Female Perceptions of Male Body Movements

16

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Introduction

The morphology of both the human face and body affects people's social perception of others, and this has consequences for human mate preferences (for review, see Fink & Penton-Voak, 2002; Gangestad & Scheyd, 2005; Rhodes, 2006). Evolutionary psychologists argue that the sensitivity towards variation in facial and body morphology is neither arbitrarily nor culturally bound, but reflects evolved cognitive mechanisms which facilitate mate selection and reproductive success (for review see Grammer, Fink, Møller, & Thornhill, 2003; Little, Jones, & DeBruine, 2011). Following this logic, it is thought that attractiveness decisions in particular characterize people's preference for an individual's facial and/or body morphology, as they convey aspects of mate quality. This quality includes physical and personality characteristics, both of which affect the way we perceive the attractiveness of others (Buss, 1985; Buss & Barnes, 1986; Buss & Schmitt, 1993).

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While the evidence in support of the evolutionary psychology perspective on human social perception seems to be strong, most of the studies investigating the relationships between certain physical features and attractiveness perception have concentrated on static representations of faces and bodies. These studies have typically utilized two-dimensional (2D) stimuli in the form of face and/or body photographs (for review see Grammer, Fink, et al., 2003; Grammer, Keki, Striebel, Atzmüller, & Fink, 2003). Such experiments are useful for testing people's sensitivity and evaluations of static representations of the face and body, but they can only explain some proportion of the variation in everyday social perception, as there is an inherent limitation with these stimuli in terms of ecological validity. As such, there is comparably little insight into the significance of quality cues that may be derived from dynamic representations of human faces and bodies and how they could affect mate preferences.

In a meta-analysis, Langlois et al. (2000) reported that studies in attractiveness research used different types of stimulus presentation modes (photographic images, video clips, and in situ encounters) and that these different types convey different information, which subsequently leads to different attractiveness judgments. With regard to face perception, Roark, Barrett, Spence, Abdi, and O'Toole (2003) showed that the implicit social signals provided by a moving face (such as gaze cues, expression, and facial speech) mediate the effects of facial motion on recognition. As with

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faces, viewpoint-dependent perceptions are also known for the body. Doyle (2009) reported a peak shift effect in male attractiveness perception of female bodies when they were moving, suggesting that while walking, the movement of the waist and hip results in continuously alternate representations of left and right side waist-to-hip ratios (WHR; for review see Singh, 2002). This result seems to sit comfortably with the findings of Johnson and Tassinary (2005) who varied both body morphology (in terms of WHR) and motion (male exaggerated vs. female exaggerated movements) of animated human walkers, showing that when making social judgments, participants devoted particular visual attention to the waist and hip region.

These and related studies have stimulated scholars to investigate the role of movement cues within the evolutionary psychology framework. They have thus studied whether certain physical and personality characteristics, which are known to influence the perception of static representations of human faces and bodies, can also be derived from their dynamic displays (for review see Hugill, Fink, & Neave, 2010). In this chapter we do not address facial motion, which is an emerging topic that deserves attention in its own right, but instead concentrate on female perception of male body movements and review studies in support of the hypothesis that they affect female mate preferences.

Before we discuss the details of these studies, we consider it essential to give a brief review of the history of human movement research as such knowledge will facilitate the understanding and assessment of more recent approaches. We then deal with studies on key characteristics that can be derived from motion, such as age, gender, and emotional status, and discuss implications for social perception. In considering the most recent research on female perception of male body movements, we present evidence on female perceptions of physical and personality characteristics from male dance movements. Finally, we support our statements by reporting preliminary data on cross-cultural assessments of male dance movements and data on associations of female perception of different types of body movements (i.e., dancing, running, and walking).

A Brief History of Movement Research

The first scientific investigation on human body movement dates back around 150 years, when Charles Darwin performed systematic observations on how individuals communicate nonverbally with each other using direct or indirect "body language," and how this could be understood and interpreted. In *The Expression of the Emotions in Man and Animals*, Darwin (1872) stated that the "language of emotions" is evolved, adaptive, and universal to human culture and serves as a communicator in-between individuals.

At that time, the study of locomotion in living creatures was promoted by the discovery and invention of photographic techniques, as this allowed detailed movement analysis independent of the perceptual limitations of the human visual apparatus. In 1894, Etienne-Jules Marey developed a "methode graphique" in order to study the human body and the physiology of animals; later he invented a high-speed photographic technique called "chronophotography." In 1882 he used this method to capture multiple consecutive images of a variety of animals in motion on a single photographic glass plate, which he later replaced with transparent celluloid film stripes (Braun, 1992; Marey, 1894). At this time, the American businessman and racehorse owner Leland Stanford hired the English photographer Eadweard James Muybridge to analyze his horses' movements. To settle a wager and investigate whether the four hooves of a galloping horse do all leave the ground, Muybridge positioned a set of cameras in a row, activated by trip wires, and captured single shots of the passing horse within less than half a second. He proved that all four hooves lift off the ground, and this was only the beginning of a series of hundreds of thousands of images Muybridge took of animals

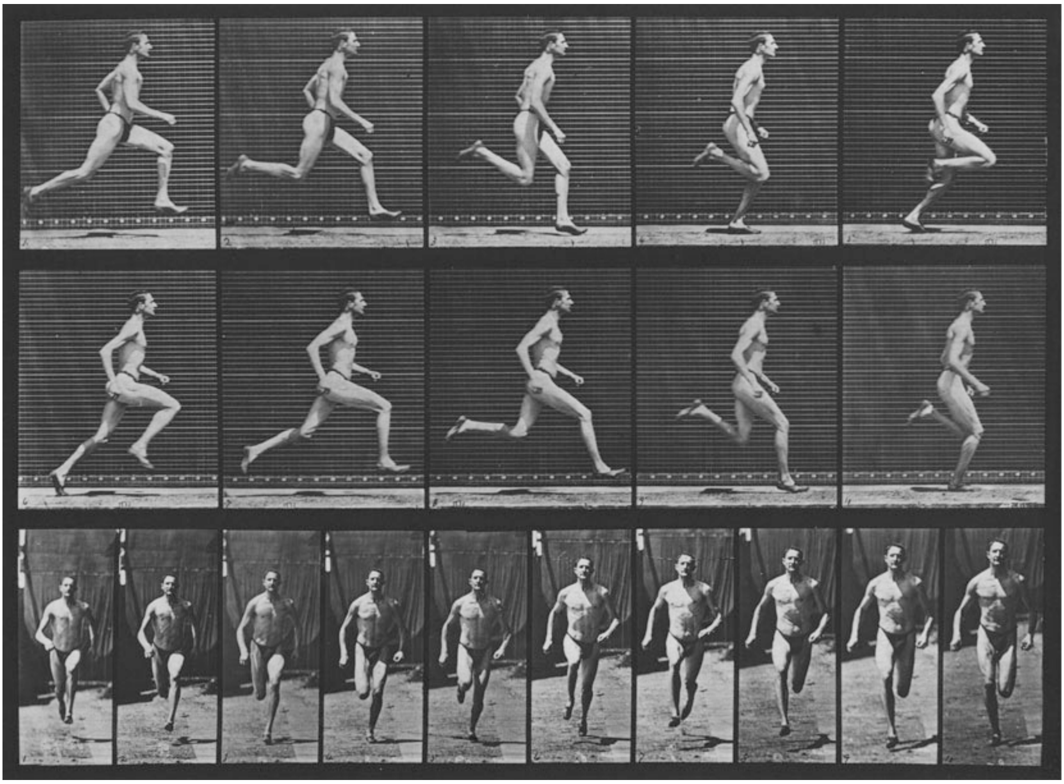

Fig. 16.1 Photographic sequence of a nude running male by Eadweard Muybridge, ca. 1887 (Muybridge Animal Locomotion, plate 60; University of Pennsylvania Digital Archives, with permission)

and humans using his motion sequence photography technique (Braun, 1992). Most famous in his time were Muybridge's studies on human bodies in motion, showing naked males and females performing everyday activities such as walking, dancing, sweeping, or dressing (see Fig. 16.1).

The work of both Marey and Muybridge marked a breakthrough in the representation of human body movement and provided the basis for the later development of cinematography, i.e., the creation of motion picture images. It took several decades before in the 1970s the Swedish psychophysicist Gunnar Johansson started his pioneering work on the scientific understanding of "biological motion," which is the depiction of movement patterns using point-light (P-L) displays. The idea behind this technique was to remove the pictographic shape information of a moving animal or human from the motion pattern itself. Johansson positioned light bulbs onto the head and major joints of a moving participant and filmed them while they walked and danced in a dark room. The resulting video clips of moving light dots were presented to observers, who were able to perceive vivid motion. In the following years Johansson refined this technique and showed that within a fraction of a second, observers were able to perceive human form from motion and identify certain actions from viewing only short clips of P-L displays (Johansson, 1973, 1976; Johansson, von Hofsten, & Jansson, 1980; see Fig. 16.2).

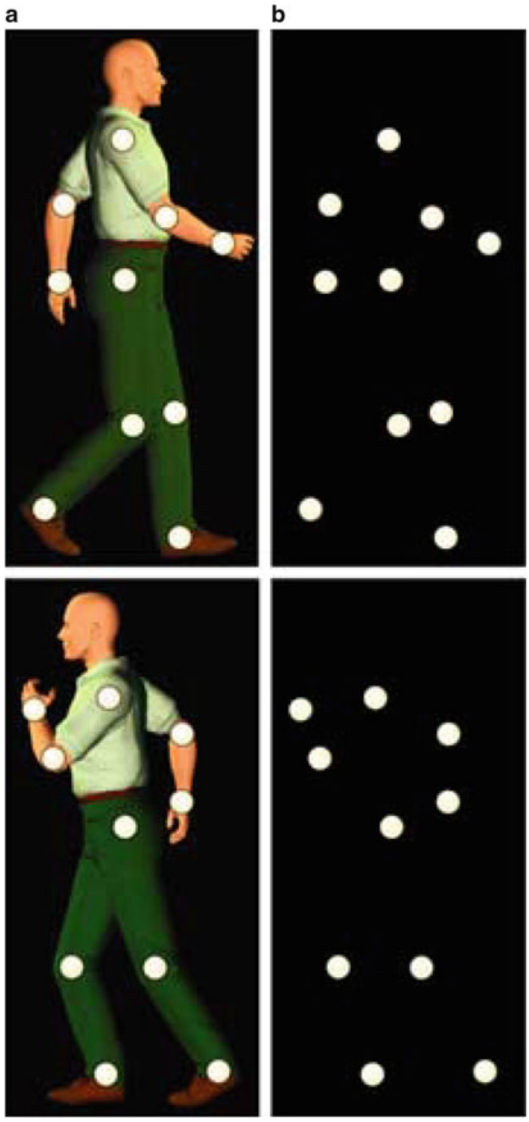

Fig. 16.2 Illustration of the point-light (P-L) displays approach to the study of biological motion as devised by Johansson (1973). Light bulbs were attached to major joints of an actor (**a**), who performed different types of movements. Participants were able to perceive the animations as "human" and identified the character's action from videos, but not from still images (frames) of P-L displays (**b**) (Figure taken from Giese & Poggio, 2003, with permission)

Once the P-L methodology was established, researchers began to use the technique to see if observers could identify specific aspects of information about the moving figure.

What Can Be Perceived from Body Movements?

Recognition of Self and Others

It is vital for humans, a highly social species, to be able to recognize their conspecifics and respond appropriately based upon previous social interactions and/or current knowledge. Relevant information about an individual is provided via several modalities (e.g., appearance, clothing, posture, smell, voice) and in a typical social setting the observer considers and integrates these multiple signals (Grammer, Fink, Juette, Ronzal, & Thornhill, 2001). While researchers were able to isolate some of the key static social cues and investigate their influence upon person perception (e.g., facial attractiveness), it was not until the development of Johansson's P-L technique that researchers could begin to focus their attention onto possible cues provided by motion.

