SOCIAL PERCEPTION OF DANCE MOVEMENTS

INVESTIGATING THE SIGNALLING VALUE OF MALE BODY MOVEMENTS USING MOTION-CAPTURE-TECHNOLOGY

Dissertation

for the award of the degree

"**Doctor rerum naturalium**"

of the Georg-August-Universität Göttingen

within the doctoral program Biology

of the Georg-August University School of Science (GAUSS)

submitted by

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from Magdeburg

Göttingen, 2015

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Date of the oral examination: 09.07.2015

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GENERAL INTRODUCTION

Evolutionary Psychology of Social Perception

Social perception is crucial. Like many social animals, humans rely on social signals although their accuracy is often questionable. Social signals in human communication vary in their sensory modalities. A special form is the perception of nonverbal cues, including facial and verbal expressions, gestures, postures, physical appearance and body movements (Bull, 2001; DePaulo, 1992). Humans typically employ these displays in social encounters, although they may not be consciously aware of it. This is paraphrased in Watzlawick's (1967) statement "one cannot not communicate"; in other words, sharing information between a signaller and a receiver is a constant process in social interaction. Nonverbal signals are always present. A signaller can consciously or unconsciously, intentionally or unintentionally display them, and even if an individual's motivation is not to communicate, this itself results in communication. Similarly, the receiver cannot not perceive. Further, a signaller can alter a message in order to elicit a certain response in the perceiver (Eco, 1976; Grammer, Fink, & Renninger, 2002). Decoding the actual meaning of a social signal and deciding about its accuracy is a major challenge in social encounters, given the assessment of a signal determines an individual's behavioural response.

There have been various attempts to determine how a social signal is communicated and translated into meaning. Mehrabian (1967) suggests that up to 93% of a signal's meaning may originate from nonverbal cues. In contrast, Barker, Edwards, Gaines, Gladney, and Holley (1980) stated that an individual spends 45-53% of its time on listening (receiving, attending to and assigning meaning to auditory stimuli). Obviously, the conclusions derived from these and related recent studies are equivocal, and there may be conceptual and methodological reasons explaining this discrepancy. By tradition, nonverbal behaviour has often been categorized in that researchers have been assessing the frequencies of occurrence of certain behavioural categories. Grammer, Fieder, and Filova (1997) argued that with this approach part of the information that is essential for decoding the meaning of a signal is not captured, given that the categorical approach to the investigation of social signals does not necessarily inform about their quality. This may be especially the case with body movement where the same type of movement can have different meanings, depending on the way it is performed. To illustrate, observers can

categorize different emotions from simple arm movements (such as angry knocking), depending on the kinematics of the movements, i.e., varying magnitude of velocity, acceleration and jerk (Pollick, Paterson, Bruderlin, & Sanford, 2001).

Recent research on the attractiveness of human body movement has made considerable progress in the assessment and interpretation of body movements (for review see Fink, Weege, Neave, Ried, & do Lago, 2014; Fink, Weege, Neave, Pham, & Shackelford, 2015). This has been driven by technological advances in capturing and deciphering the information that is conveyed through movement, and the conceptual approaches to their signalling quality. In addition to experimental psychology studies of how humans perceive body movement, the framework of evolutionary psychology suggests the maintenance of an integrative perspective, especially when it comes to the gender- and context-specific interpretation of body movement perception. A common insight is that individuals rely on so-called "thin slices" of behaviour, that is, brief sequences of information from observations and minimalistic interactions, which seem to be sufficient for a consensus in impression formation and trait attributions (Albright, Kenny, & Malloy, 1988; Ambady & Rosenthal, 1992). These impressions are thought to be persistent (Berry, 1990; Kenny, Horner, Kashy, & Chu, 1992); whether these judgements are accurate or not, seems to be secondary. Evolutionary psychologists argue that people attempt to derive so called "honest cues" of an individual's quality from physical cues, including movement, and this has consequences for their mating decisions. However, it is well established that people tend to make quick assessments about others, especially in complex social situations. According to theory, this facilitates processing relevant information under social and environmental constraints. We live in a world of uncertainty, where information availability is limited; thus our rationality in assessments is bounded, and social complexity is definitely no exception to this phenomenon (Gigerenzer & Selten, 2002). Depending on the affordances offered by social situations, people use cognitive heuristics, such as stereotyping to quickly and efficiently translate perceptual stimuli into categorical meaning.

Because social stereotyping is so dominant in human life, it is hypothesized that human perception is influenced by evolved mechanisms that "guide" individuals in their behavioural decisions. Possible the best-known example of social stereotyping, initially reported by Dion, Berscheid, and Walster (1972), is that of relationships between attractiveness and social quality ("What is beautiful is good"). These authors showed that people tend to assign positive traits to attractive people (e.g., sensitive, kind, interesting), independent from whether these people actually score high on these traits or not. Such

attentional bias is already observable soon after birth. Newborns spend longer time looking at attractive faces (Slater et al., 1998) and interact more positively with attractive female strangers (Langlois, Roggman, & Rieser-Danner, 1990). This effect maintains throughout the whole life and has a substantial impact on social judgments and behaviour (Eagly, Ashmore, Makhijani, & Longo, 1991; Langlois et al., 2000). Todorov, Mandisodza, Goren, and Hall (2005) showed that from faces of unfamiliar congressional seats candidates, raters made inferences on the candidates' competence, predicting the factual past election outcomes. There is a series of other studies showing a similar effect on court ruling (Kulka & Kessler, 1978; Zebrowitz & McDonald, 1991), employment situations (Hamermesh, 2011) or school grading (Dunkake, Kiechle, Klein, & Rosar 2012).

Human adaptive problems and mating preferences

Evolutionary theory states that social perception is informed by mental adaptations that have been shaped by evolutionary processes. Human ancestors faced various adaptive problems (such as threat detection and survival) that emerged from selection pressures. Although the world of today has additional challenges, some fundamental ones remain the same. One of the main adaptive problems is mate selection. On an observational level, there are two sexes in most animal species, including humans. Constant pressures of rapid-evolving parasites may have led to the development of sexuality (Hamilton, 1980). While anisogameous reproduction enhances a species' reproductive fitness through genetic diversity from high levels of recombination, it has morphological and behavioural consequences for the sexes. In mammals, females are much more limited in their maximum reproductive rate than males, but they have in contrast to males, the assurance of genetic parentage due to internal gestation (e.g., Symons, 1979). This results in various adaptive problems, which are thought to be the cause of differences in male and female mate preferences and mating strategies. These differences can be explained by the degree of investment an individual provides as parent (Trivers, 1972; see also Andersson, 1994; Clutton-Brock & Parker, 1992). Theory proposes that females usually have higher parental investment than males (e.g., producing energetically costly eggs, pregnancy, nursing), and are consequently the "choosier" sex males are competing for.

In humans, there is evidence for sex-specific mate preferences, such that women across cultures are attracted by a men's ability to acquire resources whereas men value a women's relative youth and physical attractiveness, as being cues to their reproductive capacity (Buss, 1989, 2008). Men, more than women, are involved in violent and homicidal

acts (Daly & Wilson, 1988), show more physically aggression (Ellis et al., 2008) and display more traits correlated to competitive and fighting ability (such as upper body muscle mass and strength; Lassek & Gaulin, 2009; Sell et al., 2009).

