This is the Authors' Copy of the final post-review manuscript published as
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.
doi: 10.1037/a0031827
There may be minor differences in this draft with respect to the published version of the paper.

Dance as a subject for empirical aesthetics

Julia F. Christensen

University of the Balearic Islands

Beatriz Calvo-Merino

Universidad Complutense de Madrid and City University London.

Author note

Julia F. Christensen, Human Evolution and Cognition (IFISC-CSIC) and Department of Psychology, University of the Balearic Islands, Spain; Beatriz Calvo-Merino, Department of Psychology, Universidad Complutense de Madrid, Spain and Department of Psychology City University London, UK.

Julia Frimodt Christensen was supported by a *FPU* Ph.D. scholarship from the Spanish Ministry of Education (AP2009-2889), and by the research project FFI2010-20759 funded by the Spanish Ministry of Science and Innovation. Beatriz Calvo-Merino was supported by a City University Fellowship and a *Ramon y Cajal* Research Grant by the Spanish Ministry of Science and Innovation (RYC-2008-03090).

Both authors contributed to the paper equally.

We are grateful to Marcos Nadal for very useful comments and discussions on previous drafts of the paper and to dancers and choreographers (Tom Sapsford and MavinKhoo) for their help and assistance during some of the projects described throughout this paper.

Correspondence concerning this article should be addressed to Julia F. Christensen, University of the Balearic Islands, University Campus, Department of Psychology, Building: GuillemCifre de Colonya, 07122 Palma, Spain, julia.christensen@uib.es

Abstract

The purpose of this paper is to highlight the possibilities that research on dance appreciation offers empirical aesthetics, as well as the challenges it poses. Behavioral and neuroimaging approaches have, to date, mainly focused on the perception and recognition of human body movement and structure. A small number of studies, nonetheless, have explicitly taken the basic research on the perceptual, emotional and cognitive processes engaged during movement observation, together with their neural concomitants, as a starting point to understand the aesthetic experience triggered by the observation of a dance. We provide an overview of these studies and, thereafter, point out avenues for future research on dance appreciation within the scope of empirical aesthetics. We also note some methodological and conceptual issues that should be taken into account in the design of empirical studies of the aesthetic appreciation of dance, including dance theory scholarship and humanistic approaches to dance practice. Finally, we describe how common movement features of dance styles around the world suggest that humans may be endowed with an evolved cognitive ability to appreciate and to be aesthetically moved by dance.

Keywords: Neuroaesthetics, dance, body, movement, aesthetic experience

Dance as a subject for empirical aesthetics

1. INTRODUCTION

Ever since its inception with Fechner's (1876) work, empirical aesthetics has mainly been concerned with understanding the perceptual, affective and cognitive mechanisms involved in the appreciation of painting, music and architecture. Dance, together with other performing arts, has received relatively little attention. The psychological and neural underpinnings of the aesthetic experience of this dynamic art form remain, consequently, largely unexplored. With the advent of cognitive neuroscience techniques, such as functional magnetic resonance imaging (fMRI), scientists have recently attempted to determine the neural mechanisms involved in the aesthetic experience derived from artworks (Cela-Conde, Marty, Maestu, Ortiz, Munar, et al., 2004; Jacobsen, Schubotz, Höfel, & Cramon, 2006; Kawabata & Zeki, 2004; see Cela-Conde, Agnati, Huston, Mora, & Nadal, 2011; Di Dio & Gallese, 2009; Chatterjee, 2010; and Nadal, Munar, Capó, Rosselló, & Cela-Conde, 2008, for reviews).

Although much of neuroaesthetics has followed the traditional tendency of empirical aesthetics to focus mainly on painting and music, a number of researchers have begun using these novel techniques to understand how our brains represent the human body, posture, movement, and dance (Aglioti, Minio-Paluello, & Candidi, 2012). The present paper will argue that research on the aesthetic appreciation of dance has a great deal to contribute to the field of empirical aesthetics as a whole, especially because of its contrast with the common use of static artworks as stimuli (paintings, sculptures, faces, architecture).

It might be helpful to begin by clarifying the notion of dance. Judgments about the kind of movements that constitute dance depend on individual, social and cultural preferences and traditions, as well as on particular artistic subcultures' aesthetic and moral constraints. The Encyclopedia Britannica, nevertheless, provides a pragmatic initial characterization. It defines dance as an art form that generally involves body movements, which are usually rhythmic and performed to music, used as a form of expression, social interaction, or presented in a spiritual or performance setting.

This simple definition is certainly quite general, and yet it identifies a number of key concepts that can ground a scientific approach to the aesthetics of dance. These core components present in all dance forms are the focus of the next section (section 2). We thereafter propose and discuss procedures for a successful experimental approach, suggesting, for instance, possible improvements of stimulus material (section 3). We tentatively answer the question of whether, moving beyond research focusing only on the components (i.e. the body, the movement), it is possible to study "the whole thing" (i.e. the dance). In the more exploratory last part of the paper (section 4) we propose future avenues of research in the field of empirical aesthetics of dance, specifically touching on common movement features of dance styles around the world. We suggest that such possible universals would support the notion of an evolved human cognitive ability to appreciate dance and to be aesthetically moved by it.

2. THE COMPONENTS OF A DANCE: BODY, MOVEMENT AND EMOTION

How do spectators perceive dance? How do they represent the key features of dance? Researchers addressing these questions have focused on the role of the basic elements of dance: body, movement and emotional expression. After reviewing the literature on these components (subsections 2.1.1. through 2.1.3.) we will show how this basic knowledge has been used to advance our understanding of the neurobiological underpinnings of dance appreciation (subsection 2.2.).

2.1. The perception of dance

Advances in the neuroscience of action have led the development of a suitable framework for the study of such a complex stimulus as *dance* (Calvo-Merino, 2010; Cross & Ticini, 2011). As mentioned above, dance is more than just a type of motor pattern of the human body. Yet, before attempting to deal with what makes *dance* appreciation special, we need to understand how its constituents are processed at a basic level. Therefore, in what follows we will briefly review how the human processing system perceives and represents bodies and movement, the emotions they convey.

2.1.1. Representing the human body

The body is the instrument of dance. It is the structure performing the movement that, ultimately, conveys the artist's communicative message. The latter is a key element of what turns a movement into *a dance*. But, what are the brain mechanisms that allow us to extract information about this basic element of a dance, the body? A region in the extrastriate cortex, known as the extrastriate body area (EBA), responds specifically to the sight of human bodies (Downing, Jiang, Shuman, & Kanwisher, 2001).

Interestingly, the neural processing of body and movement are not independent. There is, in fact, a remarkable overlap. Thus, most brain regions classically associated with movement processing, such as the complex visual motion areas (Kourtzi & Kanwisher, 2000; Senior, Barnes, Giampietro, Simmons, Bullmore, Brammer, et al., 2000) and the motor regions (Urgesi, Moro, Candidi, & Aglioti, 2006), are also sensitive to static body postures. Their involvement while viewing static images suggests that the brain is able to extract the sense of movement even from a mere snapshot of it (Urgesi, Moro, Candidi, & Aglioti, 2006). Thus, given the general difficulty of investigating how the brain processes such a complex stimulus as human movement, these stimuli have successfully been used to study the cognitive and neural mechanisms underlying movement representation, affording a high level of experimental control (Orgs, Bestmann, S., Schuur, F. & Haggard, P., 2011; Urgesi, Maieron, Avenati, Tidoni, Fabbro, & Aglioti, 2010).

2.1.2. Observing a movement

Any dance movement is executed according to a master plan, a cognitive structure of movements (Bläsing, Tenenbaum, & Schack, 2009) rooted in specific neural networks of the dancer's brain. At the time of performance the movement is perceived by an observer, whose neural system integrates perceptual, cognitive and emotional processes. The way in which the dancer's motor planning and action execution are eventually transformed into the observer's perceptual experience is probably one of the central questions in the neuroaesthetics of dance.

A clue about the mechanisms relating action performance and perception appeared in 1992. Giacomo Rizzolatti and his group in Parma (Italy) observed that certain neurons in monkeys' premotor cortex fired in a similar fashion both when they executed a movement and when they observed another individual performing the same movement. They named these cells *mirror neurons (MNs)* (di Pellegrino, Fadiga, Fogassi, et al., 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996). These experiments revealed that, at least in the case of monkeys, the brain relies on a similar mechanism for performing and representing movement. Many follow-up studies described the properties of the MNs in the monkey brain in detail (Umiltà, Kohler, Gallese, Fogassi, Fadiga, Keysers, et al., 2001; for reviews see Rizzolatti & Craighero, 2004 and Rizzolatti & Fabbri-Destro, 2010). Additionally, a series of exploratory fMRI studies with human participants soon suggested that a similar action-execution and action-perception system exists in the premotor and parietal cortices of the human brain (Decety, Grèzes, Costes, Periani, Jeannerod, Procyk, Grassi, & Fazio, 1997; Grafton, Arbib, Fadiga, & Rizzolatti, 1996).

Since then, researchers have arduously tried to demonstrate the existence of a genuine human Mirror Neuron System (MNS). Much of what we now know about the neural processing of movement is the result of this effort, which began with a TMS study showing motor resonance in the human motor cortex (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995) and has grown to reach the level of a recent intracraneal cell recording study in humans (Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). The range of movements that have been used to investigate the neural mechanism of human movement perception in laboratory settings varies from simple hand actions (Grafton, et al., 1996; Grèzes, Costes, & Decety, 1999), to complex whole body movements such as dance movements (Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006; Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005; Cross, Hamilton, & Grafton, 2006; Orgs, Dombrowski, Heil, & Jansen-Osmann, 2008), including minimal representations of actions using point light displays (Saygin, Wilson, Hagler, Bates, & Sereno, 2004).