In an initial study using the P-L technique, Cutting and Kozlowski (1977) filmed six close friends as they walked along a straight line. Two months later the same individuals were shown the videos presented from a sagittal viewpoint and asked to identify each walker and provide information as to how they had reached their decision. While the initial performance was not so good (accuracy of 38 % compared to 16.7 % expected by chance), it improved on subsequent trials to 59 %. The observers stated that they were using cues provided by body movement, such as speed, rhythm, amount of arm swing, and stride length, to make their judgments. Interestingly self-recognition was at 46 %, and at first this seems surprisingly good as we hardly view ourselves from a third-person perspective, but perhaps the observers were simply picking the stimulus that they hadn't recognized as being one of their friends?

Stevenage, Nixon, and Vince (1999) expanded this research by investigating how easy it would be to train individuals to recognize gait in unknown individuals under different lighting conditions. They had six volunteers walk in a straight line under daylight, dusk, and

P-L conditions. Observers viewed each walker and were told their "names" and then had to see if they could recognize the same individuals in subsequent clips. It was found that observers could easily learn to recognize the walkers, and this was not influenced by lighting condition or gender of the observer, but female walkers were easier to subsequently identify than males.

In an attempt to uncover the mechanisms that individuals use to recognize someone by their gait, Troje, Westhoff, and Lavrov (2005) presented male and female observers with P-L stimuli from different viewpoint angles. The stimuli were systematically altered such that observers would see the normal unaltered walk, walks in which all stimuli had been normalized with respect to body size or body shape, and two conditions in which walking frequency was altered. After an initial presentation in which observers saw the stimuli and were told the names of the walkers, they then received a series of training sessions. Recognition performance reached a ceiling of 90 % correct recognition after five training sessions, with frontal views providing greater accuracy. The most important cues for recognition were hip rotation, lateral body sway, ratio between hip and shoulder width, and elbow position. Observers were able to accurately identify an individual when their stimuli had been normalized for body shape and walking frequency, leading the researchers to conclude that structural information plays a secondary role to gait kinematics for personal identification. Jokisch, Daum, and Troje (2006) confirmed that recognition of friends was better from a frontal viewpoint, but viewing angle did not influence recognition of self. Clearly then, observers can readily recognize conspecifics just from their body movement patterns, but as mate selection forms an integral part of our sociocultural world, we would expect that the ability to determine the sex of another individual would be not only possible but vital.

Sex and Gender Identification

Using the P-L technique, Kozlowski and Cutting (1977) presented male and female walkers in sagittal view to 30 observers, who were asked to indicate the sex of the walker. Accuracy was significantly above chance and was most accurate when the whole body was presented for viewing. Interestingly, when participants were asked which parts of the movement they thought indicated the person's sex, 76 % of the sample stated that "maleness" was being indicated by shoulder sway, while the entire sample identified hip movements as indicating a female gait. A subsequent meta-analysis of relevant studies confirmed that sex identification accuracy is approximately 66 % from side views and around 71 % from frontal views (Pollick, Kay, Heim, & Stringer, 2005).

Runeson and Frykholm (1983) investigated whether a person could actively deceive an observer into believing they were viewing a member of the opposite sex. Volunteers were asked to perform a range of actions as normal, in an exaggerated gender-typical manner, and in a way that they thought the opposite sex would perform the action. Sex identification accuracy of the P-L stimuli was high in the natural and exaggerated conditions, while accuracy was only slightly lower for the deception condition. This suggests that dynamic displays (even if the person is attempting to fake them) can provide a strong clue as to the sex of a person.

Barclay, Cutting, and Kozlowski (1978) noted that P-L stimuli duration influenced recognition accuracy. In their study males and females were recorded walking and observers viewed four gait samples differing in duration (0.4, 0.8, 1.6, and 4.4 s) and had to judge whether the walker was male or female. Not surprisingly, accuracy was highest at the longest duration, falling to below chance at the two shortest intervals. Thus, viewing at least two complete gait cycles appears to be crucial for sex recognition. In a subsequent experiment the authors reported that sex recognition was severely impaired if the presentation rate was slowed down, a feature that they explained by the observation that in real life we do not see males and females walking in such a manner, and so there are no adequate reference points for comparison.

A key factor in judging the sex of a P-L walker could be the difference in the structural sway of the shoulders and hips (males have broader shoulders and females have a wider pelvis). Cutting (1978a, 1978b) provided support for this by creating artificial walkers differing only in these attributes. Movements of the shoulders or the hips provided in isolation did indeed provide diagnostic cues as to the sex of the walker. Mather and Murdoch (1994) held these anatomical differences constant and established that recognition was still significantly above chance and could be determined by lateral body sway. Here the dynamic cues clearly outweighed the structural cues.

Using a more advanced three-dimensional (3D) motion capture camera system, Troje (2002) recorded males and females walking on a treadmill and created P-L animations that comprised the original walker or were manipulated to display exaggerated male or female movement patterns. Sex recognition accuracy was optimized when the animation was seen in the frontal view and gradually declined as the viewing angle changed. When the viewer was deprived of structural information, performance was barely affected, but when deprived of dynamic information, performance was severely impaired. In order to confirm exactly what observers are looking at when asked to make a sex discrimination decision, Saunders, Williamson, and Troje (2010) presented clips of P-L animations derived from real male and female walkers where their gender could be exaggerated by the technique developed by Troje (2002). Observers viewed an original walk, which had been gender "exaggerated" and was rotated from a front-facing view by up to 90°; viewer gaze patterns were recorded via eye-tracking equipment. When asked to determine the sex of the animation, eye-tracking analysis revealed that observers focused their attention primarily on the shoulders and the hips. Changing the viewing angle and the degree of "maleness"/"femaleness" significantly affected recognition performance, though this did not seem to affect viewing fixations.

The research described thus far appears to suggest that body movement in addition to form is crucial for accurate sex identification. However, other researchers have questioned this with regard to the P-L methodology. Male and female bodies are morphologically distinctive, a key difference being the size of the waist, which is known to affect judgments of both sex and gender (Lippa, 1983; Singh, 2002). P-L animations provide little information about body shape neither in general nor of the waist specifically, and while researchers have been able to manipulate the shoulder-to-waist ratio (e.g., Mather & Murdoch, 1994), it is impossible to manipulate the WHR using the P-L technique. Johnson and Tassinary (2005) used animated stimuli that depicted a human form of ambiguous sex, which varied both in WHR (ranging from a ratio of 0.5 to 0.9) and in gait (extreme shoulder swagger to extreme hip sway). Observers were shown the figures and asked to judge the sex of the walker and their gender (i.e., how masculine or feminine they were). Judgments of the sex and gender of the walker were more strongly influenced by morphology than by the motion.

In a similar study, McDonnell, Jorg, Hodgins, Newell, and O'Sullivan (2007) created four different animated figures (virtual characters or "avatars")—a realistic male, a realistic female, an androgynous character, and a P-L walker. Motion-captured walks from males and females and walks specifically created to be gender neutral were then applied to the figures, and observers were asked to state whether the figure was male or female. Not surprisingly female walks applied to the female figure and male walks applied to the male figure were perceived as being gender congruent. Neutral walks applied to the male and female figures were also rated as being gender congruent showing that body morphology takes precedence over motion. However, when neutral walks were applied to an androgynous character, motion then became more important in making gender judgments. So, studies have clearly shown that the sex of an individual can easily be determined via the P-L and other motion capture techniques. Humans thus appear to be primed to derive important sociosexual information from an individual's body movements.

Sexual Orientation

As morphology and motion both contribute to assessments of sex and gender, it raises an interesting question as to whether observers can accurately discern the sexual orientation of a walker. Folk wisdom dictates that homosexual males and females possess "gaydar"—the ability to discern homosexuality in others, and there is a cultural stereotype that homosexual males walk in a more feminine manner, while lesbians walk with a more masculine style. Johnson, Gill, Reichman, and Tassinary (2007) set out to specifically assess perceptions of sexual orientation by presenting animated figures that varied morphologically (five levels of WHR) and dynamically (five levels of motion ranging from extreme shoulder swagger to extreme hip sway). Judgments of sexual orientation of walkers perceived to be male were strongly affected by motion but not morphology, while perceptions of sexual orientation of walkers perceived to be female were influenced by both motion and morphology. In a subsequent experiment, males and females categorized themselves as heterosexual or homosexual and were recorded walking on a treadmill. Males and females transformed the movies into figural outlines that were then rated. Accuracy of judgments of sexual orientation was significantly above chance, though accuracy was higher for male than female targets. The adaptive benefit of being able to correctly identify someone's sexual orientation is obvious, and research suggests that such identification may be possible from observing movement patterns. However, support at present is limited; clearly, additional research addressing this question is necessary.

Emotion Perception

Numerous expressive statements underpinned by nonverbal communication govern everyday social interactions. While a significant amount of research has focused on the perception and understanding of emotions from facial expressions, relatively little work had focused on emotions expressed via body movements. An initial attempt by Walk and Homan (1984) assessed viewers' ability to identify different types of dancing and emotions displayed by female actors presented as P-Ls. Mimed emotional sequences (anger, disgust/contempt, fear, happiness, sadness, and surprise) were found to be difficult to interpret on an initial presentation, but following the second presentation, accuracy improved markedly. Interestingly females averaged higher accuracy compared to males, reflecting a consistent finding that females are better at interpreting nonverbal cues than males (Hall, 1978).

In a study also using dancers, Brownlow, Dixon, Egbert, and Radcliffe (1997) asked observers to judge happy from sad in P-L presentations. Sad movements were characterized as non-energetic, slow, sweeping movements, while happy movements were energetic and exaggerated. Dittrich, Troscianko, Lea, and Morgan (1996) also had two experienced dancers (one male, one female) portraying a series of emotions (anger, disgust, fear, grief, joy, and surprise) using both P-L and standard recording techniques. Emotion recognition accuracy was 88 % in the standard video recording condition and 63 % in the P-L animated condition (still significantly above chance).

Atkinson, Dittrich, Gemmell, and Young (2004) asked ten actors to portray anger, disgust, fear, happiness, and sadness in typical, exaggerated, and extremely exaggerated forms. Observers then rated the different versions of the stimuli (P-L dynamic, P-L still, full video dynamic, full video still). Not surprisingly performance was best in the full video dynamic conditions, followed closely by P-L dynamic stimuli. Exaggerating body movements led to a significant increase in accuracy (and higher ratings for "emotional intensity") with the exception of sadness. Focusing just on walking, Roether, Omlor, Christensen, and Giese (2009) asked male and female volunteers to walk in a straight line employing a neutral gait and then with emotionally expressive gaits (anger, fear, happiness, and sadness). Analysis revealed emotion-specific postural and kinematic features of gait; greater head inclination (denoting sadness) and greater elbow flexion (revealing anger and fear) indicated specific emotional states. In addition, walking speed and increases/decreases in the size of particular movements were associated with specific emotions.

It thus appears that observers can detect emotions expressed in movements with a fair degree of accuracy, but what about individuals who have deficits in the processing of social cues? Hubert et al. (2007) assessed emotion recognition in individuals with autism and Asperger's syndrome, and in a group of matched controls. Observers saw 5 s clips of P-L displays comprising actors performing a range of actions (e.g., climbing, jumping) and emotional states and were simply asked to describe what they saw. The autistic participants performed at the same level of the controls in describing the actions, but significantly worse when asked to identify and describe the emotions being portrayed. Once more, the available evidence suggests that humans are primed to perceive key information about another individual (in this case their emotional state) via their body movements.

