studies on 'structural mere exposure' have shown that familiarity with visual and auditory sequence structure increases preference for the same sequences and new sequences that are arranged according to the same rules (Gordon & Holyoak, 1983; Kuhn & Dienes, 2005; Newell & Bright, 2001; Opacic et al., 2009; Rohrmeier & Rebuschat, 2012; Zizak & Reber, 2004). In one of these studies (Guido Orgs, Hagura, et al., 2013) participants were exposed to sequences of seven body postures. These body postures were either arranged to produce a smooth, predictable movement path or a jerky movement path with multiple reversals of movement direction. Additionally, body postures were either arranged in a symmetrical or asymmetrical sequential order. For symmetrical sequence, the first posture was the same as the last posture, the second posture was the same as the sixth and so on. For asymmetrical sequences fourth and fifth picture were swapped, thus disrupting the symmetry of the sequence. Following an initial exposure phase to either symmetrical or asymmetrical sequences, participants with no prior experience in dance judged how much they like each apparent movement sequence. In both exposure groups, fluent symmetrical movement sequences were preferred to all other sequences and their aesthetic appeal did not change depending on whether these sequences had been watched before. This finding suggests that simple stimuli are generally preferred to complex ones, and fits will aesthetic accounts of ease of processing fluency and gestalt principles: Smooth, symmetrical movements are preferred to complex, jerky and asymmetrical movements because they are more predictable and more easily perceived and recognized. However, for jerky and asymmetrical sequences the study observed a 'structural mere exposure effect'. Liking for these movement sequences increased with prior experience, suggesting that movement that are initially disliked due to their high complexity and unpredictable become more enjoyable the more often they are seen. Importantly, observers in this study did not learn how to perform these movements. Repeated visual exposure only was sufficient to make these initially 'ugly' movement sequences more appealing. Unusual and more complex arrangements of movement therefore require repeated exposure to become enjoyable.

The brain has dedicated mechanisms that process stimulus structure and meaning of movement sequences. EEG studies using goal directed everyday actions such as preparing coffee showed that expectation violation in the action domain are comparable to those in the language domain and are associated with similar neural correlates of semantic surprise (Maffongelli et al., 2015; Proverbio & Riva, 2009). (Amoruso et al., 2014) show that event related potentials (ERPs) are sensitive to the perception of choreographic 'errors' in tango performance. Similarly, (Ahlheim, Stadler, & Schubotz, 2014) showed that observers are indeed sensitive to surprise as function of the probability of action steps within an action sequence. In an fMRI experiment participants observed another person assembling objects according to a fixed set of arbitrary rules which were unknown to the observers. Following an exposure session, observers were able to predict movement transitions based on having acquired some knowledge of the underlying compositional rules. Importantly, activation in the anterior intra parietal sulcus (aIPS) scaled with the conditional surprise elicited by these action sequences, suggesting an involvement of the human AON in learning and extracting sequential structure from action sequences. For observing dance movement, violations of the progression of the movement sequences have also been related to activity in the basal ganglia (Schiffer & Schubotz, 2011)

To summarise, the effects of familiarity with static, dynamic and sequential visual aspects of observed movement do not necessarily require that the spectator has action expertise with the movements that are being observed. Rather, surprise and aesthetic pleasure in this context depends on the spectator's prediction of "what comes next".

Motor familiarity

The size of the movement vocabulary in dance is set by the physical constraints of the human body and stylistic and compositional decisions of the choreographer. Professional dancers have typically undergone years of specialised training to expand their motor repertoire. In dance performances that involve professional dancers, spectators will not be able to perform the movements that they are observing. Typically, the spectator does not command the same motor repertoire as the dancer. However, if visual motion perception is an 'embodied process', in the sense of linking the observed actions of others to one's own motor repertoire, then the receiver must have the capacity to make the movement they observe (Aglioti, Cesari, Romani, & Urgesi, 2008; B. Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005; Beatriz Calvo-Merino et al., 2006; Cross, Hamilton, & Grafton, 2006; Gardner et al., 2015; Kirsch & Cross, 2015; G. Orgs et al., 2008). Even though frequent spectators of dance performance may acquire substantial visual expertise with the observed movements, they will not acquire motor familiarity. To acquire motor familiarity, actions need to be performed (Casile & Giese, 2006; Catmur, Mars, Rushworth, & Heyes, 2011; Cook, Bird, Catmur, Press, & Heyes, 2014). Movements with low motor familiarity might therefore be less aesthetically pleasant than movements for which the observer has the corresponding motor representation (Beilock & Holt, 2007; Topolinski, 2010).