Despite some controversies (Hickok, 2009), it is now generally accepted that MN mechanisms bring together information related with the observed action through internal motor resonance. This was demonstrated, for instance, in an fMRI study where dancers with different types of motor training (Ballet dancers and Capoeira dancers) watched short video clips of Ballet and Capoeira movements (Calvo-Merino, Glaser, Grèzes, Passigham, & Haggard, 2005). Brain responses in putative MN motor simulation regions were larger when the dancers watched the dance style they were familiar with (i.e. Ballet dancers seeing Ballet movements and Capoeira dancers seeing Capoeira movements), compared to the other style (i.e Ballet dancers seeing Capoeira movements and *vice versa*). This study, together with others that have specifically used dance moves as a tool to evaluate the contribution of motor representations during action observation, have revealed the crucial role of a system that matches action execution and observation (Calvo-Merino et al., 2006; Cross et al., 2006; Orgs et al., 2008).

The evidence, thus, suggests that dancers' movements elicit some sort of motor resonance in observers' brains. But, what is the role of the observer's motor simulation mechanism in the aesthetic experience of dance? Before we address this question, in section 2.2, we still need to consider the third basic element of dance: Emotion.

2.1.3. Emotion perception in body and movement

Expressing emotion through movement is a key element in the performing arts. The perception of emotional expression should, therefore, be an integral aspect of the analysis of psychological and neural processes involved in dance observation. Although people can clearly *recognize* emotions in dance movements (Camurri, Lagerlof, & Volpe, 2003; Hejmadi, Davidson, & Rozin, 2000; Van Meel, Verburgh, & De Meijer, 1993), little is known about the role emotion processing plays specifically in the *aesthetic appreciation* of dance movements. Moreover, the lack of neuroimaging studies of emotion recognition using dance stimuli makes it difficult to provide a clear picture of the neural bases of the emotional processes involved in *dance* appreciation.

Nevertheless, many studies have focused on how emotional information is extracted from bodies and movement. Facial emotional expressions (Little, Jones, & Debruine, 2011; Adolphs, 2002; Bastiaansen, Thioux, & Keysers, 2009) and static body postures (de Gelder, 2009; Pichon, de Gelder, & Grèzes, 2008) have received most attention as sources of emotional information. But it has also been shown that humans are able to recognize emotional expression from movement information, even when it is very limited, such as in point light displays (Pollick, Lestou, Ryu, & Cho, 2002).

Neuroimaging studies have shown that understanding the emotions of others engages brain regions normally involved in experiencing the same emotion (Bastiaansen, Thioux, & Keysers, 2009; Wicker, Keysers, Plailly, Royet, Gallese, & Rizzolatti, 2003; Keysers, Kaas, & Gazzola, 2010). Van den Stock, Tamietto, Sorger, Pichon, Grèzes, & de Gelder (2011) showed that the perception of emotion expressed through body actions is related with activity in the superior temporal sulcus (STS), precuneus, and geniculate nucleus. Even the observation of emotional body movements of musicians interpreting a piece of music—shown in silence, without the music—increases activity in the inferior parietal gyrus (IPG), insula and the anterior cingulate cortex (ACC) (Petrini, Crabbe, Sheridan, & Pollick, 2011). The identification of the emotion expressed in point light displays of emotional human movements is accompanied by increased activity in the extrastriate body area (EBA) (Atkinson, Vuong, & Smithson, 2012). The observation of emotional whole body gestures is also related to increases in the activity of the EBA, as well as the ventral striatum (Peelen & Downing, 2007).

Thus, there seems to be specialized brain systems that enable people to efficiently perceive and process emotion conveyed by facial expressions and a number of emotional bodily movement cues. Given that dance is, *par excellence*, an instance of emotional bodily movement, we could expect that the neural mechanisms involved in general affective processing play an important role also while viewing dance. A recent study using repetitive transcranial magnetic stimulation (rTMS) confirmed this expectation, clearly showing that relatively long segments of dance choreography indeed elicited genuine emotional responses (Grosbras, Tan, & Pollick, 2012). Moreover, when the rTMS was applied over the posterior parietal cortex, the subjectively appreciated emotion of a movement changed, enhancing the emotional ratings. Although this study revealed how an observer's affective reaction to a dance is associated with activity in the posterior parietal cortex, the impact of the processing and representation of emotions conveyed by dance on its aesthetic enjoyment remains to be examined.

2.2. The aesthetic experience of dance

As noted in the introduction, only recently has dance become a serious interest for empirical aesthetics. Researchers have begun by characterizing the physical properties of certain aspects of dance and their possible relation to naïve observers' aesthetic preferences (Daprati, Iosa, & Haggard, 2009), by examining observers' reaction to dance movements in an audience context (Stevens, Vincs, & Schubert, 2009), and by describing the neural mechanisms that contribute to the aesthetic experience of dance (Calvo-Merino, Urgesi, Orgs, Aglioti, & Haggard, 2010a; Calvo-Merino, Jola, Glaser, & Haggard, 2008; Cross, Kirsch, Ticini, & Schuetz-Bosbach, 2011). See figure 1 for examples of stimuli used in these and other studies.

Daprati and colleagues' (2009) study is a good example of the first line of research noted in the preceding paragraph. The authors aimed to understand the impact on viewers' preference of limb-angle differences in static Ballet positions taken from the performances of a particular opera house (London Royal Ballet, Sleeping Beauty), recorded at different times over a 40-year period. They thus presented naïve experimental participants with two versions of a number of Ballet postures. One depicted the way each of them is currently performed, and the other depicted the way it was performed decades ago. Participants were asked to indicate which version they preferred. The results of their regression analysis revealed greater preference for the portrayals of current positions over the older portrayals of the very same Ballet position (see figure 1 (e) for an example of stimuli used). The authors argued that the performing arts show a slow and progressive change in portrayed aesthetic qualities that parallels the preferences of audiences, though their data could also be viewed as showing that audience preferences have changed following developments in Ballet aesthetics during the last decades.

The allusions to audience preferences bring us to the second line of research noted above, centered specifically on spectators' reactions to dance in an audience context. Stevens and colleagues (2009) developed a methodological framework suitable for investigating audience engagements during a dance performance. Their "portable Audience Response Facility" (pARF) includes a handheld pen-like stylus used to input data into a Personal Digital Assistant (PDA). This device allows the recording of emotional states, in the form of valence and arousal, at discrete time points or continuously during a live dance performance (Stevens, Malloch, McKechnie, & Steven, 2003; Stevens, Schubert, Schubert, Morris, Frear, Chen, Hearly, et al., 2009; Stevens, Vincs, & Schubert, 2009; Stevens, 2005; Vincs, Schubert, & Stevens, 2007). These studies revealed how the emotional engagement during the course of a performance changed as a function of the executed movements. Additionally, the agreement among observers was larger for arousal than for valence.

The third aforementioned strand of research, which aims to understand the neural concomitants of the aesthetic experience of dance movements, takes us from real dance performances and fully ecological stimuli back to the laboratory. Calvo-Merino and colleges (2008) were pioneers in the use of neuroimaging techniques to test—taking into account the knowledge about body and movement perception processing in the human brain reviewed above—whether individual subjective preferences for particular dance movements modulated the ongoing brain activity while watching them. Their results revealed stronger responses in both visual and motor regions when participants watched dance moves they liked more than when they watched movements they liked less (Calvo-Merino et al., 2008). Because they also wished to explore how these brain activations responded to the different dynamic properties of the dance movements, the experimental dance stimuli used in their study were classified with the help of a choreographer according to three physical parameters (speed, vertical and horizontal displacement and part of the body used). Like this, the researchers were able to determine which particular dance movements elicited stronger or weaker resonance in aesthetic sensitive areas. This analysis indicated that stronger motor resonance and higher liking ratings were associated with high-speed movements with a high level of vertical displacement. An example of dance movements used in this experiment can be found in figure 1 (b).

Another recent study investigated how the observer's physical ability to perform the movement influenced the perception of beauty of a dance movement (Cross, Kirsch, Ticini & Schuetz-Bosbach, 2011). Movements that were rated as beautiful and gauged as difficult to reproduce were accompanied by stronger activation in posterior regions of the action observation network, such as the occipitotemporal and parietal cortices, suggesting a close connection between embodied simulation of a movement and its perceived aesthetic qualities.

The identification of movement features that are generally most preferred, and the study of the neural underpinnings of the aesthetic experience derived from such features, has benefited from the decomposition of actual movements into pure motion stimuli. For example, using transcranial magnetic stimulation (TMS), Calvo-Merino et al. (2010a) were able to demonstrate that the aforementioned body perception regions, such as the EBA and the premotor cortex, contribute in a complementary manner to the final aesthetic experience derived from looking at dance postures (Calvo-Merino et al., 2010a).

This set of findings has received support from research on the aesthetic appreciation of sculptures depicting human bodies. Di Dio, Macaluso, & Rizzolati (2007) hypothesized that the anatomical realism found in the bodies of static classical Greek sculptures would engage motor processing that would contribute to their aesthetic enjoyment. Classical artists—they argued—must have discovered a kind of aesthetics based on using plastic art to stimulate not only the visual cortex, but also the motor cortical regions (Skoyles, 1998). Di Dio and colleagues (2007) used fMRI to measure brain activity while participants viewed photographs of original Greek sculptures, which conformed to the golden ratio proportions, and slightly altered versions of the same pieces, which were modified to break the original proportions. Di Dio and colleagues (2007) suggested that their results revealed a double beauty evaluation system: one based on objective beauty and another on the subjective experience. The former was argued to include brain structures such as the insula (associated with the processing of emotional states) and the latter was characterized by activations in the amygdala (a key piece in the brain's affective system).

Taken together, these and similar studies have highlighted the importance of the link between the neural mechanisms involved in perceiving and representing bodies, movements and dance (namely sensoriomotor, visual and emotional processing) and the aesthetic experience they elicit. Such a link suggest that early motor and sensory processing mechanisms play a relevant *aesthetic role* in the appreciation of dance.

<<Insert figure 1 about here>>

2.3. Summary

Figure 2 graphically summarizes the brain regions involved in body and movement perception (panel a), and specifies those that are recruited when processing dance stimuli (panel b). Panel (c) shows the brain regions whose activity has been related with the *aesthetic appreciation* of dance movements. This illustration is by no means exhaustive; it intends only to provide a schematic overview.