Social Significance of Body Movement Perception

The evidence we have presented so far demonstrates that humans have a deep-seated ability to perceive critical aspects of person identification from their body movements. Individuals are able to extract information about conspecifics from their gait that could be used to make relevant social decisions; this even extends to making inferential decisions about individuals. Thus, observers can also accurately estimate the weight of an item being raised by an actor from the lifting motion depicted via the P-L technique (Bingham, 1993) and the elasticity of a surface by observing a P-L figure moving across it (Stoffregen & Flynn, 1994). Such decisions are made very rapidly, despite attempts to mask the information (Cutting, Moore, & Morrison, 1988; Johansson, 1976). An advantage of dynamic cues is that they are visible over much greater distances than are say facial expressions, thus providing advance warning of another's possible intentions. It is logical to conclude that the ability to decode information about other people appears to have an innate evolutionary basis; if that is the case, then we should be able to identify the neurological underpinnings of such abilities.

Evidence from Neurobiology/Brain Imaging Studies

Converging lines of evidence point to specific regions of the cortex being involved in the processing of biological motion. Single-cell recordings in macaques have revealed that neurons in the posterior superior temporal sulcus (STS) of both hemispheres were selectively responsive to both form and motion (Perrett et al., 1985). In humans, research using positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) has shown that an analogous region is preferentially activated when observers view P-L figures (Bonda, Petrides, Ostry, & Evans, 1996; Grossman et al., 2000). Further confirmation is provided from studies of individuals with brain injuries localized to this region; damage to the STS causes a specific deficit in biological motion recognition, but spares other aspects of motion perception (Schenk & Zihl, 1997a, 1997b). In an extension of such research, Heberlein, Adolphs, Tranel, and Damasio (2004) asked participants with and without brain damage to view P-L animations and make judgments about their emotional state and personality. Individuals with damage to the right somatosensory cortices were impaired in judging emotions, while impairments in judging personality were associated with damage to the left frontal operculum. This dissociation implies that we possess distinct neural systems for perceiving emotions and personality.

In individuals without brain damage, temporary neurological disruption can be created via transcranial magnetic stimulation (TMS). When

TMS was applied to the scalp overlying the STS, observers experienced difficulties in recognizing P-L sequences presented with "noise" (Grossman, Battelli, & Pascual-Leone, 2005). Thus, both "bottom-up" and "top-down" studies indicate that the STS is specialized for the processing of biological movement. The STS shares reciprocal connections with the amygdala and orbitofrontal cortex, both of which play an important role in social perception and cognition (Adolphs, 1999). There is thus a complex subcortical/cortical system involved in social perception and cognition that begins with the initial processing of movement as "biological" and which then infers the actions, intentions, and emotions of another individual (Allison, Puce, & McCarthy, 2000).

Universality of Body Movement Perception

The fact that the human ability to decode information from P-L animations is done rapidly and accurately and is subserved by dedicated neurological components suggests that the detection and interpretation of biological motion is a fundamental evolutionary mechanism. If this is so, then one might expect to find early developmental abilities in the perception of biological motion. In support, Bertenthal, Proffitt, and Cutting (1984) demonstrated that by 4 months of age, human infants could distinguish between P-L animations presented normally or inverted. In a similar study Simion, Regolin, and Bulf (2008) showed that 2-day-old infants could differentiate between biological motion and random motion P-L displays and prefer to look at human motion than nonhuman motion. Further research has revealed that human infants can also extract meaning from displays of biological motion. For example, Yoon and Johnson (2009) showed that by a year old, infants could track the "gaze" of a P-L actor, despite the absence of socially informative features (face and eyes), indicating that biological motion perception and social cognitive abilities are closely integrated early in development. Children with developmental disorders associated with profound deficits in social processing (i.e., autism) also experience difficulties in the processing of biological motion in the form of P-L animations (Blake, Turner, Smoski, Pozdol, & Stone, 2003; Moore, Hobson, & Lee, 1997).

If the perception of biological motion is a hardwired adaptation, then one might also expect to find substantial cross-cultural agreement in the perception of certain attributes. While the study of facial expressions of emotion has revealed cultural universals in presentation and perception (Ekman & Friesen, 1971; Ekman et al., 1987), surprisingly little research has focused on cross-cultural perceptions of body movement. Gestures, postures, and spatial orientation vary greatly between and within cultures, though some appear to be universal; for example, greeting behaviors (head nod, eyebrow flash, smiling, mutual gaze) share common components (Argyle, 1988). More recently, Pica, Jackson, Blake, and Troje (2011) presented P-L stimuli of walking cats, pigeons, and humans to the Mundurucu people in the Amazonian territories in Brazil and found that they could readily perceive the global shape that was depicted in the walking characters. Considering this finding, it is likely that the variation in human body movements is perceived in a similar fashion across countries and societies. In pursuing this line of research, we report preliminary data of a study that tested possible similarities of Brazilian and German females' attractiveness perceptions of male dance movements.

Study 1: Brazilian and German Females' Perceptions of British Males' Dances

We had two samples, one of Brazilian and one of German females. Both judged the virtual characters (avatars) of 80 British male dancers (all nonprofessional dancers, whose movements were captured using 3D optical motion capture technology; aged 18–42 years, $M = 21.6$, $SD = 4.0$) on perceived attractiveness. Brazilian females were recruited from the student population at the Escola Superior de Educação Física de Jundiaí, a college near São Paulo (Brazil). Of all 111 participating females, aged 17–42 years, we selected only those who identified themselves as

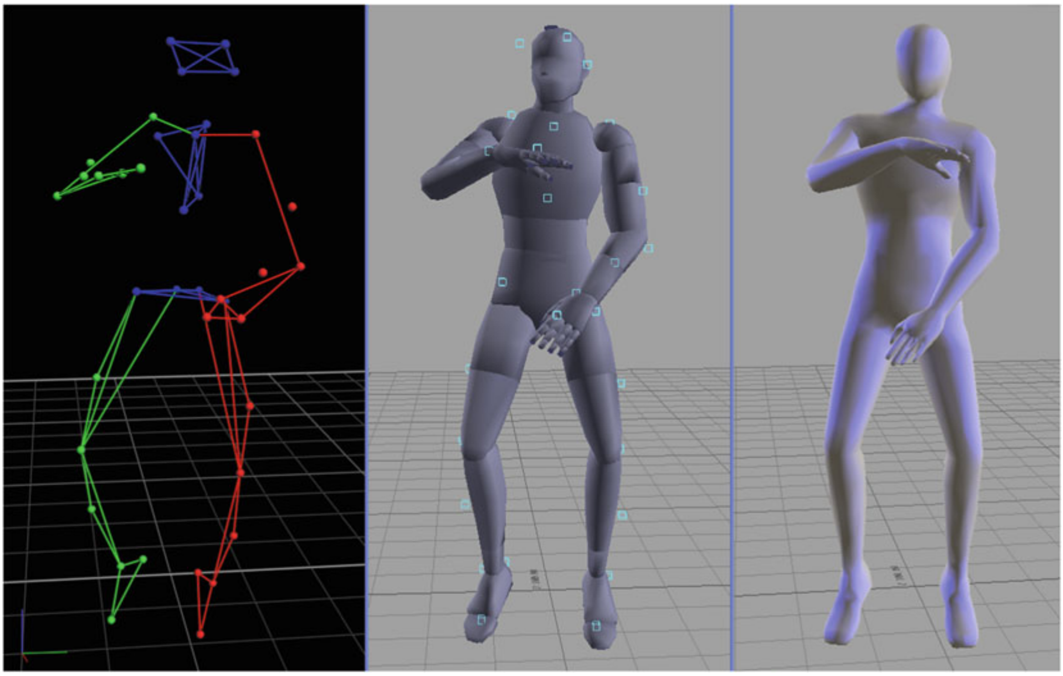

Fig. 16.3 Snapshots of the creation process of a virtual dance character. The initial stick figure with captured markers (*left*), application of the motion data to the actor (*middle*), and the final avatar for presentation (*right*) (Figure taken from Fink et al., 2012, with permission)

having "Latin American" descent. Thus, 48 females remained ($M = 22.4$, SD $= 6.0$) for the statistical analysis. Female judges in Germany were recruited from the local student population at the University of Göttingen (Germany). Of 139 females, aged 17–36 years, six participants did not identify themselves as being of European descent; thus, our sample for the analysis was 133 females ($M = 23.6$, SD $= 2.7$).

These participants were recruited in the course of a large-scale project on body movements in relation to anthropometric and personality characteristics at Northumbria University (UK), in which male dance movements were captured with a 12-camera optical motion capture system (Vicon, Oxford) at a constant rate of 100 Hz. Thirty-nine retroreflective markers were attached to each participant in accordance with the Vicon Plug-In-Gait marker set to capture all major body structures. After performing one static calibration capture ("T-pose"), participants were instructed to dance for 30 s to a basic drum beat rhythm. The resulting motion capture data of each participant were applied to a gender-neutral, shape- and texture-standardized virtual character using Autodesk MotionBuilder (Autodesk, Inc., San Rafael, CA, USA) (see also Fink et al., 2012; Neave et al., 2011; Fig. 16.3).

Brazilian females provided dance attractiveness ratings using Qualtrics web-based software (www.qualtrics.com). Of the entire set of 80 male dance characters, a subset of ten dancers was randomly chosen for each female rater and presented on 21″ computer screens. The length of each dance clip was trimmed down to a sequence of 10 s (chosen from the middle of each dance recording; see also Weege, Lange, & Fink, 2012). Participants could view the videos as long as they wished (and replay them). Ratings were made on a 5-point Likert-type scale (1 = very unattractive to 5 = very attractive), which was presented below each clip in the form of radio buttons. German females provided attractiveness ratings of dance characters using the same setup, but they were presented with a random selection of 20 dances of the entire set of stimuli.

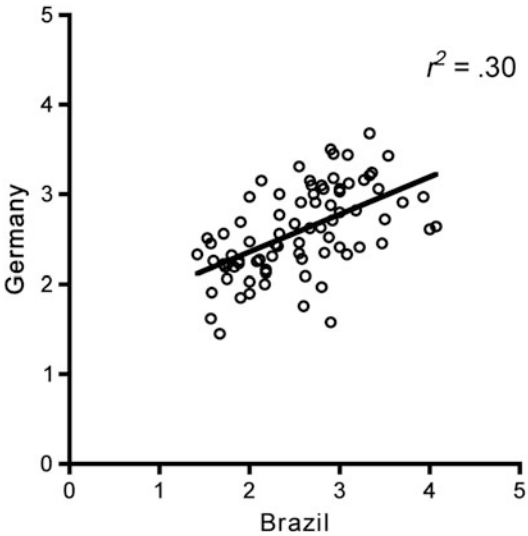

Fig. 16.4 Scatterplot of the association between Brazilian and German females' attractiveness judgments of gender-neutral dance characters with the body movements of British male dancers applied (see Fig. 16.3)

Brazilian females' attractiveness judgments ranged from 1.42 to 4.07 ($M = 2.56$, $SD = 0.65$) and those of the German sample from 1.45 to 3.68 ($M = 2.59$, $SD = 0.49$) with no significant differences between the two samples ($t = -0.55$, $p = 0.59$). Zero-order correlation statistics (Pearson r) revealed a significant positive association of Brazilian and German females' assessments of (British) males' dance attractiveness ($r = 0.55$, $p < 0.001$; see Fig. 16.4).

A more detailed inspection of possible differences between Brazilian and German females' judgments of male body movement attractiveness considered personality of male dancers (as assessed via the NEO-FFI inventory; Costa & McCrae, 1992) as covariates. There was a significant difference between Brazilian and German females' ratings of male dance movements ($F = 4.42$, $p < 0.05$) as well as significant interaction effects of country * neuroticism ($F = 5.51$, $p < 0.05$) and country * conscientiousness ($F = 8.06$, $p < 0.01$). Extraversion ($p = 0.34$), openness ($p = 0.73$), and social agreeableness ($p = 0.74$) did not show significant interaction effects with country as factor.