Perception of physical appearance and body movement

How do people decide on a potential mate's quality, given that relevant aspects such as reproductive potential, genetic quality, resource holding potential, or the willingness to invest in offspring are not directly identifiable? It is known that physical appearance, especially facial and body morphology, affects how humans perceive the attractiveness of others, which has implications for mate related motives (e.g., Gangestad & Scheyd, 2005; Rhodes, 2006). Evolutionary psychologists argue that attractiveness decisions reflect people's preferences for certain physical characteristics, as a product of evolved psychological mechanisms that aim to identify a potential partner's quality in terms of health, fitness, reproductive potential and parental abilities, to ultimately enhance their reproductive fitness (e.g., Grammer, Fink, Møller, & Thornhill, 2003; Little, Jones, & DeBruine, 2011). Attractiveness perceptions of the face and body can be based on physical and psychological aspects of mate quality (Buss, 1994), and are usually found to be similar across individuals of different age, sex, race and culture (Grammer et al., 2003; Langlois et al., 2000; Rhodes, 2006; Thornhill & Gangestad, 1999).

Most studies on human attractiveness perception have made use of static representation of the face and body. This circumstance has also been described as lack of ecological validity (Tovée & Cornelissen, 2001), a critique that receives support and denial. While some researchers take the view that different kinds of stimuli have consequences on the reliability of attractiveness judgements (Langlois et al., 2000; Rubenstein, 2005), others argue that attractiveness perception from facial images is comparable to those made from moving faces (Koscinski, 2013; Roberts et al., 2009). However, although physical appearance signals aspects of mate quality, this cannot capture the whole picture of the dynamic and complex structure of our social environment. Body movement is often the first cue that is perceivable in social situations, as it is visible from distance or poor light conditions when other cues such as facial expressions are not available (Grossman & Blake, 1999; Montepare & Zebrowitz-McArthur, 1988). Thus, humans rely on the ability to identify socially relevant information from body movements, to understand certain person's attributes and intentions, in order to modulate their behaviour (Blake & Shiffrar, 2007).

The scientific investigations of the signalling qualities of human body movement can be traced back to Johansson (1973), who invented the point-light (PL) technique, to capture and study the mere pattern of "biological motion". He attached light bulbs onto major joints of an actor and recorded his movements in the dark. Johansson documented that observers were able to identify human form and certain actions within 200 ms from those PL-displays, but not from a static snapshot of just one single frame of the video (Johansson, 1973, 1976; Johansson, von Hofsten, & Jansson, 1980). Research continuously expanded the PL-display technology and accumulated a great deal of evidence for the importance of motion perception. Humans seem to be endued with mental abilities to discern socially relevant information from motion cues alone (see for review: Blake & Shiffrar, 2007). From the mere moving pattern of few point lights, humans can well identify an actor's identity (e.g., Cutting & Kozlowski, 1977; Jokisch, Daum, & Troje, 2006), performed action, such as walking or skipping (e.g., Dittrich, 1993; Norman, Payton, Long, & Hawkes, 2004), gender (e.g., Kozlowski & Cutting, 1977; Pollick, Kay, Heim, & Stringer, 2005) even in a faked condition (Runeson & Frykholm, 1983), sexual orientation (Ambady, Hallahan, & Conner, 1999; Johnson, Gill, Reichman, & Tassinary, 2007), age (Montepare & Zebrowitz-McArthur, 1988), emotional status (e.g., Dittrich, Troscianko, Lea, & Morgan, 1996; Roether, Omlor, Christensen, & Giese, 2009; Walk & Homann, 1984), social dominance (Montepare & Zebrowitz-McArthur, 1988), and even the weight of a lifted object (Runeson & Frykholm, 1981).

The sensitivity towards biological motion perception is present at a very young age. Infants selectively attend to those motion patterns that are derived from biological rather than non-biological motion (Fox & McDaniel, 1982; Simion, Regolin, & Bulf, 2008). There seems to be cross-cultural similarities in judging intentions (such as chasing) from motion trajectories alone (Barrett, Todd, Miller, & Blythe, 2005). These findings give reason to consider an evolutionary basis of biological movement perception.

Evolutionary perspective on the significance of dance movements

Comparative literature suggests that elaborate courtship displays in many bird species are sexually selected, as females prefer especially skilled and vigorous males that perform with high - energy expenditure (Barske, Schlinger, Wikelski, & Fusani, 2011; Byers, Hebets, & Podos, 2010). Darwin (1871) suggested that sexual selection has not only shaped courtship dances in animals but also in humans, considering dance as potential cue to an individuals' qualities. From behavioural observations of anthropologists and ethnologists it

is proposed that dance, as a special form of "purposefully selected and controlled rhythmic" body movement, plays a crucial role in many facets of human social interaction, involving courtship rituals that are firmly established in many cultures (Kaeppler, 1978; Hanna, 2010). Dance movements can vary with respect to speed, rhythm, amplitude and direction in space, it involves one or more individuals "performing" with or without music in a certain rhythmical fashion, and the dancing prowess is strongly influenced by the physical virtuosity in terms of limb coordination, flexibility and strength (Bläsing et al., 2012). Due to its complexity that might have arisen through the process of bipedalism (Niemitz, 2010) and its physical demand (such as flexibility, muscularity and stability), dance is likely to contribute to mating decisions as it displays various cues to a performer's physical fitness, health, endurance, youthfulness and creativity (Hanna, 2006, 2010). From this perspective it seems plausible to include dance movements in the list of features (next to facial, bodily or vocal traits) that can give some indication of an individual's genetic and cognitive make up.

There is some evidence that certain male physical and personality characteristics not only affect women's perception of static facial and body images, but also women's evaluations of men's dance movements (Fink, Seydel, Manning, & Kappeler, 2007; Fink et al., 2012a; Hugill, Fink, Neave, & Seydel, 2009; Hugill, Fink, Neave, Besson, & Bunse, 2011; McCarty, Hönekopp, Neave, Caplan, & Fink, 2013). To investigate biomechanical characteristics that differentiate a "good" from a "bad" dancer, Neave et al. (2011) presented video clips of 19 motion-captured male dances (avatars) to female judges, who rated them on perceived dance quality. The authors identified specific movement characteristics that seem to provoke women's evaluations of dancing ability, in that a "good" dancer displayed more variable and large body movements, especially of the head, neck and trunk as well as fast (right) knee movements than a "bad" dancer. Considering comparative findings on females' preferences for male vigorous and skilled motor behaviour, Neave et al. suggest that human dance movements could also serve women as reliable indicator to an individual's health, fitness, genetic quality and developmental history. In golden-collared manakins (*Manacus vitellinus*), males perform elaborate and acrobatic displays, and females choose their mating partner on the basis of subtle differences in display performance (Barske et al., 2011). Thus, the way a certain movement is performed (e.g., varying in speed or amplitude) seems to be crucial for the evaluation of mate quality. This might also apply to human male dance movements. Whether women's dance quality assessments reflect their actual preference in terms of desired traits in a potential romantic partner, and which

physical and/or personality measures of male quality account for women's perception of male dances, remains to be investigated.