<<Insert figure 2 about here>>

Four brain regions underlying the basic perception of body and motion also seem to be crucial components of distributed neural systems that support biological movement perception, dance perception and the aesthetic experience of observed dance movements. Such regions are the ventral premotor cortex (~BA 6), the medial temporal/medial superior temporal areas (MT/MST; BA 18, 19), the inferior parietal gyrus/lobule (BA 39/40), and the occipitotemporal cortex (BA 37 ~ Extrastriate body area, EBA). This general framework is backed by two recent meta-analyses based on Activation Likelihood Estimation (ALE). Caspers, Zilles, Laird and Eickhoff (2010) combined ALE methods and probabilistic cytoarchetectonic maps to show the existence of a bilateral neural network involving frontal premotor, parietal and temporo-occipital cortices, for both action observation and imitation. Grosbras, Beaton and Eickhoff

(2012) followed up on this with a meta-analysis based on studies using stimuli of one of three movement categories: body, hands or face. The aim was to find a potential neural network of (general) human movement perception. A conjunction analysis showed an overlapping in the right superior temporal sulcus and bilaterally in the junction between middle temporal and lateral occipital gyri. Overall, these studies highlight the importance of these neural regions for the integration of human movement perception.

The ventral premotor cortex is regarded as part of a network that specifically encodes sensorimotor stimuli involving action. This suggests that its role during the aesthetic experience of dance may be related with the observer's motor simulation response. Activity in the inferior parietal gyrus and the occipitotemporal cortex (EBA) has also been associated with the processing of emotional body movements, such as emotional point light displays of emotions, emotional gestures, or the emotional movements of a musician (without music) (Atkinson, et al., 2012; Peelen, Atkinson, Andersson, & Vuilleumier, 2007; Petrini, et al., 2011).

Surprisingly, however, activity in classical emotion-processing regions, such as the insula, the orbitofrontal cortex, and the anterior cingulate cortex (Adolphs, 2002; Keysers, Kaas, & Gazzola, 2010; Petrini, et al., 2011), has so far been reported only for tasks of dance observation (Cross, Kirsch, Ticini, & Schuetz-Bosbach, 2011; Jang & Pollick, 2011). Activity in such regions has not been found to be especially relevant in tasks of aesthetic appreciation of dance movements, which may be puzzling considering the rather large amount of empirical and theoretical work linking emotional and affective processes with art appreciation (Leder, Belke, Oeberst, & Augustin, 2004; Aharon, Etcoff, Ariely, Chabris, O'Connor, Breiter, 2001; Blood & Zatorre, 2001; Brown, Martinez, & Parsons, 2004; Vartanian & Goel, 2004).

However, the fact that activity in classical emotion processing brain regions has not been reported during the aesthetic experience of dance does not mean that these regions are not involved in the pleasurable experience of appreciating dance. It simply means that *so far* there is not enough evidence available to make such claims.

One possible reason for the lack of this kind of findings might be that, at least in some instances, the stimulus materials used in neuroimaging experiments lacked the potential to fully elicit a strong aesthetic experience in the observer. Further studies exploring different paradigms and dance stimuli properties are required to provide a more detailed insight also into the affective aspects of the aesthetic appreciation of dance movements. In what follows, we suggest ways of optimizing stimulus materials to trigger more genuinely hedonic aesthetic experiences while watching dance movements—possibly also in laboratory settings.

3. DANCE AESTHETICS: BRINGING THE COMPONENTS TOGETHER

Necessary methodological precautions and constraints inherent to empirical aesthetics make it difficult to achieve a truly holistic approach to dance in experimental settings (Jola, Ehrenberg & Reynolds, 2011). However, we believe that three main methodological issues related with the design and preparation of dance movement stimuli can push research in that direction. First, the cultural significance of dance styles around the world, as well as their choreographies' historical and artistic meaning, is remarkably varied. It is important to recognize this. Second, dance theory and humanistic approaches to dance practice are essential for a meaningful selection of movement sequences within the theoretical-technical principles of any dance style. Finally, a broad knowledge of dance styles could lead to studies taking into account the similarities between dance movements from around the world (see also section 4).

Whether this can be achieved depends largely on researchers' knowledge of dance and on fruitful collaborations between scientists and artists (e.g. dancers, choreographers). In this section we suggest how integrating views from multiple disciplines on such issues can enhance the internal and external validity of stimuli used for scientific research on the aesthetic appreciation of dance.

We focus on four experimental design issues that are especially relevant for dance: (i) the presence of the face, body or movement in experimental stimuli, (ii) the accompaniment of music, (iii) the length of the movements and video-clips used as stimuli, (iv) the explicit control of emotional expression in dance stimuli.

3.1. Facial, bodily and movement information in dance stimuli

Dance explicitly uses two expressive channels: the body and the face. Faces are processed automatically and effortlessly by specific cognitive and neural mechanisms (Kanwisher, McDermott, & Chun, 1997), and have a strong perceptual and affective effect on viewers. This is most probably true also when dance stimuli include the dancers' faces and facial expressions. It is also true that body morphology and proportions have an impact on viewer's affective responses. If researchers aim experimental participants to focus solely on the movement, the presence of the face and/or the morphology of the body could interfere with this objective. Therefore, in many studies on emotional body and movement perception, researchers have blurred the actor's/ dancer's face (e.g. Calvo-Merino et al., 2005; de Gelder & Van den Stock, 2011). Another way to overcome this confound is to use a technique called point light displays, where only dynamic information is presented. While this is an excellent manner of investigating the effect of movement, including dance, regardless of face and body factors, it should be considered that this type of stimuli are not present in real life or real dance performance and the results have to be interpreted as such.

In addition, we still ignore much about how the human brain processes the movement of multiple bodies (and faces). Hence, the presence of multiple dancers in the same stimulus could be considered as a fascinating additional independent variable for future studies.

3.2. Music and dance go together

Dance is commonly thought to be inextricably linked to music (Carroll & Moore, *forthcoming*). Besides choreographies that use the absence of music as a stylistic element, as far as we know, there are no other dance forms in the world that are executed without music. Moreover, music can enhance the communicative intention of a dance.

On the other hand, though, there is little question that music is a separate art form that fosters its own aesthetic experience according to its particular principles. Therefore, we suggest that when the research objective is to study the underlying psychological and biological processes of the aesthetic experience of *dance movements*, music could be a confounding factor. Accordingly, most studies using dance movements display these without music (e.g. Calvo-Merino et al., 2005; Cross et al., 2011), though some studies on motor observation have indeed used music during dance observation (e.g. Cross, Hamilton, Kraemer, Kelley, & Grafton, 2009). A different question, which still has not been addressed thoroughly, is how the human cognitive system integrates music and dance into an overall aesthetic experience. A proper understanding of the biological mechanisms underlying such aesthetically moving experiences of dance will undoubtedly require finding a satisfactory answer to this question.

3.3. Dance stimulus length

Dance stimuli used in experimental studies are usually only fragments of larger movement sequences. When the pieces of a choreography are taken apart the whole aesthetic-artistic experience which is built up throughout the choreography might be lost. It is unlikely that a three-second dance movement stringed among a series of control stimuli and many other dance fragments will have the same effect on the observer as it would if viewed embedded within the choreography. Hence, ideally, scientific approaches to dance should use live dance performances as stimuli in order to truly grasp the essence of a "viewing dance experience". Jola and colleagues (2012) showed that this is possible. They used live dance performances of Ballet, Indian dance and non-dance to test whether visual expertise in dance would be related to enhanced corticospinal excitability in body parts that are particularly prominent in the respective dance styles, such as the arms in the case of Ballet. Their results indeed showed that visual expertise in Ballet movements was related to enhanced corticospinal excitability in the arms (Jola, Abedian-Amiri, Kuppuswamy, Pollick, & Grosbras, 2012).

When the objectives of a study preclude the use of a live performance as stimulus technical-practical knowledge of a dance style can minimize the "fragmenting" impact of the common experimental procedures. Through their theoretical frameworks, dance styles define the beginning and the end of their movements. Although these initial and final points may not be intuitive to laypeople (however, see Pollick, Noble, Darshane, Murphy, Glowinski, et al., 2012), they definitely are to the expert. Cooperative work of experimenters and expert dancers or choreographers can lead to acceptable compromises between the laboratory and the dance space. For instance, a group of dance experts could rate the technical adequacy and meaningfulness of edited stimuli in a pre-selection phase.

3.4. Conveying emotion with dance

Unless executed for technical rehearsal purposes, dance movements embody a communicative intention, which generally has a strong emotional component. The dancer's emotional expression and the observer's subsequent emotion perception and recognition are crucial processes in the aesthetic experience of dance. Some studies on emotion recognition from bodily movements have used dance to identify movement parameters that genuinely convey specific emotions. These studies have shown that participants are able to recognize and distinguish the following sets of emotions in dance: (i) anger, disgust, fear, humor, sadness, heroism, love, peace, wonder and *lajya*[1] (Hejmadi, Davidson, & Rozin, 2000); (ii) joy, sadness and anger (Sawada, Suda, & Ishii, 2003); (iii) happiness, sadness, disgust, anger, surprise and fear (Dittrich, Troscianko, Lea, & Morgan, 1996); (iv) sadness and happiness (Brownlow, Dixon, Egbert, & Radcliffe, 1997), (v) anger, grief, fear and joy (Camurri et al., 2003); and (vi) joy, grief, anger, fear, surprise, disgust, interest, shame, contempt, sympathy, antipathy and admiration (De Meijer, 1989). There is, however, some controversy as to whether participants are able to recognize and perceive more than Ekman and Friesen's (1971) six basic emotions. Moreover, the role of the genuine *experience* of emotions triggered by dance movements in the aesthetic experience of such movements is still not clear.