Although these data should be considered as preliminary, they suggest both cross-cultural similarities and differences of Brazilian and German females' assessment of male dance movements, as there was a significant correlation between females' attractiveness ratings of both countries, but also differences between them when considering dancer's personality as a covariate. As such these data suggest that there is cross-cultural consensus in females' perceptions of male dance movements, which is moderated by the dancer's personality, possibly because Brazilian and German females put different emphases on certain (personality) aspects they derive from dance movements when evaluating them.

The previous sections have demonstrated that the processing of biological motion is of fundamental importance to human social perception. The fact that such processing shows cross-cultural similarities and has a neurological basis attests to its adaptive significance. In considering the ultimate question on whether and how females assess male dance movements, and if they are indeed able to derive certain aspects of male quality from body movement, the following section deals with studies that have been conducted in the attempt of identifying quality cues, which are known to play a role in the assessment of static representations of male facial and body morphology, such as symmetry, physical strength, and personality. We review studies that show the significance of movement in mate selection in both animals and humans and suggest that the human body provides a single condition-dependent ornament of quality. We discuss evidence from studies showing links between dancing and symmetry and strength and personality. We conclude by describing some cutting-edge research, which employs stimuli in the form of controlled virtual characters (avatars) combined with detailed biomechanical assessments in order to assess the possibility that male dance moves are providing cues to their reproductive quality.

Body Movement Within the Evolutionary Psychology Framework

Animals of various species show a variety of dynamic displays, primarily in the context of courtship as part of ritualized patterns in order to attract potential mating partners. An inspection of the literature shows that such displays can be found at various taxonomic levels, and it is most often the males that employ them. Female fruit flies, for example, choose (male) mating partners based on "dance" movement as compared to "scissoring," which is observed in isolated males (Maynard-Smith, 1956). In arthropods, it has been reported that in some species of spiders, males attract mating partners via abdominal sway, and those who sway their abdomen with a higher frequency have higher reproductive success (Clark & Morjan, 2001; Singer et al., 2000).

Such "courtship dances" are particularly well studied in male birds, which use head and beak movements, plumage erection, and flight performances as part of their arsenal (in addition to singing) to attract female mating partners (Patricelli, Uy, & Borgia, 2003; Williams, 2001). In fish, female sticklebacks prefer males with high swimming speed (Rowland, 1995). Finally, there is related behavioral observation in nonhuman primates, as our closest relatives in evolutionary genealogy, with male chimpanzees displaying typical dynamic displays such as the "bipedal swagger" as part of their courtship behavior (Goodall, 1968). Considering such comparative studies on the significance of male movements as feature that should attract female conspecifics, it is probably not surprising that researchers have also begun to identify similar behavioral patterns in human male courtship.

Dance as Male Motor Behavior

It was in fact Darwin (1871) himself, who suggested that human dance is a sexually selected courtship signal that relates to an individual's quality. However, as it was the case with other seminal suggestions of Darwin, it took science almost a hundred years to catch up on this insight and apply a systematic approach to the study of human dance. There are anthropological and ethnographic reports on the role of human dance suggesting that dance is an activity displayed in rituals as a form of social communication and in courtship context (for reviews see Kaeppler, 1978; Kurath, 1960). These studies have predominantly focused on behavioral observation and were not concerned with identifying links between male quality, dancing ability, and female choice.

Meanwhile it is known from the comparative biological study of male motor performance that features such as vigor and strength are conveyed via body movements (Byers, Hebets, & Podos, 2010). Furthermore, there is corroborating evidence for the hypothesis that as in animals, human dance may be an adaptive behavioral display in sexual selection, which communicates health, strength, and thus sexual attractiveness (Hanna, 1987, 2010; Hugill et al., 2010). Dance is a universal form of human expression and is strongly associated with physical virtuosity. Dancers at the peak of their abilities exhibit limb coordination, strength, flexibility, and aesthetic qualities far in advance of the average person. They are able to learn complex sequences of movements, and synchronize their actions to changing musical speed and rhythm (Bläsing et al., 2012). Thus, dancing expertise reflects the interplay between physical, cognitive, and aesthetic qualities and as such is a likely candidate for an "honest" signal.

Features that have been studied in relation to female perceptions of males' dances primarily relate to physical and personality characteristics, which are known to affect female perceptions of static representations of male morphology (i.e., faces and bodies). From that research it is known that certain male physical and personality characteristics affect female partner preferences. In brief, it has been reported that females prefer male masculine features, particularly around the time of ovulation, and this has been shown to be the case for faces (Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak et al., 1999) and bodies (Little, Jones, & Burriss, 2007). In addition, cross-cultural research states that females have a preference for certain male personality characteristics that indicate male status (Schmitt, 2005; Schmitt et al., 2003). Recent research suggests that these features are—to some extent—also conveyed via male body movements (dance in particular) as they reflect aspects of male mate quality. Taken together, this research expands the study of the role of male facial and body morphology in female mate preference by suggesting that male quality is signaled not only via (static) physical features but also via dynamic displays. The general assumption of these studies is that if dance, for example, is a sexually selected trait, it should reflect the genetic or phenotypic quality of the dancer.

The Case of Dance and Symmetry

One of the most frequently used epigenetic measures of developmental homeostasis (as proxy to genetic and phenotypic quality) has been fluctuating asymmetry (FA), which is characterized by small and random deviations from symmetry of bilaterally symmetrical structures (Ludwig, 1932). Such minor physical anomalies occur in response to genetic and environmental stress, including disease, parasitism, or elevated levels of sex steroids, and manifest themselves in the form of right minus left differences in physical structures (Livshits & Kobyliansky, 1991). The relationships of human facial and body FA with behavioral, cognitive, and health measures have been studied quite extensively in the past 15 years (for reviews see, Grammer, Fink, et al., 2003; Thornhill & Møller, 1997), although the predictive value of FA for attractiveness has been questioned, particularly in human males (Weeden & Sabini, 2005; for a comment see Grammer, Fink, Møller, & Manning, 2005).

Probably inspired by this line of research, Brown et al. (2005) set out to investigate associations between body FA and dance perception in a sample of Jamaican males and females.[1] They hypothesized that symmetrical individuals would be perceived as being better dancers and that this should be particularly the case for males, as females are considered to be more selective in choosing their partners, while males invest more in courtship display (Trivers, 1972). Clearly, the correlations of symmetry and dance quality assessments should be stronger in males than in females. In addition, they tested whether FA of male and female evaluators had an effect on their judgments of opposite-sex dancing ability (assuming that judges who themselves have high FA would adjust their preferences accordingly and express weaker preferences for low FA dancers). Using 3D optical motion capture technology, Brown et al. collected dances of 183 young males and females, who danced for 1 min to the same song while their body movements were tracked. FA of each dancer was measured from nine morphological features (i.e., ankles, ears, elbows, fingers, and wrists) following the protocol of Trivers, Manning, Thornhill, Singh, and McGuire (1999) and summarized into a composite FA score corrected for trait size. Based on these scores, the authors selected 20 symmetrical (ten males, ten females) and 20 asymmetrical dancers (ten males, ten females) and presented their dance movements in the form of 3D skeleton animations to a sample of 155 young male and female Jamaican judges, who scored them on a visual analogue scale for perceived dancing ability.

Brown et al. reported a significant main effect for both symmetry and sex, as well as an interaction effect between them, these being independent of age and body mass index (BMI). In other words, the dance animations of both symmetrical males and females were perceived as significantly better than those of asymmetrical males and females, though the effect was stronger with male than with female dancers. In addition, it was reported that female evaluators had a stronger preferences for symmetrical male dancers

[1] The Brown et al., (2005) paper was retracted on December 19, 2013.

than male evaluators and that male evaluators gave higher ratings to female dancers than did female assessors. Finally, it was found that FA of male evaluators was negatively related to their preferences for symmetry in female dancers, which would argue for a condition-dependent adjustment of preferences in males. These results seemed to be in accord with the hypotheses, and the authors admitted in fairness that they did not know what actually caused these reported associations. Systemic health, neuromuscular coordination capability, parasite resistance, and energetic expenditure were identified as possible mediators that should be addressed in future studies.

There is certainly much to like about this study. It used 3D motion capturing, which allowed the presentation of dance movement independent from body morphology and texture features; still it comprised a set of anthropometric measurements that facilitated the authors to control for possible covariates (such as age and BMI). Moreover, it followed standard protocols in assessing FA by creating a composite measure of symmetry rather than relying on the study of associations of single traits' FA with perception. In 2005 it was the first systematic assessment of male and female dance quality within the evolutionary psychology framework and as such groundbreaking.

However, there has been controversy about the actual value of this study, as a later reanalysis of the data by Trivers, Palestis, and Zataari (2009) could not confirm many of the original results reported by Brown et al. (2005). Using recalculated (average) dance ratings, Trivers et al. obtained a significant overall model, as reported in Brown et al. (2005). However, unlike in the 2005 publication, none of the independent variables or covariates turned out to be significant predictors of dancing ability. That is, the reanalysis could not confirm the significant main effect of symmetry and sex (as well as their interaction) on dance perception and did not detect a significant effect of age and BMI, although it is noted that with one exception (sex * FA interaction, $p = 0.15$), all p values were smaller than 0.10. An omnibus pairwise comparison of ratings of symmetrical/asymmetrical male and female dancers based on the recalculated dance scores revealed a significant difference only for symmetrical/asymmetrical male dancers ($p = 0.03$). In terms of the variation in dance ratings explained by the difference between symmetrical/asymmetrical males and females, Trivers et al. arrive at lower numbers than reported by Brown et al. (males, 22.3 % vs. 48 %; females, 12.8 % vs. 23 %). Finally, with regard to the hypothesized effect of evaluator FA on dance ability ratings, Trivers et al. (2009) could not replicate the significant association reported for male evaluators judging female dancers. At this point, we omit from presenting additional data of the reanalysis that were in 2005 presented as (online) supplementary data. However, one result reported by Trivers et al. is possibly noteworthy, and that is the one of a significant relationship between facial attractiveness and dance ability ($p = 0.03$). The authors state that different from that in the Brown et al. report, this finding is based on attractiveness ratings by Jamaican peers only, but they also acknowledge that ratings are missing for many dancers.

The discrepancies between the Brown et al. (2005) report and the reanalysis by Trivers et al. (2009) raise the questions whether there is in fact a relationship between FA and dancing ability and, if so, whether it is especially present in young males. In an attempt to answer this question, Trivers et al. had 162 dances evaluated by two (Rutgers) dance students. There was no significant association between symmetry (mean FA measured in 1996 and 2002) and dancing ability either with or without age and BMI as covariates. In considering the 2002 data only, the authors found a significant but weak relationship between symmetry and dance ability in males ($p = 0.04$) and an almost significant association in females ($p = 0.05$), which disappears when entering age and BMI as covariates into the model.

In conclusion, it seems that the hypotheses of the Brown et al. (2005) paper cannot be fully supported after the reanalysis by Trivers et al. (2009). However, using recalculated data, it still seems that there is some effect in support of the assertion of associations between FA and dancing ability, albeit a smaller effect than originally stated. We still feel that it is worth investigating this relationship, particularly from the perspective that females should be more sensitive to the variation in male dance movements than vice versa. The present evidence, however, suggests that even if such an effect were true, it may explain only a relatively small proportion of the variance in female perceptions of male dance movements. Thus, we consider it worthwhile to include additional measures of biological "quality" such as physical strength and personality, both of which are known to affect female preferences of static representations of male face/bodies, also in the investigation of what characterizes a "good" male dancer.