Physical strength could be a possible factor explaining some variation in male dance movements, as it is predictive for various health parameters (e.g., bone-mineral density: Kritz-Silverstein & Barrett-Connor, 1994; protein loss: Windsor & Hill, 1988; physical functioning and performance: Fredericksen et al., 2002; Kuh, Bassey, Butterworth, Hardy, & Wadsworth, 2005; cardiorespiratory fitness: Vaara et al., 2012), and is negatively associated with disability (Giampaoli et al., 1999) and mortality in male adults (Rantanen et al., 2000). Handgrip strength (HGS) - a measure of overall body strength and muscularity (Mathiowetz et al., 1985; Wind, Takken, Helders, & Engelbert, 2010) - is strongly influenced by genetic factors (Fredericksen et al., 2002) and is developed differently in men and women (Isen, McGue, & Iacono, 2014). Indeed, men are substantially physically stronger (Miller, MacDougall, Tarnopolsky, & Sale, 1993; Thorngren & Werner, 1979) and have up to 75 % more muscle mass than women (Lassek & Gaulin, 2009). It is argued that physical strength serves as a honest indicator for mate quality since it correlates with many physical characteristics, such as body morphology (Gallup, White, & Gallup, 2007; Sell et al., 2009), facial masculinity, attractiveness and dominance (Fink, Neave, & Seydel, 2007; Windhager, Schaefer, & Fink, 2011), digit ratio (Fink, Thanzami, Seydel, & Manning, 2006) and fluctuating asymmetry of bodily traits (FA, a measure for developmental stability; Møller & Swaddle, 1997; Palmer & Strobeck, 1986) (Fink, Weege, Manning, & Trivers, 2014).

The association between HGS and FA is insofar interesting as both are associated with various fitness components in humans (e.g., HGS - physical functioning and performance: Rantanen et al., 2000; FA – sperm quality: Manning, Scutt, & Lewis-Jones, 1998; FA – morbidity: Waynforth, 1998). Further, it has been shown that FA, like HGS is related to male facial and body morphology (e.g., Fink, Neave, Manning, & Grammer, 2006; Fink et al., 2007b; Gallup et al., 2007; Gangestad & Thornhill, 2003; Tovée, Tasker, & Benson, 2000). Men with masculine physical features, that appear to vary in relation to HGS (stronger males have overall robust facial features such as a prominent jaw line; Windhager et al., 2011) have low levels of facial and body FA (Gangestad & Thornhill, 2003), and women perceive faces of physically stronger men more attractive, masculine and dominant than faces of weaker men (Fink et al., 2007b; Gangestad, Thornhill, & Yeo, 1994). Given their findings on a physical strength/developmental stability link, Fink and colleagues (2014b) speculate that only men with good overall condition can overcome the immunosuppressive impact of testosterone, which positively affects testosterone assisted muscle growth and

physical strength (Finkelstein et al., 2013). The authors suggest that physical strength is not only important in male-male contests (e.g., Muñoz-Reyes, Gil-Burmann, Fink, & Turiégano, 2012; Sell, Hone, & Pound, 2012), but also for intersexual selection processes. Morphological traits and body movements could inform women on traits that are related to physical strength, such as competitive ability (fighting ability). Identifying male strength may be beneficial for women, given that physically stronger men are more likely able to protect the family and/or compete for resources rather than their weaker counterparts (Puts, 2010). In fact, women seem to be able to accurately judge physical strength from static representations of male faces and bodies, and this relates to their evaluations of men's fighting ability (Sell et al., 2009). There is preliminary evidence that body movements also convey information about a men's physical strength. Hugill et al. (2009) reported a positive association between men's HGS and women's perception of the attractiveness and assertiveness of their dances. Men's physical strength is further associated with women's assessments of men's dances quality and certain biomechanical characteristics, such that physically stronger men performed larger, faster and more variable arm movements (McCarty et al., 2013).

Certainly, humans use various (static and dynamic) traits that are related to an individual's physical condition and health (e.g., strength) when they judge on a potential partner's qualities. However, this can only explain some proportion of how we perceive others. Personality is thought to influence attractiveness decisions (Barber, 1995; Buss, 1994; Holtzman & Strube, 2010; Noor & Evans, 2003). Although the perception of personality is often associated with the beauty bias in social perception (Dion et al., 1972), it is argued, that such stereotyping works in favour of an individual's search for desired personality traits in a potential partner (Little, Burt, & Perrett, 2006; Zhang, Kong, Zhong, & Kou, 2014). Accuracy in personality trait attribution is reported for judgments of extraversion and conscientiousness (e.g., Albright et al., 1988; Borkenau & Liebler, 1992). These findings are mostly based on face-to-face approaches or videotaped material, which makes an isolated examination of certain traits that affect personality attribution, quite difficult. Little and Perrett (2007) reduced the informative input and had observers judging personality traits from composite facial images of high and low scorers on certain personality characteristics. They found that judges were better than chance at guessing personality characteristics from facial information alone; this was particularly true for extraversion and conscientiousness. Although consensus on judgments of e.g. extraversion might arise from the physical attractiveness halo effect (Albright et al., 1988), there seems

to be a "kernel of truth" in the social perception of unfamiliar faces (Penton-Voak, Pound, Little, & Perrett, 2006) and bodies (Naumann, Vazire, Rentfrow, & Gosling, 2009). Whether a "kernel of truth" applies to the perception of body movements is not well understood. Luck, Saarikallio, Burger, Thompson, and Toiviainen (2010) recorded 60 dancers that were preselected for extreme scores of self-reported personality (based on the "Big Five" Inventory) using motion capture technology. Kinematic analysis revealed associations between extraversion and neuroticism with distinct movement characteristics. Extraverted dancers displayed overall jerky and accelerated movements of the central body, head, and feet in an energetic and expressive way, whereas neurotic counterparts showed similar movement pattern but lacking speed and energy. Hence, dance movements may vary as a function of personality, whether observers use this link to make judgments on a potential mate's quality is not clear. There seems to be an association between men's risk-taking behaviour and women's perception of their dance movements (Hugill et al., 2011). The authors presented men's dances in form of quantized (blurred, grey-scaled) videos to female participants, who gave evaluations on the dancer's attractiveness and risk-taking behaviour. Women's perceptions of men's attractiveness and risk-taking behaviour correlated positively with men's (self-reported) sensation seeking propensity. The authors concluded that women derive certain personality traits that are associated with good physical condition (e.g., sensation seeking propensity) from dance movements, which consequently may affect their mating decisions.

Women's attractiveness perceptions of male dance movements seem to be comparable across different cultures. Fink et al. (2014a) presented dance video clips of virtual dance characters (avatars) to a Brazilian and German female sample and collected their attractiveness evaluations. They found a positive association between Brazilian and German females' assessments of men's dance attractiveness. Considering men's personality (as assessed via the NEO-FFI inventory; Costa & McCrae, 1992) as covariates, revealed a significant difference between attractiveness judgements of Brazilian and German females, and a significant interaction effect of neuroticism and conscientiousness with country factor. The authors conclude that there seems to be cross-cultural agreement in women's assessments of male dance attractiveness, which is moderated by different male personality traits. The authors speculated that differences in the perception of dance movements might be due to sociocultural influences, but should be comparably small to the agreement on general evaluations of certain person's qualities from dance movements. From an evolutionary viewpoint, the ability to gain information about a men's personality could have

been an advantage for women in terms of avoiding aggression, harm or untrustworthiness, and to identify parental abilities, which ultimately increases their reproductive fitness.