Consequently, when creating dance movement stimuli for empirical studies, attention should be paid to emotion standardization. Technical perfection in dance can

[1] Lajya is defined "*as a positive emotion in India, though its nearest translations (embarrassment, shame, shyness) could be considered negative in the West.*" (Hejmadi, Davidson & Rozin, 2000, p. 183).

undoubtedly produce astonishing and impressive kinds of motor patterns. Yet, as noted above, dance is more than movement sequences. Emotionless dance movements constitute, thus, impoverished experimental stimuli for empirical aesthetics. Dancers participating as models in experimental studies of aesthetic appreciation should be clearly instructed to embody affect and emotions in their movements, following the objectives of the particular study they are contributing to. Without such instructions regarding emotional expression and embodiment, dancers might focus merely on the technical correctness of movement execution, as they do for rehearsal purposes in a class.

3.5. Summary

Throughout this section we have outlined how some methodological issues could enhance the internal and external validity of dance stimuli. We have highlighted the importance of observers' emotions in response to a dance. We have pointed out that observers are indeed able to recognize emotions in dance movements, and that neuroimaging studies have shown that emotion processing is triggered when observing emotional whole body movements. To date, studies related to dance and dancers' expertise have focused on such issues as motor control, timing and online movement synchronization, sequence learning and memory, visual and motor imagery, neural coupling between action and perception and some neuroaesthetics questions (Bläsing, Calvo-Merino, Cross, Jola, Honisch and Stevens, 2012). An important issue that still needs to be resolved—so we believe—refers to the neural concomitants of the observers' affective response to emotion perceived in danced movement. We are still, however, even further away from a true understanding of the affective dialog between dancer and spectator, an essential aspect of the genuine aesthetic experience of dance.

4. UNIVERSAL FEATURES OF DANCE MOVEMENTS: FUTURE DIRECTIONS IN DANCE AESTHETICS

Part of dance's scientific appeal lays in the fact that it appears to be a universal human behavior, that all human cultures exhibit some kind of dance. In spite of the many different dance styles around the world, there seem to be universal elements across cultures, including: (i) Dance movements and positions; (ii) The use of ornamentation (e.g. point shoes, tap shoes, Flamenco shoes, tutus, fans, snappers, ankle bells, scarves, etc.); (iii) The function of dance in certain events; (iv) Symmetry, synchronization, lines and solos; and (v) Dance structure (outline or structure of a choreography). In this final section we review and describe some of these universal features of dance, aiming to identify movement qualities and other aspects that enhance viewers' aesthetic experience (Calvo-Merino et al., 2008). We hypothesize that humans are endowed with an evolved cognitive ability to derive pleasure from something as abstract as a movement in space, leading to an aesthetical appreciation of certain movements, which today we refer to as dance. The ability to derive pleasure from dance movements could constitute a highly adaptive capability, possibly functioning as an important social cohesion element.

4.1. Dance movements and positions

Anecdotic evidence and unsystematic inspection of dance movements of different dance styles suggests that there might be certain universal aesthetic preference for particular movements and positions across cultures. As an example, figure 3 shows three instances of female body positions and movements that appear in three different formal dance styles (Ballet, Indian and Oriental dance).

This is, obviously, only conjecture at this point in time. However, scientists could identify universal preferences for dance positions and movements by isolating movements that are repeatedly found in both formal and non-formal dance styles around the world. Thereafter, cross-cultural experiments on aesthetic preference could determine whether, and to what extent, particular features confer such movements a universal appreciation. The comparison between Indian and Ballet dance provides an illustrative example of cross-cultural commonalities. Panel (3a) represents a particular pattern of movement that consists in raising one leg to the back. This movement with a bend in the knee is called *Attitude* in Ballet. In both dance styles, the leg is not only raised to the back and the knee bent, but the leg is also turned out from the hip so that the knee is visible from the side and does not face the floor. Panel (3b) shows the extreme turn-out that is practiced in both dance styles. The raise of the leg to the side (even up to 180º) is called *À la seconde*, and the position on two feet is called *2nd position* in Ballet. Again, the choice of the extreme turn out is remarkable. Panel (3c) represents another recurrent feature of different dance styles: the extreme back curve, especially in the case of female dancers.

<<Insert figure 3 about here>>

Obviously, Ballet has incorporated many elements from other dance styles, but the fact that particular movements and not others were introduced and adapted by Ballet could constitute an indirect indicator of universalities in human aesthetic preference for movements. Conversely, it could be argued against the notion of movement "universals", that the human body has only a limited set of movement possibilities and, thus, that it is constrained to some extent regarding, for instance, limb angles and rotations. But, still, why these movement combinations and not others? After all, there are myriad ways to move, and yet many dance styles are rather similar in their movement repertoire.

4.2. Ornamentation

The use of ornamentation to heighten certain aspects of a particular dance style is a common feature across cultures. Such footwear as point shoes, tap shoes, Flamenco shoes, or even just naked feet, serve the aim of enhancing the dancer's footwork, highlighting the particular communicative intention of that dance. Similarly, dresses accentuate important aspects of the dancer's body. The tutu makes the "sublime" ballerina's waist look very graceful and narrow, just as the trousers and skirts of Hindu and Oriental dancers. One could speculate, from an evolutionary perspective, that such dance ornaments highlight body features related to fertility.

Additional complements such as fans, particular hand movements (like the undulating hand circles of oriental dance or Flamenco), snappers, ankle bells, scarves and the like are popular throughout dance styles for the purpose of movement enhancement. Finally, the use of a more or less complex stage design and color and light work is a frequent method to serve the experience of the overall meaning of the choreography. In fact, all dances use some kind of setting within which the dance is taking place (Dox, 2011).

In sum, ornaments are a type of movement enhancement, apparently universally present in dance styles across the world. Scientists could thus study their distinctive implication and importance in the aesthetic experience. Furthermore, also the use of stage props and particular colorings of backgrounds and costumes could be considered a challenge to empirical aesthetics.

4.3. Dance usage

The pleasure of "moving in synchrony" appears to be common to all human cultures (Wiltermuth & Heath, 2009). It is observable in the protolanguage of mothers and their children (Schögler & Trevarthen, 2007; Trevarthen & Daniel, 2005), in the rhythmicity of human non-verbal communication, and in dance. Thus, dance has often been considered a crucial cohesion element in human culture (Wiltermuth & Heath, 2009). It probably served various functions in such activities as prayer, healing and social gathering for special events from its beginnings. Besides neurobiological aspects, social and psychological aspects also have an influence on the experience of dance: As we dance, we communicate—and we enjoy it. Dance occurs with a special communicative intention among individuals. Empirical aesthetics could thus aim to determine the role of the communicative intention in the dance movement in the aesthetic experience.

4.4. Symmetry, synchronization, lines and astonishing solos

Extensive work on human visual preferences shows that humans prefer cardinal to oblique lines (Latto, Brain, & Kelly, 2000), and curved to sharp forms (Bar & Neta, 2006). Miura and colleagues (2010) showed how smooth and fluent dance movements were preferred over awkward ones (Miura, Sugiura, Takahashi, Sassa, Miyamoto, Sato, et al., 2010). As Hagendoorn (2005) noted, many human dances conform to these characteristics at least to some extent, suggesting the possibility of some underlying universal aesthetic preferences for particular visual features, also in dance movements. Additional evidence can be found in the recurrent features of synchronized movement sequences of various dancers together and the implementation of so-called *solos* (i.e. a single performer dancing alone) of particularly skilled individual dancers.

Unsystematic inspection of many dance forms suggests that their movements are indeed grounded on features that seem to draw the attention of the human cognitive system, including symmetry in space and movement, synchronization between elements, horizontal and vertical lines, as well as curvilinear and smooth movements and forms (Hagendoorn, 2005). We suggest three intriguing questions, that follow from this unsystematic analysis of different dance styles, for future empirical testing: (1) There is a tendency to train dancers' bodies to attain a rather extreme degree of flexibility. Could this training aim to reach the extreme vertical and horizontal lines that seem to be favored by human perception? (2) Many dance styles consider very stretched feet a virtue. Could it aim to increase visual pleasure by presenting an even longer line? (3) Most dance forms consider extreme turn out of the legs to be important. Could it be that these turned out limbs—in addition to allowing particular angles and lines of the legs—trigger an evolutionarily engrained appreciation related to fertility or male display behavior, which results in a pleasurable experience when watching such movements? For instance, Sütterlin has suggested that particularly the "*2nd position*" is related to male display behavior in tribal dances (Eibl-Eibesfeldt & Sütterlin, 1992; Sütterlin, 1994; Sütterlin, 2009). See the illustration in figure 4.

<<Insert figure 4 about here>>

4.5. Dance structure

Throughout its history, dance has often used movement to depict social life situations and associated emotions, clearly manifest in African and Indian dance.

Modern and Contemporary dance also focuses on social life and the individual's struggle with existence, especially Contemporary choreographies, which appear to focus much more on the individual's emotional life. Thus, it could be hypothesized that the contents of the dance choreographies all over the world have evolved by moving away from clear narratives, as in ancient classical Hindu and western Medieval Ballet dances that helped the audience to follow a story in which a message was conveyed through movement, towards very refined formal structures where the pure emotional or the pure aesthetic expression through movement prevails over giving external cues in the choreographic structure and stage design (Glass, 2005). The audience is invited to infer or interpret the meaning of the choreography from the movement alone, partly through emotional resonance—also referred to as kinesthetic empathy (Jola, Ehrenberg & Reynolds, 2011)—and partly by means of knowing the general meaning of the choreography beforehand. Audiences expect to perceive a *message* in the movements, whether intellectually or emotionally stimulating. Furthermore, empirical research with static artworks has shown how the aesthetic experience can be altered as a function of the meaning that a participant sees in an artwork (Kirk, Skov, Hulme, Christensen, & Zeki, 2009; Leder, Carbon, & Ripsas, 2006; Russell, 2003). Knowing and understanding the "story" behind an artwork appears to be crucial to its aesthetic experience.

Considering the long and ongoing tradition of narratives and "plots" in dance choreographies around the world, it is highly likely that the aesthetic experience of dance is, at least to a certain extent, also determined by the perceived or informed plot *or meaning* behind the movement, though this remains an intriguing question for future research in empirical aesthetics of dance.