Perception of Strength from Dance Movements

It has been reported that females are able to perceive male physical strength from static representations of male faces and bodies and that they are quite accurate in making these assessments (Fink, Neave, & Seydel, 2007; Sell et al., 2009). More recently, Windhager, Schaefer, and Fink (2011) showed that male facial configurations associated with measures of physical strength (i.e., handgrip strength) are characterized by an overall robust facial morphology, which does not necessarily resemble that of an attractive face. However, the reported associations of female perception of male facial masculinity and dominance with physical strength seem to be robust. Evolutionary psychologists have argued that this link may be caused by female adaptive preferences for male physical fitness, athletic abilities, and thus competitiveness, all of which are on the proximate level moderated by testosterone (T), and thus, T may shape male faces accordingly. But can females also derive these qualities from male dance movements?

In the attempt to investigate the association of female perceptions of male dance movements and physical strength, Hugill, Fink, Neave, and Seydel (2009) recoded dance movements of 40 heterosexual male students at a German University, all nonprofessional dancers, and recorded 30 s of their dance movements using a digital video camera. Male dancers provided a measure of handgrip strength in addition to physical assessments of height and weight. Video clips were converted into grey-scale and blurred by using a Gaussian filter in order to degrade information about face/body morphology and texture. Fifty female judges rated 10 s of these video clips on perceived attractiveness and assertiveness. It was found that handgrip strength of male dancers correlated significantly positively with female assessments of attractiveness ($r = 0.35$) and assertiveness ($r = 0.31$), this result being independent of the dancers' weight. To clarify this, females perceived dances of males who were physically stronger as more attractive and assertive (with these two attributes being highly intercorrelated, $r = 0.72$). Thus, Hugill et al. concluded that male physical strength is signaled not only via static representations of male morphology but also via their dance movements.

Hugill et al. speculated that the association between physical strength and dancing ability in males could be moderated by an effect of T on both measures. There is indeed evidence for a dose-dependent effect of T on athletic abilities and physical strength in males (Di Luigi, Romanelli, & Lenzi, 2005) as T improves muscular volume and thus physical performance (Cardinale & Stone, 2006). Studies on static representations of male faces/bodies report that females are quite accurate in assessing physical strength from male morphology (Fink, Neave, et al., 2007; Sell et al., 2009), thus arguing that women may have developed cognitive adaptations to assess male physical strength as it correlates with competitiveness. Studies on women's perceptions of male faces reported a preference for male faces associated with high levels of circulating T (Penton-Voak & Chen, 2004). Similar studies on the relationship of male dancing ability and circulating T do not exist, at least not within the evolutionary psychology framework.

However, there is preliminary evidence that digit ratio (2D:4D), a proxy of prenatal T, correlates with female perceptions of dominance, masculinity, and attractiveness of male dances. Here, Fink, Seydel, Manning, and Kappeler (2007) recorded dances of 52 heterosexual Caucasian male students (using the same protocol as in Hugill et al., 2009) in addition to digit ratio and other anthropometric measures (e.g., height, weight). The dances of six males with the lowest (high prenatal T) and six males with the highest (low prenatal T) 2D:4D ratios were presented to a panel of 104 women. Dances of males with low 2D:4D ratios were judged significantly higher on assertiveness, attractiveness, and dominance, while measures of physical morphology did not differ significantly between low and high 2D:4D dancers. The study concluded that prenatal levels of T might serve to organize not only male facial characteristics but also male dance movements. Furthermore, Fink, Seydel, et al. (2007) suggested that the female preference for male dancers with low 2D:4D might reflect the preference for males who are supposedly more successful in competition, thereby signaling higher status. Other studies on the relationship of 2D:4D and male competitiveness and strength seem to support this. For example, Manning and Taylor (2001) showed that male professional soccer players had lower 2D:4D ratios than controls, concluding that prenatal T promotes male development and the maintenance of traits which are useful in sports and, more generally, male competition. In addition, Fink, Thanzami, Seydel, and Manning (2006) reported physical strength (as measured via handgrip strength) as higher in males of two ethnic groups (Germany and Mizos males), thus concluding that prenatal T may have an early organizing effect on strength in males.

Whether or not male dancing ability and female perceptions of it are indeed systematically related needs to be confirmed in future studies. However, the present evidence suggests that T has an effect on male physical features that females are able to derive from their dancing ability. Studies of associations of T with facial and body morphology and female preferences for certain configurations of them indicate that females have a preference for "masculine" features, particularly at times of high fertility (Johnston et al., 2001), and that T is crucial in developing them. As it is known from the study of male facial masculinity, females tend to associate negative personality attributes with extreme forms of male masculinity. For example, Johnston et al. (2001) reported that while females preferred masculine-looking male faces at times of peak fertility, they considered these faces as aggressive, manipulating, and selfish. More feminized versions of male faces were rated at times outside of the fertile window and were also judged more positively in terms of their personality. We are about to examine whether the "dual sexual strategy hypothesis" (Thornhill & Gangestad, 2008) that has been reported for male physical features also applies to female perceptions of male body movements. However, independent from possible influences of the ovulatory cycle, there is evidence that females derive certain personality characteristics from male dance movements.

Perception of Personality from Body Movements

People readily ascribe emotions, intentions, and personality to animated figures that may not even have biological forms. For example, Koppensteiner (2011) asked male and female observers to view animations consisting of a ball, whose trajectory varied in terms of its amplitude and speed. In an initial session volunteers had been asked to alter the animation using these parameters so that different personality types reflecting the "Big Five" (high and low values of extraversion, emotional stability, conscientiousness, agreeableness, and openness) could be represented. Averaged values were then used to create prototype stimuli that were shown to raters; they had to state which personality was being displayed. Significant differences between low and high values of each personality factor were found, with extraversion being identified with the highest levels of agreement.

In terms of human dancing, it should be expected that the personality of the dancer would be reflected in their dance moves. Luck, Saarikallio, and Toiviainen (2009) recorded male and female dance movements and converted them into P-L stimuli. The dancers also completed an assessment of the Big Five. Correlations were found between certain personality traits and specific movement parameters, but they failed to reach significance. Their only significant findings were in relation to neuroticism and openness. Neuroticism was positively correlated with acceleration of the feet and jerky movements of the feet, while openness was negatively correlated with jerky movements of the central body. In a more comprehensive study, Luck, Saarikallio, Burger, Thompson, and Toiviainen (2010) asked over 900 volunteers to complete the Big Five Inventory (Costa & McCrae, 1992; Digman, 1990; McCrae & Costa, 1997), and a sample of 60 extreme scorers were asked to dance to different musical clips from six genres. The different personality dimensions were associated with different movement patterns, with extraversion and neuroticism eliciting the clearest characteristics. Extraverts produced higher movement speeds of the head, hands, and central body; neuroticism was associated with jerky and accelerated movements, especially of the head, hands, and feet. This work demonstrates that personality traits may be reflected by specific movement patterns when dancing, and so the interesting question relates to how might such information be used in female judgments of male mate quality.

Fink et al. (2012) sought to test whether female perception of male dance quality also shows systematic associations with global descriptors of the dancer's personality, i.e., the Big Five. Using a set of 48 humanoid dance characters (as described above; see Fig. 16.3) that were presented to a sample of 53 female judges, the authors hypothesized that male dance quality perception should show positive correlations with extraversion, openness, conscientiousness, and agreeableness scores and a negative association with neuroticism. There was some support for these hypotheses, as male dancing ability was correlated significantly positively with conscientiousness and social agreeableness. Male extraversion showed a positive correlation with female dance quality perception, but this was not significant. Neuroticism and openness were negatively correlated with dance quality judgments, but again these relationships failed to reach statistical significance. Thus, as with face perception (Penton-Voak, Pound, Little, & Perrett, 2006), there seems to be some kernel of truth behind the assumption that male dancing ability signals certain aspects of their personality to females. Fink et al. argue that their finding provides evidence for the assertion that, in addition to aspects of health and fitness, male dance quality may also convey aspects of personality and is thus in line with earlier studies suggesting that movement signals information about an individual's psychological propensities and intentions (Cutting & Proffitt, 1981). Although these data should be considered as preliminary, we may speculate that if an association between male personality and female perception of their dance movements turns out to be true, this would suggest that male dance movements play a significant role in female mate preferences.

The relationship between female perceptions of male body movements need not be restricted to dance. Koppensteiner and Grammer (2010) presented stick-figure animations of public speeches from German Houses of Parliament members (20 males and 20 females) to a sample of male and female judges who rated them on the Big Five. Certain movement parameters were associated with specific judgments of personality; for example, figures which displayed high overall activity with amplitude in horizontal and vertical arm movements were regarded as being more extraverted; figures displaying a greater amplitude in their head movements were rated as being less conscientious and less emotionally stable. This demonstrated that viewers extract meaning from certain body parts and from movement patterns, which are partly independent of the specific body parts used.

In a subsequent study using the same stimuli, Koppensteiner and Grammer (2011) found that judges attributed different personalities to male and female body movements, such that animations of male speakers received higher ratings on "extraversion" and "emotional stability" than female speakers, while "agreeableness" was perceived to be "typically female." Thus, the authors concluded that gender-related differences in even global descriptors of personality are communicated via body movement. However, the authors admitted that they were unable to disentangle personality perceptions that might be due to actual sex differences from those that are due to gender stereotypes. This issue is perhaps reflected in the work of Thoresen, Vuong, and Atkinson (2012). They assessed personality traits in 14 females and 12 males and recorded them as they walked in a straight line. Observers showed strong reliability of their personality judgments, but little validity, as their judgments did not match with the actual personality of the walker. Observers thus agree with one another that a person appears to be extraverted in how they walk, but this is not in accord with how the walkers rate themselves! In a subsequent study these authors demonstrated that the perception of emotion, masculinity, and attractiveness might act as mediating factors for the attribution of personality traits.

So, global aspects of personality appear to be conveyed by certain movements, but what about specific aspects of personality? We have already explained that females seem to assess male physical strength from their dance movements, and recent research suggests that this relationship is moderated by T (Fink, Seydel, et al., 2007; Hugill et al., 2009). It has been reported that both prenatal and circulating T is one of the major endocrinological substrates that moderate sex differences and sex-dependent behavior (Collaer & Hines, 1995; Manning, 2002). One of the most robust sex differences in human personality characteristics is that of risk-taking behavior with males being more willing to engage in risky situations than females (Zuckerman, 1991; Zuckerman, Eysenck, & Eysenck, 1978), possibly due to a stronger exposure to T. Evolutionary psychologists have argued that this difference may reflect evolved aspects of male masculinity resulting from sexual selection, as males advertise their quality (to both males and females) through the display of risky behavior (Wilke, Hutchinson, Todd, & Kruger, 2006; Wilson & Daly, 1985). There is indeed evidence that females are particularly attracted to males who engage in high-risk activities, particularly in the context of short-term relationships (Bogaert & Fisher, 1995; Farthing, 2005).

Recent research reports that male risk taking is associated with physical strength by concluding that this relationship is possibly driven by an effect of T on both measures (Fink, Täschner, Neave, Hugill, & Dane, 2010). Thus, in considering the associations of female perceptions of male dances and strength and (prenatal) T and the evidence of the effect of T on risk-taking behavior in males, Hugill, Fink, Neave, Besson, and Bunse (2011) hypothesized that females might derive male risk-taking behavior also from their dance movements. They recorded dances of 50 males and had them judged by 60 females on perceived attractiveness and risk taking following the protocol of Hugill et al. (2009). It was found that females rated dance movements of males who scored high on the SSS-V (Sensation Seeking Scale Form V; Zuckerman, 2007; Zuckerman et al., 1978) higher on attractiveness and risk-taking behavior. In particular, thrill and adventure seeking, disinhibition, and boredom susceptibility showed significant positive correlations with perceptions of dance attractiveness. The authors concluded that females are able to perceive male sensation seeking propensity from dance movements and that this may have consequences on female assessments of potential male partners. In addition, Hugill et al. suggested that the female sensitivity towards risk-taking propensity (as derived from dance movements) might indicate that male body movement signals aspects of personality and emotion, which has consequences on interpersonal behavior, including that of mate preference and selection.