Interestingly, (Beatriz Calvo-Merino, Ehrenberg, Leung, & Haggard, 2010) showed that experts and non-experts used a different style of visual processing during dance observed. Expert dancers familiar with the observed dance move perceived the movements in a holistic manner, while non-experts engaged in a more analytical visual analysis of the observed action. Despite this initial different visual processing of the perceived dance, everybody can enjoy a dance performance despite the type of visual processing they use may depend of their level of experience. Yet spectators clearly enjoy skill and virtuosity across dance styles, from breakdance to ballet. Indeed, some studies in movement aesthetics suggest an inverse relation between motor familiarity and preference: The more spectacular (use of jumps, big vertical and horizontal displacements or whole body movements) a movement is, the more likely it is to be liked (B. Calvo-Merino et al., 2008). Similarly, contorted body postures are preferred to less contorted body postures (Cross, Mackie, Wolford, & de C. Hamilton, 2010). Aesthetic appreciation of movements that can not be performed by the observers is in line with both remoteness from the habitual as well as the artistic notions of virtuosity. For example, a spectator might dismiss the aesthetic value of a dance piece saying: "I could do this myself". Indeed, (Cross et al., 2011) report an inverse relationship between the estimated ability to perform a movement and preference. Movements that were rated low for feasibility were preferred to movements which scored higher on feasibility. Interestingly, mere exposure accounts of aesthetic experience predict the opposite: familiar and feasible movements should be preferred to unfamiliar movements, as greater familiarity with a movement is associated with increased processing fluency (Beilock & Holt, 2007; Topolinski, 2010). In two recent studies designed to directly test the relationship between movement familiarity or feasibility and aesthetic preference, Kirsch and colleagues found that participants who physically train to perform particular dance movements report liking those movements more after training compared to before training (Cross et al., 2011; Kirsch, Dawson, & Cross, 2015a). When these findings are considered in light of those by Cross and colleagues (2011) that show more liking for less familiar movements, we start to see that the relationship between physical aptitude and aesthetic preferences is likely much more complex than any one theory can capture.

In summary, existing studies have produced mixed findings on the relationship between motor familiarity and preference. Whereas some studies show that knowing how to perform a movement correlates positively with aesthetic preference, other studies suggest that novel and complex movements outside of the motor repertoire of the observer are actually preferred to known movements. Two opposing influences seem to be important in aesthetic appreciation of dance. On the one hand observers enjoy watching movement that are simple and easily mapped onto existing motor representations. On the other hand, observers enjoy watching movements that exhibit a high level of skill and virtuosity.

Dance Making Knowledge

In creating dance performances, performers and choreographers often engage in a prolonged and highly collaborative artistic process (Kirsh, 2011; Kirsh, Muntanyola, Jao, Lew, & Sugihara, 2009). Staged choreographies result from an extended period of artistic research rather than linearly from a single idea or intention. Some compositional decisions or tasks to develop movement material will be deliberately applied, others may be purely intuitive (see int his volume deLahunta et al, Chapter XXX) .

Dance performances vary considerably with respect to their reproducibility. Many traditional dance performances involve a fixed series of steps that are supposedly performed in a consistent and similar way every time the performance is staged. Many classical and modern dance pieces fall into this category of fixed step choreographies. On the other end of the spectrum dance performances may be fully improvised, with a movement vocabulary that is never repeated across different performances. In this case choreographies are often characterised by more flexible rules and tasks which govern the movements that the performers execute on stage. Such task-based choreographies (e. g. by William Forsythe or Deborah Hay, see http://motionbank.org/) sometimes involve direct participation of the audience, producing an interactive and dynamic environment that emphasis communication between performers and spectator in both directions.

Aesthetic appreciation of dance performances will therefore not only depend on perceptual and motor familiarity with the movements that are being performed, but also by the conceptual knowledge of the spectator. Complexity and originality of improvised dance movements can only be appreciated if the spectator is aware that these movements are in fact improvised on the spot and do not follow a set sequential structure. As in other art forms many contemporary dance works are often characterised by the absence of a story, a conventional movement vocabulary, music or professionally trained performers (Siegmund, 2006). A choreography primarily consisting of performers walking or running across the stage may induce high levels of motor familiarity, but will not be appreciated if it does not comply with the spectator's definition of what dance is, or should be (Vicary et al., forthcoming). The expertise of the spectator is therefore characterised by perceptual and motor experience with the movement message on the one hand, and conceptual knowledge about dance making and its cultural and art-historical context on the other hand (Brieber, Nadal, & Leder, 2015; Bullot & Reber, 2013; Gerger & Leder, 2015; Leder & Nadal, 2014).

Research on the role of context and conceptual knowledge on the aesthetic experience of dance are largely absent from the literature. Studies on appreciating the visual arts however show that these effects do have a pronounced impact on aesthetic judgements. For example changing titles of paintings or experiencing art in museums as compared to a psychological laboratory alters aesthetic experiences. Indeed, (Jola & Grosbras, 2013) show that immersion in the performance and enjoyment are indeed increased for watching live as compared to videotaped dance performances. Such findings are in line with the notion of dance as an intrinsically social art form that involves direct communication between a spectator and a performer via movement.

Summary and Conclusion

The aesthetics of human movement and dance are still poorly understood. Yet in recent years our understanding of the psychological and brain mechanism involved in human movement perception has greatly improved. Framing dance aesthetics as communication via movement provides a flexible and inclusive approach to identifying the components of dance aesthetics. The components identified in this paper may neither be independent nor combine in a simple and exhaustive way to fully explain why we enjoy watching performative art such as dance. Clearly more research with a strong focus on ecological validity is needed to see whether compartmentalising dance into visual, action and social features is a useful approach. Similarly, multisensory aspects of the dance experience, particularly in relation to the influence of music on movement aesthetics have not received much attention in the existing research literature. However, a clear theoretical framework is needed in order to formulate predictions and testable hypotheses. Future studies will inform as to whether these predictions hold for live performances and other performing arts in which watching movement is an important aspect, such as acting, pantomime and musical theatre.

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