5. FINAL CONCLUSION: LET'S DANCE

Dance is a fascinating field of study that is still rather unexplored by empirical aesthetics. Only a small number of studies have so far used genuine dance movements as experimental stimuli to address questions regarding the aesthetic experience of dance. As we have tried to argue throughout this paper, dance constitutes a broad research field for those interested in the neural foundations of aesthetic experience, and affords many stimulating possibilities to test their hypotheses.

The art form *dance* is a dynamic, rapidly changing phenomenon that poses tough challenges to fully control all the relevant variables in a laboratory setting. For sure, with one single motion a ballerina may aesthetically move an audience of 400 people. However, whether the aesthetic power of this movement can be studied in a laboratory setting remains to be established by exciting research still to come in the emerging field of the neuroaesthetics of dance.

REFERENCES

Adolphs, R. (2002). Recognizing Emotion From Facial Expressions: Psychological and Neurological Mechanisms. *Behavioral and Cognitive Neuroscience Reviews, 1*(1), 21-62.

Aglioti, S.M., Minio-Paluello, I., Candidi, M., (2012). The beauty of the body. *Proceedings Lyncei Academia, 23*(3), 281-288. doi: 10.1007/s12210-012-0169-1

Aharon, I., Etcoff, N., Ariely, D., Chabris, C. F., O'Connor, E., & Breiter, H. C. (2001). Beautiful faces have variable reward value: fMRI and behavioral evidence. *Neuron, 32*(3), 537-551.

Aleong, R., & Paus, T. (2010). Neural Correlates of Human Body Perception. *Journal of Cognitive Neuroscience, 22*(3), 482-495. doi: 10.1162/jocn.2009.21211

Astafiev, S. V., Stanley, C. M., Shulman, G. L., & Corbetta, M. (2004). Extrastriate body area in human occipital cortex responds to the performance of motor actions. *Nature Neuroscience, 7*(5), 542-548. doi: 10.1038/nn1241

Atkinson, A. P., Vuong, Q. C., & Smithson, H. E. (2012). Modulation of the face- and body-selective visual regions by the motion and emotion of point-light face and body stimuli. *Neuroimage, 59*(2), 1700-1712. doi: 10.1016/j.neuroimage.2011.08.073

Bar, M., & Neta, M. (2006). Humans prefer curved visual objects. *Psychological Science, 17*(8), 645-648.

Bastiaansen, J. A., Thioux, M., Keysers, C. (2009). Evidence for mirror systems in emotions. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*(1528), 2391-2404.

Berlucchi, G., & Aglioti, S. M. (2010). The body in the brain revisited. *Experimental Brain Research, 200*(1), 25-35. doi: 10.1007/s00221-009-1970-7

Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences of the United States of America, 98*(20), 11818-11823.

Bläsing, B., Calvo-Merino, B., Cross, E.S., Jola, C., Honisch, J., Stevens, C.J. (2012). Neurocognitive control in dance perception and performance. *Acta Psychologica, 139*(2), 300-8. doi: 10.1016/j.actpsy.2011.12.005

Bläsing, B., Tenenbaum, G., & Schack, T. (2009). The cognitive structure of movements in classical dance. *Psychology of Sport and Exercise, 10*(3), 350-360.

Bodrogi, T. (1981). *Stammeskunst*. Budapest: Corvina Kiadó.

Brown, S., Martinez, M. J., & Parsons, L. M. (2004). Passive music listening spontaneously engages limbic and paralimbic systems. *NeuroReport, 15*(13), 2033-2037.

Brownlow, S., Dixon, A. R., Egbert, C. A., & Radcliffe, R. D. (1997).Perception of movement and dancer characteristics from point-light displays of dance. *Psychological Record, 47*(3), 411-421.

Calvo-Merino, B. (2010). Neural mechanisms for seeing dance. In B. Bläsing, Puttke M., Schacke, T. (Ed.), *The neurocognition of dance. Mind, movement, and motor skills*. Hove: Psychology Press.

Calvo-Merino, B., Glaser, D. E., Grèzes, J., Passingham, R. E., & Haggard, P. (2005). Action observation and acquired motor skills: An fMRI study with expert dancers. *Cerebral Cortex, 15*(8), 1243-1249. doi: 10.1093/cercor/bhi007

Calvo-Merino, B., Grèzes, J., Glaser, D. E., Passingham, R. E., & Haggard, P. (2006). Seeing or doing? Influence of visual and motor familiarity in action observation (vol. 16, pg 1905, 2006). *Current Biology, 16*(22), 2277-2277.

Calvo-Merino, B., Jola, C., Glaser, D. E., & Haggard, P. (2008).Towards a sensorimotor aesthetics of performing art. *Consciousness and Cognition, 17*(3), 911-922.

Calvo-Merino, B., Urgesi, C., Orgs, G., Aglioti, S., M., Haggard, P. (2010a). Extrastriate body area underlies aesthetic evaluation of body stimuli. *Experimental Brain Research*. 204(3), 447-56. doi : 10.1007/s00221-010-2283-6

Calvo-Merino, B., Ehrenberg, S., Leung, D., Haggard, P. (2010b). Experts see it all: configural effects in action observation. *Psychologial Research.* 74(4), 400-6.

Camurri, A., Lagerlof, I., & Volpe, G. (2003). Recognizing emotion from dance movement: comparison of spectator recognition and automated techniques. *International Journal of Human-Computer Studies, 59*(1-2), 213-225.

Carroll, N., Moore, M. (*forthcoming*). Moving in Concert: Dance and Music" In P. Goldie, E. Schellekens (Eds.), *Philosophical Aesthetics and Aesthetic Psychology* (chapter 19). Oxford: OUP.

Caspers, S., Zilles, K., Laird, A.R., Eickhoff, S.B. (2010). ALE meta-analysis of action observation and imitation in the human brain. *Neuroimage, 50*(3), 1148-1167. doi:10.1016/j.neuroimage.2009.12.112

Cela-Conde, C. J., Marty, G., Maestu, F., Ortiz, T., Munar, E., Fernandez, A., et al. (2004). Activation of the prefrontal cortex in the human visual aesthetic perception. *Proceedings of the National Academy of Sciences of the United States of America, 101*(16), 6321-6325.

Cela-Conde, C. J., Agnati, L., Huston, J. P., Mora, F., & Nadal, M. (2011). The neural foundations of aesthetic appreciation. *Progress in Neurobiology, 94*, 39-48.

Chatterjee, A. (2010). Neuroaesthetics: A coming of age story. *Journal of Cognitive Neuroscience, 23*(1), 53-62.

Cross, E. S., Hamilton, A. F. d. C., & Grafton, S. T. (2006). Building a motor simulation de novo: Observation of dance by dancers. *Neuroimage, 31*(3), 1257-1267.

Cross, E. S., Hamilton, A. F. d. C., Kraemer, D. J. M., Kelley, W. M., & Grafton, S. T. (2009). Dissociable substrates for body motion and physical experience in the human action observation network. *European Journal of Neuroscience, 30*(7), 1383-1392.

Cross, E. S., Kirsch, L., Ticini, L. F., & Schuetz-Bosbach, S. (2011). The impact of aesthetic evaluation and physical ability on dance perception. *Frontiers in Human Neuroscience, 5*. doi: 10210.3389/fnhum.2011.00102

Cross, E. S., Ticini, L. F. (2011). Neuroaesthetics and beyond: new horizons in applying the science of the brain to the art of dance. *Phenomenology and the Cognitive Sciences 11*(1), 5-16. *(Special Issue: Dance and Cognitive Science).* doi:10.1007/s11097-010-9190-y.

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.

De Gelder, B. (2009). Why bodies? Twelve reasons for including bodily expressions in affective neuroscience. *Philosophical Transactions of the Royal Society B: Biological Sciences, 12; 364*(1535), 3475-3484.

de Gelder, B. & Van den Stock, J. (2011). The Bodily Expressive Action Stimulus Test (BEAST). Construction and validation of a stimulus basis for measuring perception of whole body expression of emotions. *Frontiers in Psychology, 2*(181), 1-6. doi:10.3389/fpsyg.2011.0018.

De Meijer, M. (1989). The contribution of general features of body movement to the attribution of emotions.*Journal of Nonverbal Behavior, 13*(4), 247-268.

Decety, J., Grèzes, J., Costes, N., Perani, D., Jeannerod, M., Procyk, E., Grassi, F., Fazio, F. (1997). Brain activity during observation of actions. Influence of action content and subject’s strategy. *Brain, 120*, 1763-1777.

Di Dio, C., & Gallese, V. (2009). Neuroaesthetics: a review. *Current Opinion in Neurobiology, 19*(6), 682-687.

Di Dio, C., Macaluso, E., & Rizzolatti, G. (2007). The Golden Beauty: Brain Response to Classical and Renaissance Sculptures. *Plos One, 2*(11).

di Pellegrino, G., Fadiga, L., Fogassi, L. et al. (1992). Understanding motor events: a neurophysiological study. *Experimental Brain Research*, *91*(1), 176-180.

Dittrich, W. H., Troscianko, T., Lea, S. E. G., & Morgan, D. (1996). Perception of emotion from dynamic point-light displays represented in dance. *Perception, 25*(6), 727-738.

Downing, P. E., Jiang, Y., Shuman, M., Kanwisher, N. (2001). A cortical area selective for visual processing of the human body. *Science of Optimism and Hope*, *293*, 2470-2473.

Dox, D. (2011). Dance, *New Dictionary of the History of Ideas*: Encyclopedia.com: http://www.encyclopedia.com/doc/1G2-3424300186.html </doc/1G2-3424300186.html>

Eibl-Eibesfeldt, I. & Sütterlin, C. (1992). Im Banne der Angst. Zur Natur- und Kunstgeschichte menschlicher Abwehrsymbolik. Piper: München.

Ekman, P., & Friesen, W. V. (1971). Constants Across Cultures in Face and Emotion. *Journal of Personality and Social Psychology, 17*(2), 124-6.

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor facilitation during action observation: A magnetic stimulation study. *Journal of Neurophysiology, 73*(6), 2608–2611.

Fechner, G. T. (1876). *Vorschule der Ästhetik*. Leipzig: Breitkopf und Härtel.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, *119*, 593-609.