Risk taking is a costly behavioral trait, and there may be differences with regard to female preferences for males who score high on risk taking depending on the temporal context of relationship, i.e., short or long term. Hugill et al. did not differentiate between attractiveness as a short-term or long-term partner when asking females to assess male dance movements, so this is clearly an issue that needs to be addressed in future studies. However, one may speculate that there will be differences in female assessments, because for long-term relationships the negative consequences of risk-taking behavior may lower male mate value by reducing the chance of survival and thus parenting (Sylwester & Pawlowski, 2011).

Biomechanics of Dance Movements

Within the evolutionary psychology framework, most of the current evidence on female perceptions of male body movements concerns studies that assessed female evaluations of male body movement in relation to anthropometric measures (e.g., symmetry, digit ratio, physical strength) or personality characteristics (e.g., risk taking, Big Five). While such studies provide information on impression formation and preferences, it does not tell us which movement characteristics actually cause the variation in females' response. It would certainly be crucial to know how the objective assessment of variation in male body movement relates to that of female perception and evaluation. Studies on human kinetics are typically conducted in health and sports sciences (e.g., Koutedakis, Owolabi, & Apostolos, 2008), but have rarely been applied to evolutionary psychology investigations. Neave et al. (2011) reported preliminary data on biomechanical characteristics of male dance movements in relation to female judgments of dance quality. Using 3D optical motion capture technology, they collected dance movements of 19 British males and applied them to featureless virtual characters (see Fig. 16.3). Video clips (15 s) of each avatar were then presented to a total of 37 females, who rated them on dance quality (1 = extremely bad dancer to 7 = extremely good dancer). In addition, biomechanical features of the dancer's movements, especially those of three main body regions, i.e., legs (ankle, hip, and knee), arms (shoulder, elbow, and wrist), and the central body (head and trunk), were extracted and correlated with dance quality judgments. It was found that "good" dancers differ from "bad" dancers in the amplitude and variability of body movements, particularly in the head/neck and trunk region and the speed of the right knee.

This study thus provided the first evidence relating female perceptions of male dance quality to certain biomechanical characteristics. As these characteristics (movement amplitude, variability, and speed) could relate to vigor, a quality clearly established as being important in nonhuman male mating displays (Byers et al., 2010), it is tempting to conclude that human male dancing provides an honest indication of male vigor to females. However, the Neave et al. (2011) study did not specifically address this issue and so this remains to be confirmed. More recently, Weege et al. (2012) tracked the eye gaze of 46 women while they viewed pairs of male dancers (one good and one bad). Women fixated more on good dancers and their visual attention was positively correlated with the perceived attractiveness of the dancer. Clearly then women are sensitive to variation in male dance quality though to what extent such perceptions are related to his actual physical qualities (i.e., his health, physical fitness) remains to be confirmed. However, as research has already established clear links between male physical strength and his dance quality (Hugill et al., 2009), it is expected that such associations will be revealed.

If male movements form honest cues to their reproductive quality, then one would assume that the same information should be conveyed in different modalities. While male animals tend to perform a stereotypical courtship "dance," human males can potentially reveal their physical qualities in different modalities, i.e., walking, running, and dancing. It would be expected that perceived dance quality might be positively associated with perceived walking and running quality as well.

Study 2: A Comparison of Females' Perceptions of Male Dance, Gait, and Running

In this study we sought to determine possible relationships between female perceptions of male dance, gait, and running. Our initial stimuli were body movement recordings as described in Study 1 of this chapter, i.e., 3D optical motion capture data of male participants, whose dance, running, and walking movements were recorded and subsequently applied to virtual humanoid characters for presentation to female judges. Motion capture data of all movement types were available from 70 British males aged 18–42 years ($M = 21.6$, SD = 4.1). We had 120 female judges aged 15–46 years ($M = 23.8$, SD = 4.3) who were mainly recruited from the local student population at the University of Göttingen, Germany. Independent samples of 40 females each judged short video clips of males dancing, running, and walking on 15.4″ laptop computers, using MediaLab software (Empirisoft Inc., NY, USA), on perceived attractiveness on a 7-point Likert-type scale (1 = very unattractive to 7 = very attractive). The presentation order of stimuli for each experiment was randomized between participants. The calculated means of female perceptions (for each of the three movement types) were used for the statistical analyses.

Female perceptions of male dances ranged from 1.85 to 4.75 ($M = 3.28$, SD = 0.66), for running from 1.63 to 4.90 ($M = 3.42$, SD = 0.76), and for walking from 1.25 to 5.75 ($M = 3.23$, SD = 0.90) with no significant difference between the three movement conditions ($F = 2.06$, $p = 0.13$). The correlational analysis revealed that attractiveness of dance and running perceptions were significantly positively correlated ($r = 0.37$, $p < 0.001$) (Fig. 16.5a). Female perceptions of male dance attractiveness and walking attractiveness were also correlated positively, but failed to reach statistical significance ($r = 0.16$, $p = 0.19$) (Fig. 16.5b). Attractiveness perception of male running and walking movements correlated significantly positively with one another ($r = 0.54$, $p < 0.001$). Finally, there was no significant correlation of body height and weight with either of the three movement types. An additional regression analysis of dance attractiveness perception as dependent variable and running and walking attractiveness as independent variables revealed an overall significant model ($F = 5.59$, $p < 0.01$) with running, but not walking attractiveness being a

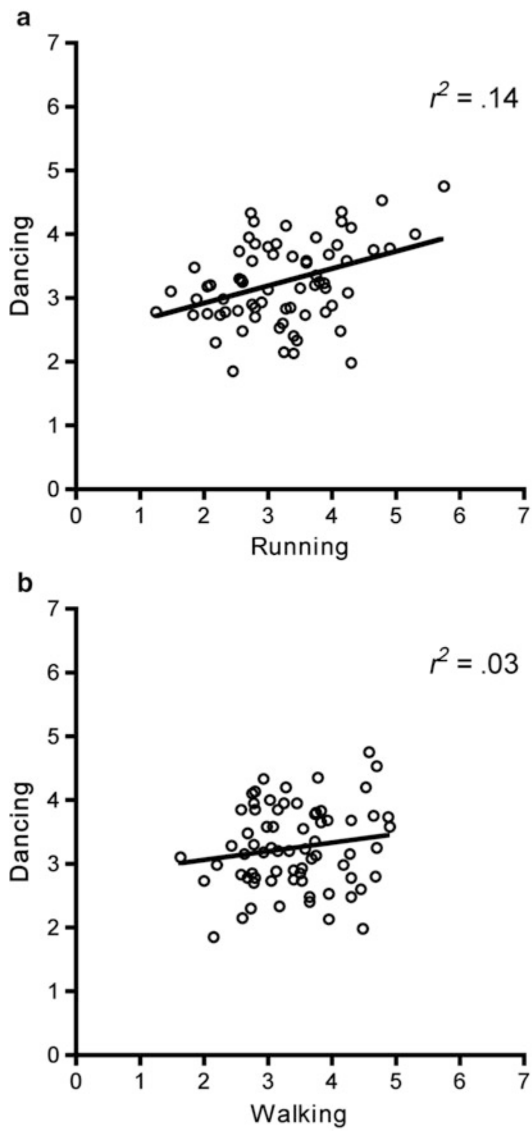

Fig. 16.5 Scatterplots of the associations between females' attractiveness judgments of male dancing and running (**a**) and walking (**b**)

significant predictor (running: $\beta = 0.41$, $p < 0.01$; walking: $\beta = -0.06$, $p = 0.64$). These results did not change substantially when adding male body height and weight as predictors of female perception of dance attractiveness.

Although we consider these data as preliminary, they show that there is considerable agreement in female perceptions of male body movements across different types of movements, with dancing being more strongly associated with running than with walking. This is perhaps not surprising as both movement styles reflect higher energy expenditure and might be more useful to females when trying to gain an impression of male physical quality. We suggest that future studies should particularly employ measures of energy expenditure in their protocols when assessing relationships between subjective perceptions of male body movements and objective measures of male quality.

Conclusion

Finding a "perfect" mate is arguably one of the most important but also difficult tasks an individual has to master during its reproductive life. Evolutionary psychologists theorize that via appropriate choice, an individual can ensure that its genes are passed on to offspring. Based on some 20 years of research, there is strong evidence that the human face and body (in static representation) provide a number of (mate) "quality" cues. Studies have shown that people are remarkably sensitive to even subtle variations of facial and/or body characteristics and react correspondingly in terms of age, attractiveness, and health assessments. Comparably little is known on the role of facial and body dynamics in this context, although it seems obvious that considering biological motion in evolutionary psychology, studies on physical appearance would bring additional ecological validity to the study of human mate preferences and choice.

In this present chapter we have reviewed evidence on the social significance of body movement with a focus on female perceptions of male body movements. The available studies suggest that females derive certain "quality" cues from male body movements and that these cues are more or less the same as those derived from static representations of male faces and bodies. In summary, the evidence is as follows:

- Females perceive dance movements of symmetrical males higher on attractiveness than those of unsymmetrical males (although this result remains to be confirmed).
- Females judge dance movements of physically stronger males higher on attractiveness, dominance, and masculinity than those of physically weaker males.
- Females perceive dances of higher risk-taking males as more attractive and assertive than dances of males who score lower on risk-taking propensity.
- Females are visually sensitive (in terms of attention) to male dance movements such that they focus more attention on "good" than "bad" dancers; and they judge better dancers to be more attractive.
- Females' perceptions of "good" male dancers are characterized by variability in males' body movements, particularly those of the upper body (head/neck and trunk region).
- Females of different societies/cultures are broadly comparable in their judgments of male dance movement attractiveness (though this evidence needs to be expanded to further populations), although there seems to be local variation in regard to the influence of personality of the dancer that drives these assessments.
- Females share judgments of different types of male body movements, such as dancing, running, and walking.

Clearly there is much that remains to be understood in relation to perceptions of human movements from an evolutionary psychology perspective. A key issue is certainly that of cross-cultural evidence. We know that human dance is strongly determined by the sociocultural background, and even within cultures, certain dance moves and actions reflect different trends and youth cultures. It is thus likely that there may be cross-cultural differences in perceptions of dance quality, though if we are correct in assuming that dance serves to accurately reflect the individual qualities of the dancer, then perhaps cross-cultural differences may be minimal. Indeed, our preliminary data on Brazilian and German females' perceptions of male dance movements suggest that in both societies, females perceive the quality of (British) male dancers similarly, although there seem to be local differences with regard to the moderating role of personality cues they derive from dance movements.

In addition, while we speculate that dance serves to convey information about the physical and psychological qualities of the dancer, it has not yet been confirmed that physical qualities such as age, health, and physical fitness, for example, are accurately signaled via dance movements. With reference to our preliminary data on the relationships between female perceptions of male dancing, running, and walking, it may be that further studies on energy expenditure of different types of body movements will reveal insight into the key cues females derive from them.

Most of the studies on female perceptions of male body movements were concerned with dance movements in which they did not explicitly test for the ability of an individual to adjust the moves to a certain beat. Neither did female judges get an idea on this (male) ability as movements were commonly presented without audio information. Just from an everyday observation, it may well be that the male ability to adjust dance movements to the beat also provides a reliable cue that women can base their assessments of dance quality and attractiveness on. In regard to the ecological validity of studies investigating male dance movement perceptions, this is an issue that needs to be urgently addressed.

Along this line, it remains to be shown how strong the cues individuals derive from body movements actually are. While it is probably obvious that body movements form an initial signal when perceiving people from distance, it is yet unknown how strong these signals are in comparison to those of facial characteristics. In other words, can the initial impression formation based on body movement be outperformed by facial and body morphology? Future research is needed to determine some feature hierarchy in people's social perception of others by adding dynamic aspects of human physical appearance. The present evidence on female perceptions of male body movements seems to suggest that static and dynamic representations of the male physique signal similar aspects of male quality. For example, females are attracted to male facial features that indicate physical strength (Fink, Neave, et al., 2007), and they seem to derive these qualities also from male body movements (Hugill et al., 2009). This suggests that not only male faces and body form a condition-dependent ornament of quality but also that movement is condition dependent. What comprises (male) condition may be manifold, although features such as symmetry, T-dependent traits, and certain personality characteristics (e.g., risk taking) are likely candidates that could explain part of the variance in attraction to females.