Aims and Hypotheses

The aim of this thesis was to investigate the social perception and potential signalling value of dance movements against the background of evolutionary psychology. 3D-motion-capture technology was utilized to capture body movements from a total of 166 participants (80 men and 86 women; for detail see Appendix), additionally objective physical and psychological measures were obtained. Motion capture technology allows to study social perception of body movements independent from morphological features and texture - such as symmetry or sexual dimorphic traits, that are known to influence attractiveness perception - by linking observers' judgments on various endpoints. The availability and application of human - like shaped characters (instead of presenting just a few light points as in PL-displays) could also add more ecological validity to the study of movement perception, as it makes the stimuli less abstract to the observer, and especially complex dance movement patterns (twist and turns, polydirectional arm and leg movements) are likely less misleading compared to a point-light cloud. Furthermore, with motion capture technology, an objective biomechanical analysis is feasible, allowing the identification of movement characteristics that guide certain social judgments.

In this thesis I summarize 3 published studies from a larger-scale project on human body movements, by focusing on women's perception of male dances. The first study **(Chapter I)**, presents data on the relationship between women's visual attention and attractiveness perception of male dance movements. Neave et al. (2011) reported an association between specific biomechanical characteristics of male dancers and women's dance quality evaluations. However, they asked women to judge humanoid characters on dance quality on a computer screen that does not necessarily reflect how perception happens in a real encounter. Further, they did not investigate women's actual preference for one or the other dance movements. Thus, it remains open whether women are visually more attentive to "good" male dancers and judge them as more attractive compared to "bad" male dancers. In addressing these questions, the study presented in **Chapter I** viewed motion-captured male dancers in form of virtual, form-standardized, humanoid characters to 50 female participants using an eye-tracking paradigm. Male dancers varied in dancing abilities, a classification based on a previous assessment. Out of 48 male dancers, the five

that were judged highest and the five judged lowest on perceived dance quality, were arranged in 25 video pairs (video of one good and one bad dancer) and presented as 10s clips to a sample of 50 female participants, while their eye gaze was tracked. Subsequently, participants rated each of the 5 "good" and 5 "bad" dance video clips on attractiveness and masculinity. It is known, that attractive stimuli receive higher visual attention starting at a very young age (Slater et al., 1998; Eagly et al., 1991; Langlois et al., 2000), continuing in adulthood where visually attentive bias and related attractiveness evaluations also apply to certain mating relevant aspects (e.g., Dixson, Grimshaw, Linklater, & Dixson, 2011; Fink et al., 2008; Rupp & Wallen, 2007, 2009). Therefore, a similar observation for women's perception of male dance movements was expected, in that "good" male dancers would receive higher visual attention and would be judged more positively than "bad" male dancers.

At this point the question arises what is it that drives women's judgments of whether certain body movements are of "good" or "bad" quality and possibly also affects women's visual attention? Physical strength is a male quality trait that has been associated with many facial and bodily characteristics, for which women exhibit a preference (e.g., Fink et al., 2007b, 2014b; Sell et al., 2009; Windhager et al., 2011). The second study (**Chapter II)**, hypothesized that a dance attractiveness and strength relationship would be present in males but not in females. Hugill et al. (2009) found a positive association between male physical strength (as measured via HGS) and women's attractiveness and assertiveness judgments based on men's dances. McCarty et al. (2013) reported that women and men perceive physically stronger men as being better dancers compared to weaker men. Although these studies have made an important contributions to the field of human body movement perception in the context of mate selection, sample sizes were quite small (N = 40 male dancer, Hugill et al., 2009; N = 30, McCarty et al., 2013), likely being underpowered, regarding the complexity of dance movements and the possible variation found in just one population. Furthermore, Hugill et al. (2009) used dance video clips of grey-scaled and blurred recordings of male dancers in white overalls, a methodology that does not eliminate all physical individual characteristics that could have affected rater's evaluations. McCarty et al. (2013) used motion-capture technology, but asked for dance quality that does not necessarily reflect preferences in the context of mate decisions. Both studies concentrated on the investigation of women's perception of male dance movements, therefore it is not known whether an association between physical strength and dance attractiveness also exists in women. The second study of this thesis (**Chapter II**) applied advanced motion-capture technology, studied a larger sample size, and also extended the study of dance

attractiveness - strength relationship to women. For this, 80 male and 86 female dance video clips (Avatars) were rated on attractiveness by opposite sex judges (50 male and 40 female) and related to HGS measures of the dancer. As physical strength is suggested to be a male typical trait usually associated with intra-sexual selection (Sell et al., 2009, 2012), that also shows developmental differences between the sexes (Isen et al., 2014), it was not necessarily expected to find an association between physical strength and dance attractiveness in women, but to replicate the relationship in men.

Physical characteristics can only explain a fraction of social perception. The relevance of personality in the attractiveness perception of body movements is largely unknown. There is some evidence that certain personality traits may be conveyed in an individual's dance movement characteristics (e.g., Luck et al., 2010), and that this affects women's evaluation of a potential partner's qualities (Fink et al., 2012a; Hugill et al., 2011). Although there is preliminary evidence that women's attractiveness perception of male dance moves are associated with global personality descriptors (e.g. agreeableness and conscientiousness; Fink et al., 2012a) and specific aspects of personality such as sensation seeking propensity (Hugill et al., 2011), nobody has yet addressed whether these associations are based on women's actual ability to extract "real" aspects of men's personality. The third study **(Chapter III)** presents data on the associations between men's self-reported personality and women's evaluations of attractiveness and personality of their dance movements. Attractiveness evaluations (40 female judges) and personality attributions (102 female judges) of 80 male dance avatars were related to men's self-reported personality (as assessed via the 60-item NEO-FFI personality inventory, that is widely used to measure the major dimensions of adult personality; neuroticism, extraversion, openness, conscientiousness and agreeableness; Costa & McCrae 1985, 1992). Based on either assumptions - "what is beautiful is good" stereotype (Dion et al., 1972) or the reconsidered "what is good is beautiful" version (Little et al., 2006) - a positive correlation was expected for women's attractiveness perceptions of male dance movements with women's attribution of all global personality descriptors (extraversion, openness, conscientiousness and agreeableness), except for neuroticism, for which a reversed association was expected. Considering the positive relationships between women's perception of men's dance quality and men's self-reported agreeableness and conscientiousness (Fink et al., 2012a), it was hypothesized that women's dance attractiveness ratings would be associated with self-reported personality of the dancer in a similar manner as with women's personality ratings. After all, it was hypothesized that

women's personality attribution of male dance movements and men's self-reported personality would not necessarily reveal a strong relationships, following findings on facial attractiveness perception that has been shown to be influenced by judges desire for certain personality characteristics in a potential partner, which they assumed to be reflected in faces (Little et al., 2006; Zhang et al., 2014). If this were true, than this would argue for a perceptional bias in body movement perception, similar to what has been reported for stereotypical perception of faces and bodies.