Glass, R. (2005). Observer response to Contemporary dance. In R. Grove, Stevens, C., McKechnie, S. (Ed.), *Thinking in Four Dimensions. Creativity and Cognition in Contemporary Dance* (pp. 154-168). Melbourne: Melbourne University Press.

Grafton, S. T., Arbib, M.A., Fadiga, L., Rizzolatti, G. (1996). Localization of grasp representations in humans by positron emission tomography. 2. Observation compared with imagination. *Experimental Brain Research*, *112*, 103-111.

Grèzes, J., Costes, N., Decety, J. (1999). The effects of learning and intention on the neural network involved in the perception of meaningless actions. *Brain 122*, 1875-1887.

Grèzes, J., Fonlupt, P., Bertenthal, B., Delon-Martin, C., Segebarth, C., & Decety, J. (2001). Does perception of biological motion rely on specific brain regions? *Neuroimage, 13*(5), 775-785. doi: 10.1006/nimg.2000.0740

Grosbras, M. H., Beaton, S., Eickhoff, S. B. (2012). Brain regions involved in human movement perception: a quantitative voxel-based meta-analysis. *Human Brain Mapping*. *33*(2), 431-54. doi: 10.1002/hbm.21222.

Grosbras, M. H., Tan, H., Pollick, F. (2012). Dance and emotion in posterior parietal cortex: a low-frequency rTMS study. *Brain Stimulation, 5*(2), 130-136. doi: 10.1016/j.brs.2012.03.013.

Grossman, E., Donnelly, M., Price, R., Pickens, D., Morgan, V., Neighbor, G., et al. (2000). Brain areas involved in perception of biological motion. *Journal of Cognitive Neuroscience, 12*(5), 711-720. doi: 10.1162/089892900562417

Hagendoorn, I. (2005). Dance Perception and the Brain. In R. Grove, Stevens, C., McKechnie, S. (Ed.), *Thinking in Four Dimensions. Creativity and Cognition in Contemporary Dance* (pp. 137-148). Melbourne: Melbourne University Press.

Hejmadi, A., Davidson, R. J., Rozin, P. (2000). Exploring Hindu Indian Emotion Expressions: Evidence for Accurate Recognition by Americans and Indians. *Psychological Science, 11*(3), 183-187.

Herrington, J. D., Nymberg, C., & Schultz, R. T. (2011). Biological motion task performance predicts superior temporal sulcus activity. *Brain and Cognition, 77*(3), 372-381. doi: 10.1016/j.bandc.2011.09.001

Hickok, G. (2009). Eight problems for the mirror neuron theory of action understanding in monkeys and humans. *Journal of Cognitive Neuroscience, 21*(7), 1229-1243.

Jacobsen, T., Schubotz, R. I., Hofel, L., & Cramon, D. Y. V. (2006). Brain correlates of aesthetic judgment of beauty. *Neuroimage, 32*(1), 486-487.

Jang, S. H., Pollick, F. E. (2011). Experience Influences Brain Mechanisms of Watching Dance. *Dance Research 29*(2), 352–377.

Jola, C., Abedian-Amiri, A., Kuppuswamy, A., Pollick, F. E., Grosbras, M. H. (2012). Motor simulation without motor expertise: enhanced corticospinal excitability in visually experienced dance spectators. *PLoS One, 7*(3), 1-12. e33343

Jola, C., Ehrenberg, S., Reynolds, D. (2011). The experience of watching dance: phenomenological-neuroscience duets. *Phenomenological Cognitive Sciences*.

Jola, C., Pollick, F., Grosbras, M. H. (2011). Arousal decrease in Sleeping Beauty: Audiences' neurophysiological correlates to watching a narrative dance performance of 2.5 hrs. *Dance Research 29*(2), 378–403

Kable, J. W., & Chatterjee, A. (2006). Specificity of action representations in the lateral occipitotemporal cortex. *Journal of Cognitive Neuroscience, 18*(9), 1498-1517. doi: 10.1162/jocn.2006.18.9.1498

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience, 17*(11), 4302-4311.

Kawabata, H., & Zeki, S. (2004). Neural correlates of beauty. *Journal of Neurophysiology, 91*(4), 1699-1705.

Keysers, C., Kaas, J. H., & Gazzola, V. (2010). Somatosensation in social perception. *Nature Reviews Neuroscience, 11*(6), 417-428. doi: 10.1038/nrn2833

Kirk, U., Skov, M., Hulme, O., Christensen, M. S., & Zeki, S. (2009). Modulation of aesthetic value by semantic context: An fMRI study. *Neuroimage, 44*(3), 1125-1132.

Kourtzi, Z., & Kanwisher, N. (2000). Activation in human MT/MST by static images with implied motion. *Journal of Cognitive Neuroscience, 12*(1), 48-55.

Latto, R., Brain, D., & Kelly, B. (2000). An oblique effect in aesthetics: Homage to Mondrian (1872-1944). *Perception, 29*(8), 981-987.

Leder, H., Belke, B., Oeberst, A., & Augustin, M. D. (2004).A model of aesthetic appreciation and aesthetic judgments. *British Journal of Psychology, 95*, 489-508.

Leder, H., Carbon, C. C., & Ripsas, A. L. (2006). Entitling art: Influence of title information on understanding and appreciation of paintings. *Acta Psychologica, 121*(2), 176-198. doi: 10.1016/j.actpsy.2005.08.005

Lestou, V., Pollick, F. E., & Kourtzi, Z. (2008). Neural substrates for action understanding at different description levels in the human brain. *Journal of Cognitive Neuroscience*, *20*(2), 324-341. doi: 10.1162/jocn.2008.20.2.324

Little, A. C., Jones, B.C., Debruine, L.M. (2011). The many faces of research on face perception. *Philosophical Transactions of the Royal Society B: Biological Sciences, 12;366*(1571), 1634-1637.

Miura, N., Sugiura, M., Takahashi, M., Sassa, Y., Miyamoto, A., Sato, S., Horie, K., Nakamura, K., Kawashima, R. (2010). Effect on motion smoothness on bran activity while observing a dance: An fMRI study using a humanoid robot. *Social Neuroscience, 5*(1), 40-58.

Mukamel, R., Ekstrom, A. D., Kaplan, J., Iacoboni, M., & Fried, I. (2010). Single-neuron responses in humans during execution and observation of actions. *Current Biology, 20*(8):750-756. doi: 10.1016/j.cub.2010.02.045

Nadal, M., Munar E., Capó, M.A., Rosselló, J., Cela-Conde, C.J. (2008). Towards a framework for the study of the neural correlates of aesthetic preference. *Spatial Vision, 21*(3-5), 379-396.

Orgs, G., Bestmann, S., Schuur, F., Haggard, P. (2011). From Body Form to Biological Motion: The Apparent Velocity of Human Movement Biases Subjective Time. *Psychological Science, 22*(6), 712-717.

Orgs, G., Dombrowski, J. H., Heil, M., & Jansen-Osmann, P. (2008). Expertise in dance modulates alpha/beta event-related desynchronization during action observation. *European Journal of Neuroscience, 27*(12), 3380-3384.

Orlov, T., Makin, T. R., & Zohary, E. (2010). Topographic Representation of the Human Body in the Occipitotemporal Cortex. *Neuron, 68*(3), 586-600. doi: 10.1016/j.neuron.2010.09.032

Peelen, M. V., Atkinson, A. P., Andersson, F., & Vuilleumier, P. (2007). Emotional modulation of body-selective visual areas. *Social Cognitive and Affective Neuroscience, 2*(4), 274-283. doi: 10.1093/scan/nsm023

Peelen, M. V., & Downing, P. E. (2007). The neural basis of visual body perception. *Nature Reviews Neuroscience, 8*(8), 636-648. doi: 10.1038/nrn2195

Penton, L. G., Fernandez, A. P., Leon, M. A. B., Ymas, Y. A., Garcia, L. G., Iturria-Medina, Y., et al. (2010). Neural activation while perceiving biological motion in dynamic facial expressions and point-light body action animations. [Article]. *Neural Regeneration Research, 5*(14), 1076-1083. doi: 10.3969/j.issn.1673-5374.2010.14.007

Petrini, K., Crabbe, F., Sheridan, C., & Pollick, F. E. (2011). The Music of Your Emotions: Neural Substrates Involved in Detection of Emotional Correspondence between Auditory and Visual Music Actions. *Plos One, 6*(4), 10. doi: e1916510.1371/journal.pone.0019165

Pichon, S., de Gelder, B., Grèzes J. (2008). Emotional modulation of visual and motor areas by dynamic body expressions of anger. *Social Neuroscience, 3*(3-4), 199-212.

Pollick, F. E., Lestou, V., Ryu, J., & Cho, S. B. (2002). Estimating the efficiency of recognizing gender and affect from biological motion. *Vision Research, 42*(20), 2345-2355.

Pollick, F., Noble, K., Darshane, N., Murphy, H., Glowinski, D., McAleer, P., Jola, C., Penfield, K., & Camurri, A. (2012). Using a novel motion index to study the neural basis of event segmentation. *Perception*, 3(4).

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience, 27*, 169-192.

Rizzolatti, G., Fabbri-Destro, M. (2010). Mirror neurons: from discovery to autism. *Experimental Brain Research, 200*(3-4), 223-237.

Russell, P. A. (2003). Effort after meaning and the hedonic value of paintings. *British Journal of Psychology, 94*, 99-110. doi: 10.1348/000712603762842138

Sawada, M., Suda, K., & Ishii, M. (2003). Expression of emotions in dance: Relation between arm movement characteristics and emotion. *Perceptual and Motor Skills, 97*(3), 697-708.

Saygin, A. P., Wilson, S.M., Hagler, D.J. Jr., Bates, E., Sereno, M.I. . (2004). Point-light biological motion perception activates human premotor cortex. *Journal of Neuroscience, 7;24*(27), 6181-6188.

Schögler, B., Trevarthen, C. (2007). To sing and dance together. From infants to jazz. In S. Braaten (Ed.), *On Being Moved. From Mirror Neurons to Empathy* (Vol. 68, pp. 281-302). Amsterdam/Philadelphia: John Benjamins Publishing Company.