Finally, the available studies on male body movements reflect human intersexual selection, thus concerning the cause for female preferences of male movements. In addition to establishing the significance of body movement in this context, it will be interesting to see to what extent they also convey information to potential male rivals. In following Puts (2010), we speculate that like static physical features, male body movement is both a cue to male quality that females employ in assessing potential mates and also a feature that other males may use to assess potential competitors.

References

Adolphs, R. (1999). Social cognition and the human brain. *Trends in Cognitive Sciences, 3*, 469–479.

Allison, T., Puce, A., & McCarthy, G. (2000). Social perception from visual cues: Role of the STS region. *Trends in Cognitive Sciences, 4*, 267–278.

Argyle, M. (1988). *Bodily communication* (2nd ed.). London: Routledge.

Atkinson, A. P., Dittrich, W. H., Gemmell, A. J., & Young, A. W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception, 33*, 717–746.

Barclay, C. D., Cutting, J. E., & Kozlowski, L. T. (1978). Temporal and spatial factors in gait perception that influence gender recognition. *Perception & Psychophysics, 23*, 145–152.

Bertenthal, B. I., Proffitt, D. R., & Cutting, G. E. (1984). Infant sensitivity to figural coherence in biomechanical motions. *Journal of Experimental Child Psychology, 37*, 213–230.

Bingham, G. P. (1993). Scaling judgments of lifted weight: Lifter size and the role of the standard. *Ecological Psychology, 5*, 31–64.

Blake, R., Turner, L. M., Smoski, M. J., Pozdol, S. L., & Stone, W. L. (2003). Visual recognition of biological motion is impaired in children with autism. *Psychological Science, 14*, 151–157.

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*, 300–308.

Bogaert, A. F., & Fisher, W. A. (1995). Predictors of university men's number of sexual partners. *Journal of Sex Research, 32*, 119–130.

Bonda, E., Petrides, M., Ostry, D., & Evans, A. (1996). Specific involvement of human parietal systems and the amygdala in the perception of biological motion. *Journal of Neuroscience, 16*, 3737–3744.

Braun, M. (1992). *Picturing time: The work of Étienne-Jules Marey (1830–1904)*. Chicago: University of Chicago Press.

Brown, W. M., Cronk, L., Grochow, K., Jacobson, A., Liu, C. K., Popovic, Z., et al. (2005). Dance reveals symmetry especially in young men. *Nature, 438*, 1148–1150.

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

Buss, D. M. (1985). Human mate selection. *American Scientist, 73*, 47–51.

Buss, D. M., & Barnes, M. L. (1986). Preferences in human mate selection. *Journal of Personality and Social Psychology, 50*, 559–570.

Buss, D. M., & Schmitt, D. P. (1993). Sexual strategies theory: An evolutionary perspective on human mating. *Psychological Review, 100*, 204–232.

Byers, J., Hebets, E., & Podos, J. (2010). Female mate choice based upon male motor performance. *Animal Behaviour, 79*, 771–778.

Cardinale, M., & Stone, M. H. (2006). Is testosterone influencing explosive performance? *Journal of Strength and Conditioning Research, 20*, 103–107.

Clark, D. L., & Morjan, C. L. (2001). Attracting female attention: The evolution of dimorphic courtship displays in the jumping spider *Maevia inclemens* (Araneae: Salticidae). *Proceedings of the Royal Society of London, Series B, 268*, 2461–2465.

Collaer, M. L., & Hines, M. (1995). Human behavioral sex differences: A role for gonadal hormones during early development? *Psychological Bulletin, 118*, 55–107.

Costa, P. T., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and the NEO Five-Factor Inventory (NEO-FFI): Professional manual*. Odessa, FL: Psychological Assessment Resources.

Cutting, J. E. (1978a). A biomechanical invariant of gait perception. *Journal of Experimental Psychology: Human Perception and Performance, 4*, 357–372.

Cutting, J. E. (1978b). Generation of synthetic male and female walkers through manipulation of a biomechanical invariant. *Perception, 7*, 393–405.

Cutting, J. E., & Kozlowski, L. T. (1977). Recognizing friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonomic Society, 9*, 353–356.

Cutting, G. E., Moore, C., & Morrison, R. (1988). Masking the motions of human gait. *Perception & Psychophysics, 44*, 339–347.

Cutting, J. E., & Proffitt, D. R. (1981). Gait perception as an example of how we may perceive events. In R. D. Walk & H. L. Pick (Eds.), *Intersensory perception and sensory integration* (pp. 249–273). New York: Plenum Press.

Darwin, C. (1871). *The descent of men, and selection in relation to sex*. Princeton, NJ: Princeton University Press.

Darwin, C. (1872). *The expression of emotions in man and animals*. London: Harper Collins.

Di Luigi, L., Romanelli, F., & Lenzi, A. (2005). Androgenic-anabolic steroids abuse in males. *Journal of Endocrinological Investigation, 28*, 81–84.

Digman, J. M. (1990). Personality structure: Emergence of the five-factor model. *Annual Review of Psychology, 41*, 417–440.

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*, 727–738.

Doyle, J. F. (2009). A woman's walk: Attractiveness in motion. *Journal of Social, Evolutionary, and Cultural Psychology, 3*, 81–92.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology, 17*, 124–129.

Ekman, P., Friesen, W. V., O'Sullivan, M., Chan, A., Diacoyanni-Tarlatzis, I., Heider, K., et al. (1987). Universals and cultural differences in the judgments of facial expressions of emotion. *Journal of Personality and Social Psychology, 53*, 712–717.

Farthing, G. W. (2005). Attitudes towards heroic and non heroic risk takers as mates and friends. *Evolution and Human Behavior, 26*, 171–185.

Fink, B., Neave, N., & Seydel, H. (2007). Male facial appearance signals physical strength to women. *American Journal of Human Biology, 19*, 82–87.

Fink, B., & Penton-Voak, I. S. (2002). Evolutionary psychology of facial attractiveness. *Current Directions in Psychological Science, 11*, 154–158.

Fink, B., Seydel, H., Manning, J. T., & Kappeler, P. M. (2007). A preliminary investigation of the association between digit ratio and women's perception of men's dance. *Personality and Individual Differences, 42*, 381–390.

Fink, B., Täschner, K., Neave, N., Hugill, N., & Dane, L. (2010). Male faces and bodies: Evidence of a condition-dependent ornament of quality. *Personality and Individual Differences, 49*, 436–440.

Fink, B., Thanzami, V., Seydel, H., & Manning, J. T. (2006). Digit ratio and hand-grip strength, in German and Mizos men: Cross-cultural evidence for an organizing effect of prenatal testosterone on strength. *American Journal of Human Biology, 18*, 776–782.

Fink, B., Weege, B., Flügge, J., Röder, S., Neave, N., & McCarty, K. (2012). Men's personality and women's perception of their dance quality. *Personality and Individual Differences, 52*, 232–235.

Gangestad, S. W., & Scheyd, G. J. (2005). The evolution of human physical attractiveness. *Annual Review of Anthropology, 34*, 523–548.

Giese, M., & Poggio, T. (2003). Neural mechanisms for the recognition of biological movements. *Nature Reviews Neuroscience, 4*, 179–192.

Goodall, J. (1968). A preliminary report on expressive movement and communication in the Gombe Stream chimpanzees. In P. C. Jay (Ed.), *Primates: Studies in adaptation and variability* (pp. 313–374). New York: Holt, Rinehart and Winston.

Grammer, K., Fink, B., Juette, A., Ronzal, G., & Thornhill, R. (2001). Female faces and bodies: n-dimensional feature space and attractiveness. In G. Rhodes & L. Zebrobwitz (Eds.), *Advances in visual cognition. Volume I: Facial attractiveness* (pp. 97–125). Westport, CT: Alex.

Grammer, K., Fink, B., Møller, A. P., & Manning, J. T. (2005). Physical attractiveness and health: Comment on Weeden and Sabini (2005). *Psychological Bulletin, 131*, 658–661.

Grammer, K., Fink, B., Møller, A. P., & Thornhill, R. (2003). Darwinian aesthetics: Sexual selection and the biology of beauty. *Biological Reviews, 78*, 385–407.

Grammer, K., Keki, V., Striebel, B., Atzmüller, M., & Fink, B. (2003). Bodies in motion: A window to the soul. In E. Voland & K. Grammer (Eds.), *Evolutionary aesthetics* (pp. 295–323). Berlin: Springer.

Grossman, E. D., Battelli, L., & Pascual-Leone, A. (2005). Repetitive TMS over STSp disrupts perception of biological motion. *Vision Research, 45*, 2847–2853.

Grossman, E., Donnelly, M., Price, R., Pickens, D., Morgan, V., Neighbour, G., et al. (2000). Brain areas involved in perception of biological motion. *Journal of Cognitive Neuroscience, 12*, 711–720.

Hall, J. A. (1978). Gender effects in decoding nonverbal cues. *Psychological Bulletin, 85*, 845–857.

Hanna, J. L. (1987). *Dance, sex and gender: Signs of identity, dominance, defiance, and desire*. Chicago: University of Chicago Press.

Hanna, J. L. (2010). Dance and sexuality: Many moves. *Journal of Sex Research, 47*, 212–241.

Heberlein, A. S., Adolphs, R., Tranel, D., & Damasio, H. (2004). Cortical regions for judgments of emotions and personality traits from point-light walkers. *Journal of Cognitive Neuroscience, 16*, 1143–1158.

Hubert, B., Wicker, B., Moore, D. G., Monfardini, E., Duverger, H., Da Fonséca, D., et al. (2007). Recognition of emotional and non-emotional biological motion in individuals with autistic spectrum disorders. *Journal of Autism and Developmental Disorders, 37*, 1386–1392.

Hugill, N., Fink, B., & Neave, N. (2010). The role of human body movements in mate selection. *Evolutionary Psychology, 8*, 66–89.

Hugill, N., Fink, B., Neave, N., Besson, A., & Bunse, L. (2011). Women's perception of men's sensation seeking propensity from their dance movements. *Personality and Individual Differences, 51*, 483–487.

Hugill, N., Fink, B., Neave, N., & Seydel, H. (2009). Men's physical strength is associated with women's perceptions of their dancing ability. *Personality and Individual Differences, 47*, 527–530.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception & Psychophysics, 14*, 201–211.

Johansson, G. (1976). Spatio-temporal differentiation and integration in visual motion perception. *Psychological Research, 38*, 379–393.

Johansson, G., von Hofsten, C., & Jansson, G. (1980). Event perception. *Annual Review of Psychology, 31*, 27–63.

Johnson, K. L., Gill, S., Reichman, V., & Tassinary, L. G. (2007). Swagger, sway, and sexuality: Judging sexual orientation from body motion and morphology. *Journal of Personality and Social Psychology, 93*, 321–334.

Johnson, K. L., & Tassinary, L. G. (2005). Perceiving sex directly and indirectly. Meaning in motion and morphology. *Psychological Science, 16*, 890–897.

Johnston, V. S., Hagel, R., Franklin, M., Fink, B., & Grammer, K. (2001). Male facial attractiveness: Evidence for hormone mediated adaptive design. *Evolution and Human Behavior, 22*, 251–267.

Jokisch, D., Daum, I., & Troje, N. F. (2006). Self recognition versus recognition of others by biological motion: Viewpoint-dependent effects. *Perception, 35*, 911–920.

Kaeppler, A. L. (1978). Dance in anthropological perspective. *Annual Review of Anthropology, 7*, 31–49.