Overall, the aim of this thesis was to apply motion capture technology to investigate the role of dance movements in social perception, by studying women's selectively processing of male dance movements and investigating potential physical and psychological characteristics that women may derive from male dance movements in order to judge on a potential partner's mate quality.

CHAPTER I

WOMEN'S VISUAL ATTENTION TO VARIATION IN MEN'S DANCE QUALITY

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Personality and Individual Differences (2012), 53 (3), Pages 236-240

Abstract

Recent research shows that 'good' male dancers display larger and more variable movements of their head, neck and trunk, and differ in certain personality characteristics from 'bad' dancers. Here we elaborate on these findings by testing the hypothesis that 'good' male dancers will also receive higher visual attention and will be judged as being more attractive by women. The eye-gaze of 46 women aged 19 to 33 years was tracked whilst they viewed pairs of video clips of male dancers in the form of avatars created using motion capture, each pair showing one 'good' and one 'bad' dancer together on the screen. In a subsequent rating task, women judged each dance avatar on perceived attractiveness and masculinity. Our data show that women viewed 'good' dancers significantly longer and more often than 'bad' dancers. In addition, visual attention was positively correlated with perceived attractiveness and masculinity, though the latter association failed to reach statistical significance. We conclude that (i) 'good' male dancers receive higher visual attention from women as compared to 'bad' dancers, and (ii) 'good' dancers are being judged as more attractive. This suggests that in following mating-related motives, women are selectively processing male dynamic displays, such as dance movements.

Keywords: attractiveness; body movement; dance; eye tracking; masculinity; visual attention.

Introduction

It is known that the morphology of both the human face and body affects people's perception of others, and that this perception has consequences for social attribution (Gangestad & Scheyd, 2005; Rhodes, 2006). Evolutionary psychologists argue that the human sensitivity towards variation in facial and body morphology is neither arbitrarily nor culturally bound, but reflects evolved cognitive mechanisms, which eventually facilitate mate selection and reproductive success (Grammer et al., 2003; Little, Jones & DeBruine, 2011). Following this logic, it is argued that attractiveness decisions characterize people's preference for an individual's facial and/or body morphology, which conveys aspects of partner 'quality'. This quality includes physical and personality characteristics, both of which affect the way we perceive the attractiveness of others (Buss, 1994). While the evidence in support of the evolutionary psychology perspective on human social perception seems to be strong, the majority of studies investigating the relationships between certain physical features and attractiveness have concentrated on static representations of faces and bodies. Thus, there has been criticism with regard to the inherent lack of ecological validity of studies that utilize photographs of faces/bodies, as they do not account for the possible effect of motion and behavioural cues (Rubenstein, 2005). There is indeed evidence that attractiveness judgements depend on the type of stimulus used (Langlois et al., 2000) and that attractiveness perception is viewpoint-dependent (e.g., Doyle, 2009; O´Toole, Edelman & Bülthoff, 1998).

Evolutionary psychology researchers have, therefore, begun to investigate the perception of body movements, and link these to objectively assessed anthropometric and biomechanical measures, and (self-reported) personality characteristics. Human dance movements have been primarily studied, possibly because dance is one of the most complex forms of movement, and because it arises in almost all human societies within a mating/courtship context (Hugill, Fink & Neave, 2010). Hanna (1987) argues that dance may be an adaptive behavioural pattern in sexual selection, as it is a medium, which displays beauty, health, strength, and thus sexual attractiveness. Recent research supports this assertion, as there is evidence that dance movements, particularly those of men, were found to correlate with body symmetry (Brown et al., 2005; but see for a re-analysis Trivers, Palestis & Zaatari, 2009), a measure of developmental stability and health, and physical strength (Hugill et al., 2009), such that high symmetric and physically strong dancers were judged as attractive by women. In addition to these anthropometric correlates, it was reported that dance quality was also associated with certain personality characteristics,

such as sensation seeking propensity (Hugill et al., 2011), and global personality descriptors (i.e., the 'big-five' of personality; Fink et al., 2012). There is thus accumulating evidence that male dance movements convey aspects of both physical and personality 'qualities', and that women are sensitive to these cues in terms of attractiveness decisions. If this were true, it is certainly of interest what exactly characterises a 'good' male dancer, i.e., which types of movements are associated with women's attractiveness judgements.

In an attempt to address this question, Neave et al. (2011) used three-dimensional motion-capture technology to identify possible biomechanical differences between women's perceptions of 'good' and 'bad' male dancers. The dance movements of men were recorded whilst dancing to a basic drum beat rhythm, and women rated video clips of shape-standardized virtual characters (avatars) for dance quality ('good' vs. 'bad' dancer). It was found that 'good' dancers displayed larger and more variable movements in relation to bending and twisting movements of their head/neck and torso, and faster bending and twisting movements of their right knee. Given that comparative biological studies have suggested that females prefer vigorous and skilled males, Neave et al. concluded that women derive information on physical condition, in terms of health, fitness and genetic quality, from men's dancing abilities.

In the present study we expand the Neave et al. finding by testing whether women are also visually selective to men's dance quality, thus introducing more ecological validity to the question of whether certain male dance moves attract more visual attention and are judged more positively than others. It is known that people spend higher visual attention to stimuli they consider attractive and that this also applies to aspects that are relevant in human mate preferences (Dixson et al., 2011; Fink et al., 2008; Lykins, Meana & Kambe, 2006; Maner et al., 2003; Rupp & Wallen, 2007; 2009). If this would apply also to the perception of human body movement, 'good' dancers should receive higher visual attention and be judged higher on attractiveness and masculinity than 'bad' dancers, as previous studies reported positive association of women's attractiveness and assertiveness perception of men's dances with male physical strength (Hugill et al., 2009).

Methods

Participants

Our initial sample comprised 50 women, aged 19 to 33 years (M = 23.90, SD = 3.21), mainly undergraduate and graduate students, who were recruited at the local university campus. All participants reported to have good visual acuity. Some had contact lenses, but

no one wore glasses. They were instructed to complete two tasks with the same stimulus material, i.e., (i) an eye tracking experiment, and (ii) a rating study. After the completion of both tasks, participants were fully debriefed, and each participant received a payment of 10 €.

Stimuli

The stimuli were obtained from the sample described in Fink et al. (2012). These authors collected dance recordings of 48 heterosexual men, all non-professional dancers, whose movements were captured using 3D-optical motion capture technology (Vicon, Oxford, UK), and applied them to a gender-neutral, featureless humanoid character (avatar) (see also Neave et al., 2011). Dance avatars were rated by 53 women for perceived dance quality on a 7-point Likert-type rating scale (1 = extremely bad dancer to 7 = extremely good dancer). Of this sample, we selected the five dancers that were judged highest and the five that were judged lowest on perceived dance quality ('best': M = 4.50, SD = .20; 'worst': M = 1.90, SD = .10; $t_{(8)}$ = 26.31, p < .001). The length of the original clips was trimmed to 10 s and scaled to 573 x 632 pixels such that a video pair would fit onto a 19" computer screen. For the eye-tracking task, one set of video files was created, comprising 25 video pairs, each pair showing one video of the 'good' and one of the 'bad' dancers group, counterbalanced with regard to the side of presentation (left/right) (Set 1; see Figure 1). In a second set we used the same experimental setup, but this time the side of presentation of 'good' and 'bad' dancers was exactly the opposite of the first set (Set 2).