Senior, C., Barnes, J., Giampietro, V., Simmons, A., Bullmore, E. T., Brammer, M., et al. (2000). The functional neuroanatomy of implicit-motion perception or 'representational momentum'. *Current Biology, 10*(1), 16-22.

Skoyles, J. R. (1998). Motor perception and anatomical realism in Classical Greek art. *Medical Hypotheses, 51*(1), 69-70.

Stevens, C. (2005). Trans-disciplinary Approaches to Research into Creation, Performance, and Appreciation of Contemporary Dance. In R. Grove, Stevens, C., McKechnie, S. (Ed.), *Thinking in Four Dimensions. Creativity and Cognition in Contemporary Dance* (pp. 154-168). Melbourne: Melbourne University Press.

Stevens, C., Malloch, S., McKechnie, S., Steven, N. (2003). Choreographic cognition: The time-Cource and Phenomenology of Creating a Dance. *Pragmatics & Cognition, 11*(2): 297-326.

Stevens, C., Schubert, E., Morris, R. H., Frear, M., Chen, J., Healey, S., Schoknecht, C., Hansen, S., (2009). Cognition and the temporal arts: Investigating audience response to dance using PDAs that record continuous data during live performance. *International Journal of Human-Computer Studies, 67,* 800-813.

Stevens, C., Vincs, E., Schubert, E. (2009). *Measuring audience response on-line: an evaluation of the portable audience response facility (pARF).* Paper presented at the Second International Conference on Music Communication Science, Sydney, Australia.

Stevens, C. J., Schubert, E., Morris, R. H., Frear, M., Chen, J., Healey, S., et al. (2009). Cognition and the temporal arts: Investigating audience response to dance using PDAs that record continuous data during live performance. *International Journal of Human-Computer Studies, 67*(9), 800-813.

Sütterlin, C. (1994). Körperschemata im universellen Verständnis. In: P.Michel (ed) Die biologischen und kulturellen Wurzeln des Symbolgebrauchs beim Menschen. P.Lang ed. Bern/Berlin.

Takahashi, H., Yahata, N., Matsuda, T., Asai, K., Okubo, Y. (2004). Brain activation associated with evaluative processes of guilt and embarassment: an fMRI study. *Neuroimage, 23,* 967-974.

Thompson, J. C., & Baccus, W. (2012). Form and motion make independent contributions to the response to biological motion in occipitotemporal cortex. *Neuroimage, 59*(1), 625-634. doi: 10.1016/j.neuroimage.2011.07.051

Trevarthen, C., & Daniel, S. (2005). Disorganized rhythm and synchrony: Early signs of autism and Rett syndrome. *Brain & Development, 27*, S25-S34.

Umiltà, M. A., Kohler, E., Gallese, V., Fogassi, L., Fadiga, L., Keysers, C., et al. (2001). I know what you are doing: A neurophysiological study. *Neuron, 31*(1), 155-165.

Urgesi, C., Berlucchi, G., & Aglioti, S. M. (2004). Magnetic stimulation of extrastriate body area impairs visual processing of nonfacial body parts. *Current Biology, 14*(23), 2130-2134. doi: 10.1016/j.cub.2004.11.031

Urgesi, C., Maieron, M., Avenanti, A., Tidoni, E., Fabbro, F., & Aglioti, S. M. (2010). Simulating the Future of Actions in the Human Corticospinal System. *Cerebral Cortex, 20*(11), 2511-2521.

Urgesi, C., Moro, V., Candidi, M., & Aglioti, S. M. (2006). Mapping implied body actions in the human motor system. *Journal of Neuroscience, 26*(30), 7942-7949.

Van Meel, J., Verburgh, H., De Meijer, M. (1993). Children's interpretations of dance expressions. *Empirical Studies of the Arts, 11*(2).

Van den Stock, J., Tamietto, M., Sorger, B., Pichon, S., Grèzes, J., & de Gelder, B. (2011). Cortico-subcortical visual, somatosensory, and motor activations for perceiving dynamic whole-body emotional expressions with and without striate cortex (V1). *Proceedings of the National Academy of Sciences of the United States of America, 108*(39), 16188-16193. doi: 10.1073/pnas.1107214108

Vartanian, O., & Goel, V. (2004). Neuroanatomical correlates of aesthetic preference for paintings. *NeuroReport, 15*(5), 893-897. doi: 10.1097/01.wnr.0000118723.38067.d6

Vincs, K., Schubert, E., Stevens, C. (2007, October 25-28). *Engagement and the 'gem' moment: How do dance students view and respond to dance in realtime?* Paper presented at the 17th Annual Meeting of the International Association for Dance Medicine and Science, Canberra, Australia.

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in My Insula: The common neural basis of seeing and feeling disgust. *Neuron, 40*(3), 655-664.

Wiggett, A. J., & Downing, P. E. (2011). Representation of Action in Occipito-temporal Cortex. *Journal of Cognitive Neuroscience, 23*(7), 1765-1780. doi: 10.1162/jocn.2010.21552

Wiltermuth, S. S., & Heath, C. (2009). Synchrony and Cooperation. *Psychological Science, 20*(1), 1-5.

Figure 1

Example of dynamic dance stimuli for dance aesthetics research (a) Scottish Ballet in Page's sleeping Beauty (Jola, Pollick, & Grosbas, 2011); (b) Example of static body postures stimuli and controls for aesthetics studies (Calvo-Merino et al., 2010a); (c) Three second Ballet movements using point lights displays (Calvo-Merino et al., *2010b*); (d) Three second video clips of Ballet and Capoeira movements (Calvo-Merino et al., 2005; 2008) (e) Static picture stimuli of one same Ballet position at different points of time during the 20th century (Daprati et al., 2009).

Figure 2

Brain regions implied in body, movement and dance perception and in the aesthetic appreciation of dance. A couple of representative studies are cited as references for each region. We do, however, want to point out that the body of research referenced here is by no means exhaustive. Anatomical regions are marked in light grey and approximate activation *foci* are represented with dark grey dots.

(a) <u>Regions implied in movement perception</u>: *Ventral Premotor Cortex* (~BA 6) (Bastiaansen, Thioux, & Keysers, 2009; Lestou, Pollick, & Kourtzi, 2008; Van den Stock, et al., 2011); *Superior Temporal Sulcus* (STS) (Grèzes, Fonlupt, Bertenthal, Delon-Martin, Segebarth, & Decety, 2001; Grossman, Donnelly, Price, Pickens, Morgan, Neighbor, et al., 2000; Herrington, Nymberg, & Schultz, 2011; Lestou, Pollick, & Kourtzi, 2008; Penton, Fernandez, Leon, Garcia, Iturria-Medina, et al. 2010); *Medial Temporal/Medial Superior Temporal Areas* (MT/MST), ~ V3 and V 5 (BA 18,19) (Grossman, et al., 2000; Kourtzi & Kanwisher, 2000; Senior, et al., 2000; Thompson & Baccus, 2012); *Inferior Parietal Gyrus/Lobule* (BA 39/40) (Bastiaansen, Thioux, & Keysers, 2009); *Motor Cortex* (BA 4) (Urgesi, Moro, Candidi, & Aglioti, 2006; Van den Stock, et al., 2011); *Somatosensocial Cortices* (BA 1,2,3) (Van den Stock, et al., 2011). Regions implied in *both* body and movement perception: *Occipitotemporal Cortex* (BA37), ~ "Extrastriate Body Area" (EBA), for body perception (Aleong & Paus, 2010; Berlucchi & Aglioti, 2010; Downing, Jiang, Shuman, & Kanwisher, 2001; Orlov, Makin, & Zohary, 2010; Urgesi, Berlucchi, & Aglioti, 2004), for movement perception (Astafiev, Stanley, Shulman, & Corbetta, 2004; Atkinson, Vuong, & Smithson, 2012; Downing, Peelen, Wiggett, & Tew, 2006; Kable & Chatterjee, 2006; Takahashi, Yahata, Matsuda, Asai, & Okubo, 2004; Thompson & Baccus, 2012; Wiggett & Downing, 2011); *Intraparietal Sulcus*, for body perception (Orlov, et al., 2010), for movement perception (Grèzes, et al., 2001).

(b) Regions (found so far) implied in dance perception: *Ventral Premotor cortex* (~BA 6) (Calvo-Merino, Glaser, Grezes, Passingham, & Haggard, 2005; Cross, Hamilton, & Grafton, 2006); Intraparietal Sulcus (Calvo-Merino, et al., 2005); *Superior Temporal Sulcus* (STS) (Calvo-Merino, et al., 2005; Cross, et al., 2006); *Medial Temporal/Medial Superior Temporal Areas* (MT/MST), ~ V3 and V5 (BA 18,19) (Cross, Kirsch, Ticini, & Schuetz-Bosbach, 2011); *Inferior Parietal Gyrus/Lobule* (BA 39/40) (Cross, et al., 2006; Cross, et al., 2011); Temporo-Parietal Junction (BA 39, 40, 22) (Jang & Pollick, 2011); *Motor Cortex* (BA 4) (Cross, et al., 2006; Jang & Pollick, 2011); *Somatosensocial Cortices* (BA 1,2,3) (Jang & Pollick, 2011); *Insula* (Cross, et al., 2011), *Orbitofrontal Cortex* (OFC) (BA 11,12) (Jang & Pollick, 2011); and *Anterior Cingulate Cortex* (ACC) (BA 24).

(c) Regions (found so far) implied in the aesthetic experience of dance movements: *Ventral Premotor cortex* (~BA 6) (Calvo-Merino, Jola, Glaser, & Haggard, 2008; Cross, et al., 2011); *Medial Temporal/Medial Superior Temporal Areas* (MT/MST), ~ V3 and V5 (BA 18,19) (Calvo-Merino, et al., 2008; Cross, et al., 2011); *Inferior Parietal*

Gyrus/Lobule (BA 39/40) (Cross, et al., 2011); *Occipitotemporal Cortex* (BA37), ~ "Extrastriate Body Area" (EBA) (Calvo-Merino, Urgesi, Orgs, Aglioti, & Haggard, 2010).