Koppensteiner, M. (2011). Perceiving personality in simple motion cues. *Journal of Research in Personality, 45*, 358–363.

Koppensteiner, M., & Grammer, K. (2010). Motion patterns in political speech and their influence on personality ratings. *Journal of Research in Personality, 44*, 374–379.

Koppensteiner, M., & Grammer, K. (2011). Body movements of male and female speakers and their influence on personality ratings. *Personality and Individual Differences, 51*, 743–747.

Koutedakis, Y., Owolabi, E. O., & Apostolos, M. (2008). Dance biomechanics: A tool for controlling health, fitness, and training. *Journal of Dance Medicine and Science, 12*, 83–90.

Kozlowski, L. T., & Cutting, J. E. (1977). Recognizing the sex of a walker from a dynamic point-light display. *Perception & Psychophysics, 21*, 575–580.

Kurath, G. P. (1960). Panorama of dance ethnology. *Current Anthropology, 1*, 233–254.

Langlois, J. H., Kalakanis, L., Rubenstein, A. J., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychological Bulletin, 126*, 390–423.

Lippa, R. (1983). Sex typing and the perception of body outlines. *Journal of Personality, 51*, 667–682.

Little, A. C., Jones, B. C., & Burriss, R. P. (2007). Preferences for masculinity in male bodies change across the menstrual cycle. *Hormones & Behaviour, 51*, 633–639.

Little, A. C., Jones, B. C., & DeBruine, L. (2011). Facial attractiveness: Evolutionary based research. *Philosophical Transactions of the Royal Society, B: Biological Sciences, 66*, 1638–1659.

Livshits, G., & Kobyliansky, E. (1991). Fluctuating asymmetry as a possible measure of developmental homeostasis in humans: A review. *Human Biology, 63*, 441–466.

Luck, G., Saarikallio, S., Burger, B., Thompson, M. R., & Toiviainen, P. (2010). Effects of the Big Five and musical genre on music-induced movement. *Journal of Research in Personality, 44*, 714–720.

Luck, G., Saarikallio, S., & Toiviainen, P. (2009). Personality traits correlate with characteristics of music-induced movement. In: *Proceedings of the 7th triennial conference of European Society for the Cognitive Sciences of Music (ESCOM)* (pp. 276–279).

Ludwig, W. (1932). *Das Rechts-Links Problem im Tierreich und beim Menschen*. Berlin: Springer.

Manning, J. T. (2002). *Digit ratio: A pointer to fertility, behavior, and health*. New Brunswick, NJ: Rutgers University Press.

Manning, J. T., & Taylor, R. P. (2001). Second to fourth digit ratio and male ability in sport: Implications for sexual selection in humans. *Evolution and Human Behavior, 22*, 61–69.

Marey, É. J. (1894). *Le Mouvement*. Paris: G. Masson.

Mather, G., & Murdoch, L. (1994). Gender discrimination in biological motion displays based on dynamic cues. *Proceedings of the Royal Society of London, Series B, 258*, 273–279.

Maynard-Smith, J. (1956). Fertility, mating behaviour and sexual selection in Drosophila subobscura. *Journal of Genetics, 54*, 261–279.

McCrae, R. R., & Costa, P. T., Jr. (1997). Personality trait structure as a human universal. *American Psychologist, 52*, 509–516.

McDonnell, R., Jorg, S., Hodgins, J. K., Newell, F., & O'Sullivan, C. (2007). Virtual shapers & movers: Form and motion affect sex perception. *Proceedings of the 4th symposium on applied perception in graphics and visualization* (pp. 7–10).

Moore, D. G., Hobson, R. P., & Lee, A. (1997). Components of person perception: An investigation with autistic, non-autistic retarded and typically developing children and adolescents. *British Journal of Developmental Psychology, 15*, 401–423.

Neave, N., McCarty, K., Freynik, J., Caplan, N., Hönekopp, J., & Fink, B. (2011). Male dance moves that catch a woman's eye. *Biology Letters, 7*, 221–224.

Patricelli, G. L., Uy, A. C., & Borgia, G. (2003). Multiple male traits interact: Attractive bower decorations facilitate attractive behavioural displays in satin bowerbirds. *Proceedings of the Royal Society of London, Series B, 270*, 2389–2395.

Penton-Voak, I. S., & Chen, J. Y. (2004). High salivary testosterone is linked to masculine male facial appearance in humans. *Evolution and Human Behavior, 25*, 229–241.

Penton-Voak, I. S., Perrett, D. I., Castles, D. L., Kobayashi, T., Burt, D. M., Murray, L. K., et al. (1999). Menstrual cycle alters face preference. *Nature, 399*, 741–742.

Penton-Voak, I. S., Pound, N., Little, A. C., & Perrett, D. I. (2006). Personality judgments from natural and composite facial images: More evidence for a 'kernel of truth' in social perception. *Social Cognition, 24*, 490–524.

Perrett, D. I., Smith, P., Mistlin, A., Chitty, A. J., Heads, A. S., Potter, D. D., et al. (1985). Visual analysis of body movements by neurons in the temporal cortex of the macaque monkey. *Behavioral Brain Research, 16*, 153–170.

Pica, P., Jackson, S., Blake, R., & Troje, N. (2011). Comparing biological motion perception of two distinct human societies. *PLoS One, 6*, e28391.

Pollick, F. E., Kay, J. W., Heim, K., & Stringer, R. (2005). Gender recognition from point-light walkers. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 1247–1265.

Puts, D. A. (2010). Beauty and the beast: Mechanisms of sexual selection in humans. *Evolution and Human Behavior, 31*, 157–175.

Rhodes, G. (2006). The evolutionary psychology of facial beauty. *Annual Review of Psychology, 57*, 199–226.

Roark, D. A., Barrett, S. E., Spence, M. J., Abdi, H., & O'Toole, A. J. (2003). Psychological and neural perspectives on the role of motion in face recognition. *Behavioral and Cognitive Neuroscience Reviews, 2*, 15–46.

Roether, C. L., Omlor, L., Christensen, A., & Giese, M. A. (2009). Critical features for the perception of emotion from gait. *Journal of Vision, 9*, 1–32.

Rowland, W. J. (1995). Do female stickleback care about male courtship vigour? Manipulation of display tempo using video playback. *Behaviour, 132*, 951–961.

Runeson, S., & Frykholm, G. (1983). Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender recognition, and deceptive intention. *Journal of Experimental Psychology: General, 112*, 585–615.

Saunders, D. R., Williamson, D. K., & Troje, N. F. (2010). Gaze patterns during perception of direction and gender from biological motion. *Journal of Vision, 10*, 1–10.

Schenk, T., & Zihl, J. (1997a). Visual motion perception after brain damage: I. Deficits in global motion perception. *Neuropsychologia, 35*, 1289–1297.

Schenk, T., & Zihl, J. (1997b). Visual motion perception after brain damage: II. Deficits in form from motion perception. *Neuropsychologia, 35*, 1299–1310.

Schmitt, D. P. (2005). Sociosexuality from Argentina to Zimbabwe: A 48-nation study of sex, culture, and strategies of human mating. *Behavioral and Brain Sciences, 28*, 247–275.

Schmitt, D. P., Alcalay, L., Allik, J., Ault, L., Austers, I., Bennett, K. L., et al. (2003). Universal sex differences in the desire for sexual variety: Tests from 52 nations, 6 continents, and 13 islands. *Journal of Personality and Social Psychology, 85*, 85–104.

Sell, A., Cosmides, L., Tooby, J., Sznycer, D., von Rueden, C., & Gurven, M. (2009). Human adaptations for the visual assessment of strength and fighting ability from the body and face. *Proceedings of the Royal Society of London, Series B, 276*, 575–584.

Simion, F., Regolin, L., & Bulf, H. (2008). A predisposition for biological motion in the newborn baby. *Proceedings of the National Academy of Science, 105*, 809–813.

Singer, F., Riechert, S. E., Xu, H., Morris, A. W., Becker, E., Hale, J. A., et al. (2000). Analysis of courtship success in the funnel-web spider *Agelenopsis aperta*. *Behaviour, 137*, 93–117.

Singh, D. (2002). Female mate value at a glance: Relationship of waist-to-hip ratio to health, fecundity and attractiveness. *Neuroendocrinology Letters, 23*, 81–91.

Stevenage, S. V., Nixon, M. S., & Vince, K. (1999). Visual analysis of gait as a cue to identity. *Applied Cognitive Psychology, 13*, 513–526.

Stoffregen, T. A., & Flynn, S. B. (1994). Visual perception of support-surface deformability from human body kinematics. *Ecological Psychology, 6*, 33–64.

Sylwester, K., & Pawlowski, B. (2011). Daring to be darling: Attractiveness of risk takers as partners in long- and short-term sexual relationships. *Sex Roles, 64*, 695–706.

Thoresen, J. C., Vuong, Q. C., & Atkinson, A. P. (2012). First impressions: Gait cues drive reliable trait judgments. *Cognition, 124*, 261–271.

Thornhill, R., & Gangestad, S. W. (2008). *The evolutionary biology of human female sexuality*. New York: Oxford University Press.

Thornhill, R., & Møller, A. P. (1997). Developmental stability, disease and medicine. *Biological Reviews, 72*, 497–548.

Trivers, R. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man, 1871–1971* (pp. 136–179). Chicago: Aldine.

Trivers, R., Manning, J. T., Thornhill, R., Singh, D., & McGuire, D. (1999). Jamaican symmetry project: Long term study of fluctuating symmetry in rural Jamaican children. *Human Biology, 71*, 417–430.

Trivers, R., Palestis, B., & Zataari, D. (2009). *The anatomy of a fraud: Symmetry and dance*. Antioch, CA: TPZ Publishers.

Troje, N. F. (2002). Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. *Journal of Vision, 2*, 371–387.

Troje, N. F., Westhoff, C., & Lavrov, M. (2005). Person identification from biological motion: Effects of structural and kinematic cues. *Perception & Psychophysics, 67*, 667–675.

Walk, R. D., & Homan, C. P. (1984). Emotion and dance in dynamic point-light displays. *Bulletin of the Psychonomic Society, 22*, 437–440.

Weeden, J., & Sabini, J. (2005). Physical attractiveness and health in Western societies: A review. *Psychological Bulletin, 131*, 635–653.

Weege, B., Lange, B. P., & Fink, B. (2012). Women's visual attention to variation in men's dance quality. *Personality and Individual Differences, 53*, 236–240.

Wilke, A., Hutchinson, J. M. C., Todd, P. M., & Kruger, D. J. (2006). Is risk taking used as a cue in mate choice? *Evolutionary Psychology, 4*, 367–393.

Williams, H. (2001). Choreography of song, dance and beak movements in the zebra finch (Taeniopygia guttata). *Journal of Experimental Biology, 204*, 3497–3506.

Wilson, M., & Daly, M. (1985). Competitiveness, risk taking, and violence: The young male syndrome. *Ethology and Sociobiology, 6*, 59–73.

Windhager, S., Schaefer, K., & Fink, B. (2011). Geometric morphometrics of male facial shape in relation to physical strength and perceived attractiveness, dominance and masculinity. *American Journal of Human Biology, 23*, 805–814.

Yoon, J. M. D., & Johnson, S. C. (2009). Biological motion displays elicit social behavior in 12-month-olds. *Child Development, 80*, 1069–1075.

Zuckerman, M. (1991). *Psychobiology of personality*. Cambridge, UK: Cambridge University Press.

Zuckerman, M. (2007). The Sensation Seeking Scale V (SSS-V): Still reliable and valid. *Personality and Individual Differences, 43*, 1303–1305.

Zuckerman, M., Eysenck, S., & Eysenck, H. J. (1978). Sensation seeking in England and America: Cross-cultural, age, and sex comparisons. *Journal of Consulting and Clinical Psychology, 46*, 139–149.