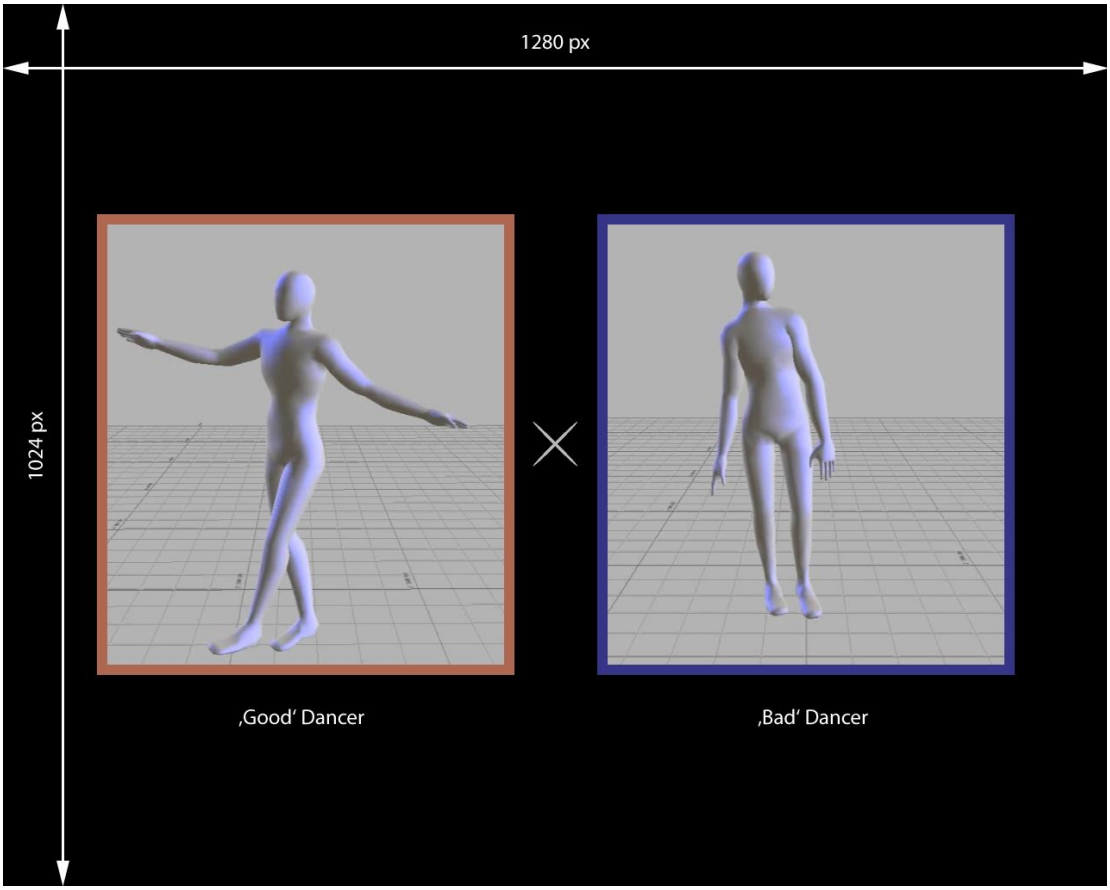

Figure 1. Screen-capture of a scene showing two virtual characters (dance avatars), one from the 'good' and one from the 'bad' dancers group, as presented in the eye-tracking experiment. The rectangles around the characters depict the areas-of interest, which were defined for all 'good/bad' dancer combinations presented. A blank image with a fixation cross (as shown) preceded the presentation of each scene.

Apparatus

The visual stimuli were displayed at a resolution of 1280 x 1024 pixels on a 19" colour-calibrated TFT screen (Iiyama ProLite E 4815, Iiyama Corp. Ltd., Nagano, Japan) at a fixed distance of 61.5 cm from the eye-tracking stand. Participants' visual attention to the video clips compositions presented were measured using the iView X High Speed system (SensoMotoric Instruments, Teltow, Germany), a stand-alone, pupil-CR video-based system that recorded the eye movement. The eye-tracking system combines a high-resolution camera and infrared lighting in a column as well as an ergonomic chin rest for a stable head position during recording and a large visual field that allows unhindered sight. Eye positions were sampled at 250 Hz, allowing tracking with a resolution < 0.01° and gaze position accuracy from 0.25° to 0.5°. Whilst viewing was binocular, only the participant's left eye was

tracked, as monocular recording is an established procedure in eye-tracking research (Lykins, Meana & Kambe, 2006; Wang, Sung & Venkateswarlu, 2005).

For each video pair two areas-of-interest (AOI) were defined using BeGaze software SensoMotoric Instruments, Teltow, Germany); one encompassed the entire size of the 'good' dancer and the other one the 'bad' dancer video clip (Figure 1). Although there are many ways to quantify and express visual attention from the raw data of continuously recorded gaze, cumulative dwell time and the number of fixations have been reported as the most useful (Duchowski, 2002; 2003). In the present experiment, we calculated the averages of these measures across all participants for the 'good' and the 'bad' dancers, respectively. Dwell time was measured in milliseconds (ms), and a fixation was defined as directed gaze within an area of 40 pixels with a minimum dwell time of 80 ms.

Procedure

In preparation for the eye-tracking task, participants were instructed to place their chin onto the device's chin-rest, and not to move or speak during the recording phase. They did not receive any particular explanation for the viewing task, except from the statement that they will see male dance characters, as this could have resulted in perceptual expectations, and thus altered focal attention (Duchowski, 2003; Yarbus, 1967). External control of the recording process was achieved remotely via an operator and PC connected via serial interface in a neighbouring room. A 13-point-calibration procedure preceded the presentation of stimuli; here the participant was instructed to focus on a target point, which then automatically moved to different locations on the screen after a minimum fixation of 400ms. Following calibration, the experiment started without delay with the presentation of the first video pair. Half of the participants were assigned to Set 1 and the other half to Set 2 of stimuli. The order of presentation within each set was randomized between participants. A blank stimulus with a fixation cross in the centre of the screen was presented prior to each stimulus scene (1 s) in order to guarantee a constant starting position for each participant. Total viewing time (excluding calibration procedure) was 4 min and 35 s.

After completion, participants were requested to judge the dance videos they saw in the eye-tracking task on perceived attractiveness and masculinity (in blocks), this time in a serial order presentation. Within each block, stimuli were presented in randomised order on a 15.4'' laptop screen set to a resolution of 1440 x 900 pixels, and statements were made on a 7-point Likert-type rating scale (1 = not attractive/masculine, 7 = very attractive/masculine) using Medialab 2006 software (Empirisoft Inc., New York).

Of the 50 women who were initially recruited, data from four participants had to be excluded from the statistical analysis, as the calibration data did not meet the required standards, rendering our final sample to N = 46. To test whether visual attention measures and judgements of 'good' and 'bad' dancers were significantly different from one another, we calculated delta scores of mean dwell time and the number of fixations, and the same for attractiveness and masculinity ratings, by subtracting the scores of 'good' from those of 'bad' dancers.