Figure 3

Examples of Movement universals from Indian dance and Ballet (drawn by JFC)

Figure 4

Example of a position of male display behavior. Rock engravings from Tahiti (left) and Australia (right); reproduced with permission from Eibl-Eibesfeldt, I. & Sütterlin, C. (1992). Im Banne der Angst. Zur Natur- und Kunstgeschichte menschlicher Abwehrsymbolik. (ed. Piper) München (page 123).

Figure 1

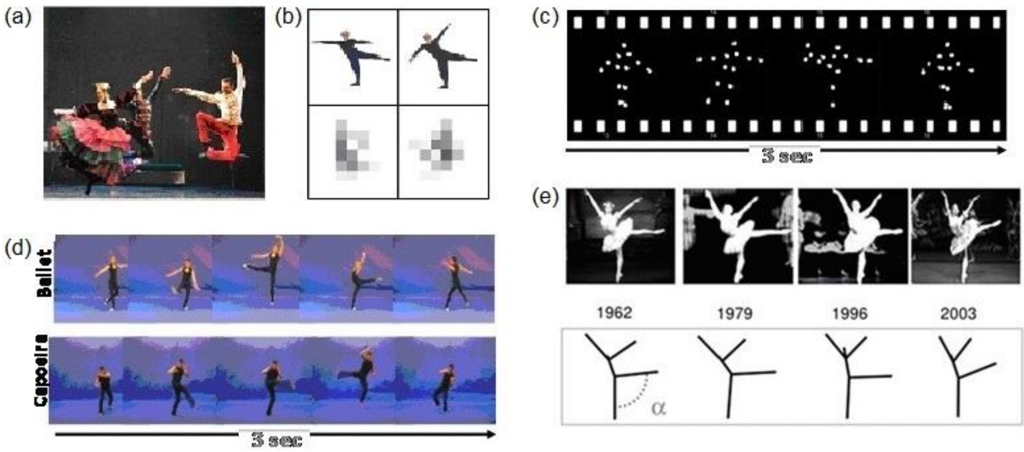

Figure 2

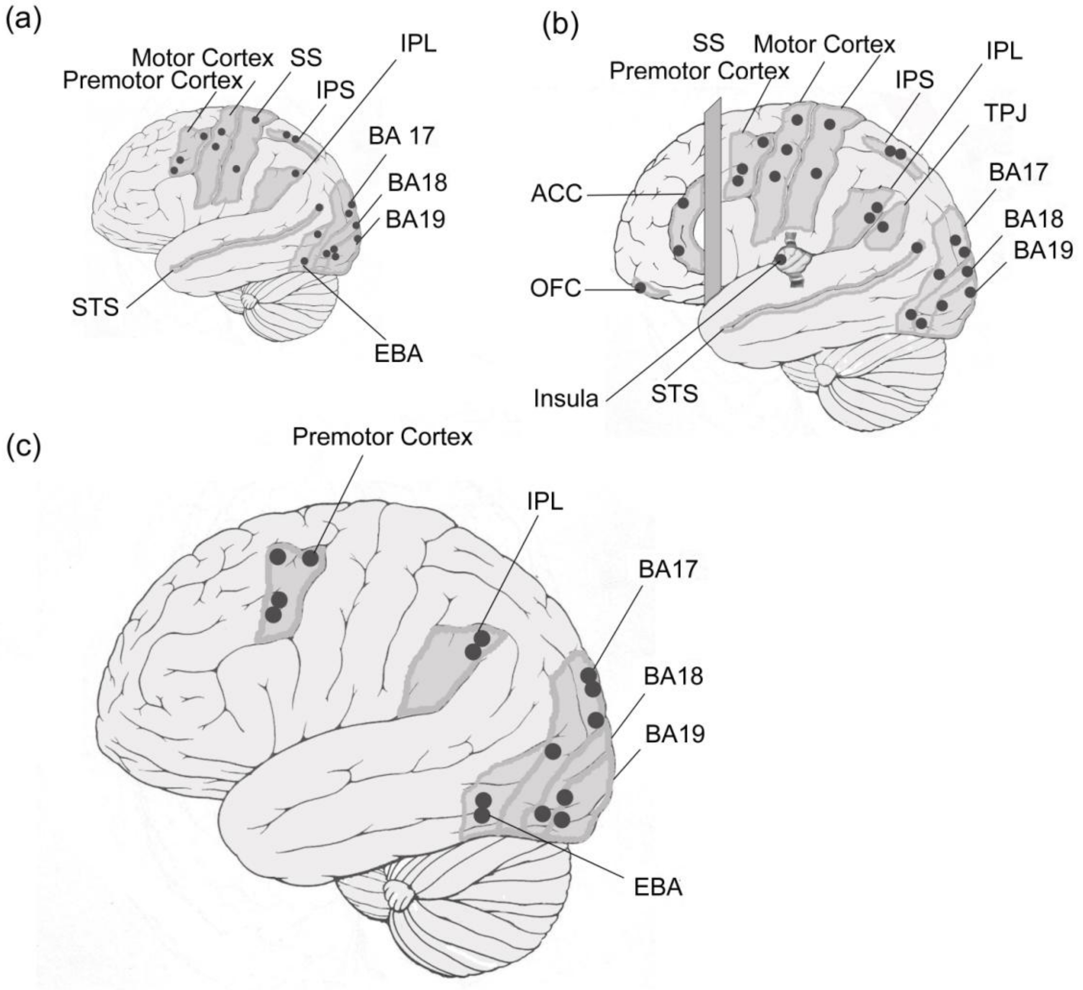
(a)
Motor Cortex
SS
Premotor Cortex
IPS
IPL
BA 17
BA18
BA19
STS
EBA
(b)
SS
Motor Cortex
Premotor Cortex
IPS
IPL
TPJ
BA17
BA18
BA19
ACC
OFC
Insula
STS
(c)
Premotor Cortex
IPL
BA17
BA18
BA19
EBA

Figure 3

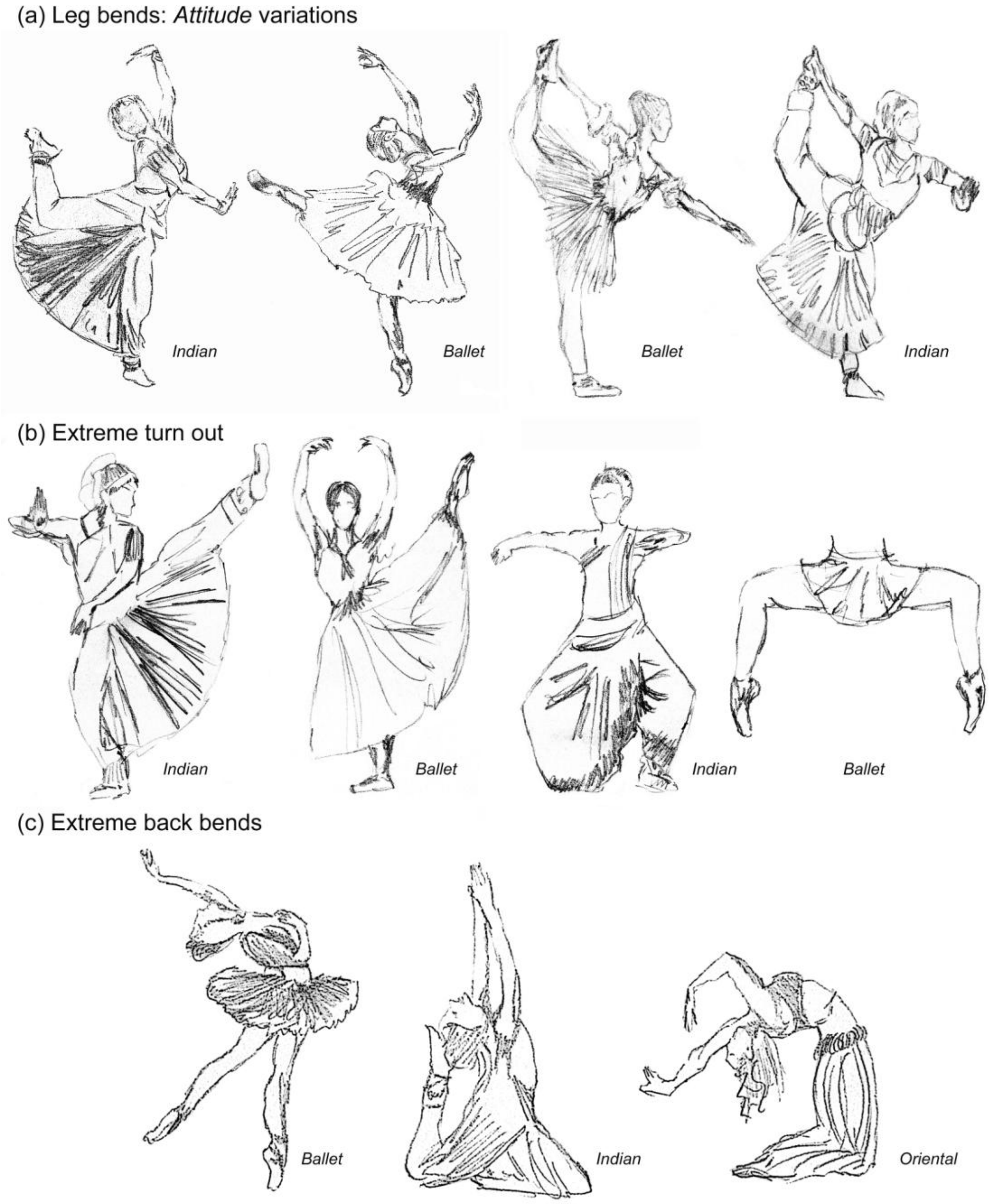
(a) Leg bends: *Attitude* variations
Indian
Ballet
Ballet
Indian
(b) Extreme turn out
Indian
Ballet
Indian
Ballet
(c) Extreme back bends
Ballet
Indian
Oriental

Figure 4