Results

Mean cumulative dwell time for 'good' dancers ranged from 2115.36 to 7242.40 ms (*M*= 5365.95, *SD* = 1020.27) whereas dwell time for bad dancers ranged from 673.04 to 2944.53 ms (*M*= 2944.53, *SD* = 719.45). Number of fixations ranged from 4.64 to 25.44 (*M* = 13.22, *SD* = 4.06) for 'good' dancers and from 2.28 to 17.44 (*M* = 8.49, *SD* = 3.04) for 'bad' dancers. A one-sample Kolmogorov-Smirnov goodness of fit test indicated no violation of the assumption of normality for the delta scores of visual attention measures and the rating data (all $Z < .98$, all $p > .29$). A one-sampled t-test (against the value of zero), revealed a significant positive deviation for dwell time and number of fixations (dwell: $t_{(45)} = 14.78$, $p < .001$, $d = 3.08$; fixations: $t_{(45)} = 12.66$, $p < .001$, $d = 2.60$; both one-tailed) and also for attractiveness and masculinity ratings (attractiveness: $t_{(45)} = 17.41$, $p < .001$, $d = 3.63$; masculinity: $t_{(45)} = 8.91$, $p < .001$, $d = 1.86$; both one-tailed). Thus, 'good' dancers received significantly higher visual attention (in terms of dwell time and the number of fixations) and were also judged higher on attractiveness and masculinity compared to 'bad' dancers.

Considering the associations of visual attention and rating data, we found that dwell time and the number of fixations correlated significantly positively (Person *r*) with attractiveness (dwell time: $r = .36$, $p < .01$; fixations: $r = .26$, $p < .05$, one-tailed). Masculinity was positively correlated with dwell time and the number of fixations but failed to reach statistical significance (both $r = .13$, both $p = .20$; both one-tailed). Attractiveness and masculinity ratings showed a significant positive correlation with one another ($r = .45$, $p < .001$, one-tailed) (Figure 2).

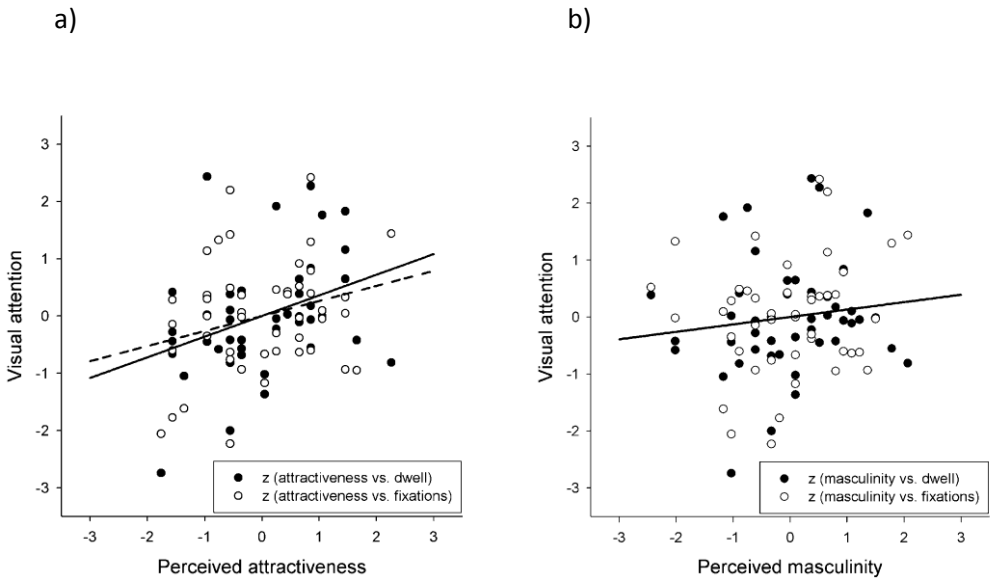

Figure 2. Associations of visual attention measures (dwell time and number of fixations) with perceived attractiveness (a) and masculinity (b) of virtual male characters varying only in dance quality (mean ratings were transformed into z-scores); attractiveness: dwell r^2 = .13, fixations r^2 = .07; masculinity: dwell r^2 = .02, fixations r^2 = .02.

Discussion

We predicted that women would be sensitive to the variation in men's dance quality, such that they would display higher visual attention to 'good' dancers, and also judge them to be higher on attractiveness and masculinity, as compared to 'bad' dancers. Our data supports these predictions as visual attention measures of dwell time and fixations were significantly different between these two groups. In addition, both visual attention measures correlated positively with attractiveness and masculinity ratings, although the associations with masculinity perception failed to reach statistical significance. Thus, we conclude that 'good' and 'bad' dancers differ in certain movement properties, and that women are sensitive to these differences, particularly with regard to attractiveness perception. Moreover, the nature of the attentional and perceptual differences seems to be grounded purely in motion cues, i.e., independent of face/body morphology, given that the stimuli used in this present study were featureless virtual humanoid characters that varied only in their dance movements. As such, our data underline the significance of body movements in attractiveness perception in its own right.

Our findings sit comfortably alongside recent research showing that male dance movements convey physical and personality properties that women 'use' in their attractiveness decisions regarding men (Fink et al., 2012; Hugill et al., 2011; Neave et al.,

2011). These studies have been influenced by the evolutionary psychology approach to the understanding of women's preferences for certain male cues that are particularly relevant in terms of partner selection (Grammer et al., 2003; Rhodes, 2006), and there is corroborating evidence that the same perceptual mechanisms and evolutionary principles that were demonstrated in research on face/body attractiveness also apply to body movement.

With regard to visual attention and gaze allocation, Foulsham et al. (2010) reported that status hierarchy could predict participants' eye gaze, such that high-status individuals in a group-decision-making task received most attention. Hence, these authors concluded that the human gaze system is attuned to the social status of individuals, as deriving status information is most useful in social interaction. Interestingly, it seems that information, which is most relevant in social interaction (e.g. action, gender and identity), can be obtained from body movement within a very short time. Foulsham et al. initially recorded 20 min of discussion among individuals, but presented only 20 s to panellists in the eye-tracking paradigm, and were still able to discern high from low status individuals (in terms of visual attention). Fink et al. (2008) presented five shape-standardized female faces, varying only in skin colour distribution, on one screen for 15 s, and Maner et al. (2003), in one study investigating men's and women's mating-related motives, presented male and female facial photographs for only 4 s. In the present study women viewed 10 s of men's dance movements and could discern between 'good' and bad' dancers (in terms of perceived attractiveness). Thus, it seems that even within very short time, people are highly selective with regard to their visual attention and social preferences.

Maner et al. (2003) also showed that women selectively attended to physically attractive male targets (faces) and that attentional capacity did not lead to biased estimates of attractive men, thus arguing for the existence of a cognitive bias which facilitates mating-related motives (see also Rupp & Wallen, 2007). Our present data suggests that a cognitive bias not only exists for women's perception of men's faces, but also for female gaze allocation to male body movements. We argue that women are sensitive to male dance quality, such that they spend higher visual attention to 'good' dancers, as these men display certain 'quality' characteristics via their dance moves, that women have a preference for. In considering the findings of Neave et al. (2011) it seems that variability in male dance movements particularly attracts female attention. According to the ecological theory of social perception (McArthur & Baron, 1983), cognition is selectively attuned to adaptively relevant features in the environment, and it has been argued that physical attractiveness is

one of the most prominent cues, presumably because it concerns a fundamental aspect of human social behaviour, i.e., mate selection. Using male faces as stimuli, Maner et al. (2003) showed that attractive male targets capture the mind of women, as women selectively attended to good-looking men. Maner et al. admitted that one of the limitations of their research was the use of static, rather than dynamic, stimuli, and they suggested that dynamic stimuli would perhaps provide stronger evidence for the selective processing of features in mating-related context. The results of this present study, using dynamic displays (i.e., dance movements) of men, and studying the relation of women's visual attention to and attractiveness judgements of them, support Maner et al.'s prediction, although it is clear that future studies should also employ more complex scenarios to investigate selective visual processing of dynamic features.

Finally, previous studies have reported positive and significant associations of women's attractiveness and masculinity perceptions of male facial and body morphology (Fink et al., 2010), the present study detected a significant positive association of dance quality only with attractiveness (but not masculinity) judgements. We do not necessarily consider this as a result that stands in contrast to previous reports on associations of male physical strength with women's perceptions of attractiveness, masculinity and assertiveness of their dances (Hugill et al., 2009), as our key feature was perceived dance quality, while in the Hugill et al. study it was physical strength. However, taken together, these results argue for some caution with regards to the (correlational) use of attributes in studies on human mate preferences. Windhager et al. (2011) arrived at a similar conclusion when they studied male physical strength in relation to both face shape and women's perceptions of facial attractiveness, masculinity and dominance. These authors reported that physical strength was more strongly associated with face shape changes that relate to perceived masculinity and dominance than to attractiveness, suggesting that masculinity/dominance and attractiveness may reflect different aspects of male mate quality. Applying this finding to our present result, we may speculate that women's attractiveness and masculinity perception of men's dances capture different aspects of dance quality. Thus, future studies on dance quality and its perception should aim to identify additional features to those reported (digit ratio, physical strength, symmetry), such as artistic performance and creativity, and test the proportion of variation they account for in attractiveness assessments.

Acknowledgements

This project was funded by the German Science Foundation (DFG), grant number FI 1450/4-1, awarded to Bernhard Fink, as well as through the Institutional Strategy of the University of Goettingen, Germany. We express our thanks to Nick Neave from Northumbria University, UK, who helped with improving an earlier version of the manuscript.

CHAPTER II

PHYSICAL STRENGTH AND DANCE ATTRACTIVENESS: FURTHER EVIDENCE FOR AN ASSOCIATION IN MEN, BUT NOT IN WOMEN

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American Journal of Human Biology (2015), 27 (5), Pages 728-730

Abstract

Objectives: Physical strength provides information about male quality and can be assessed from facial and body morphology. Research on perception of dance movements indicates that body movement also provides information about male physical strength. These relationships have not been investigated for women. Methods: We investigated relationships of handgrip strength (HGS) and dance attractiveness perception in 75 men and 84 women. Results: We identified positive relationships between HGS and opposite-sex assessments of dance attractiveness for men but not women. Conclusions: The replication of previous research investigating relationships between dance attractiveness and physical strength in men corroborates the hypothesis that dance movements provide information about male quality. We argue that these relationships are interpretable in contexts of inter- and intra-sexual selection.

Keywords: physical strength; handgrip; dance; attractiveness; males; females.

Introduction

Physical strength is sexually dimorphic. Men are typically stronger than women (Hoffman et al., 1979), particularly in upper body muscularity. Men have 75% more muscle mass than women (Lassek and Gaulin, 2009). Muscular strength is correlated positively with measures of male health (e.g., bone-mineral density: Kritz-Silverstein and Barrett-Connor, 1994; physical functioning: Fredericksen et al., 2002; cardiorespiratory fitness: Vaara et al., 2012) and negatively with male mortality (Rantanen et al., 2000). Isen et al. (2014) concluded from analyses of 2513 adolescent twins that the additive genetic variance of handgrip strength (HGS; a correlate of upper body muscularity; Wind et al., 2010) is higher in men than in women. Although heritability of HGS is high in both sexes, Isen et al. suggested that male strength shows greater phenotypic variance due to sex-related genetic expression, rendering men more susceptible to androgenic effects on the development of HGS.

People can accurately assess male strength from facial and body images and use this information to evaluate male fighting ability (Sell et al., 2009). Research has also documented associations of HGS and male facial configuration (Windhager et al., 2011) with physically strong men having round faces, wide eyebrows and a prominent jaw outline. Additionally, Fink et al. (2007) found that women rated faces of physically strong men as attractive, dominant and masculine. Preliminary investigation about whether dynamic cues (i.e., body movement) provide information about physical strength suggests that this is the case, at least in men. Hugill et al. (2009) reported a positive correlation of HGS and female perceptions of dance attractiveness and assertiveness in men. McCarty et al. (2013) found that male HGS correlated positively with female (and male) dance quality judgments. Physically stronger men displayed larger, more variable and faster movements of their arms. Taken together, these findings suggest that information about male strength is not only present in static representations of facial and body morphology but also in body movement, such as dance.

The present study aimed to replicate previous reports on relationships of male HGS and dance movement perception, and extend this to the study of women. Hugill et al. (2009) and McCarty et al. (2013) reported associations of HGS and dance attractiveness/quality in men only; thus, it is not known whether such relationships are generalizable to women. Given Isen et al.'s (2014) data on sex differences in the development of HGS and Sell et al.'s (2009) report on the adaptive consequences of assessing strength from static cues, we hypothesized that this would not necessarily be the

case, i.e., we expected to find positive relationships between HGS and opposite-sex assessments of male (but not female) dance attractiveness.

Materials and Methods

Participants were 80 men and 86 women, aged 18 to 42 years, recruited mainly from the student population at Northumbria University (U.K.) as part of a larger study on body movement. They reported to be non-professional dancers and not affected by injuries that might influence their natural movements.

Handgrip strength (HGS; kgf) was measured with a hand dynamometer (Takei Kiki Kogyo K.K., Japan), twice for each hand, and the grand mean of the two left and two right HGS measurements was used in the analysis. Body height (cm) and weight (kg) were measured to calculate body mass index (BMI) - a positive correlate of HGS (Chandrasekaran et al., 2010) - using Quetelet's equation [BMI = mass (kg)/height $(m)^2$].

Dance movements were recorded with an optical motion capture system (Vicon, Oxford, UK) running Vicon Nexus software. Thirty-nine reflective markers were attached to each participant's major joints and body parts (Plug-in-gait marker set). Participants were instructed to dance for 30 seconds to a basic drumbeat as they would in a nightclub. Dance recordings were then applied onto size- and shape-standardized, gender-neutral humanoid characters using Motionbuilder (Autodesk Inc., San Rafael, CA, USA) and rendered as 773 x 632 pixel video clips. Fifteen-second sequences were isolated from the middle of each dance video (same location in the video for all dancers) for the subsequent rating study (see also Hufschmidt et al., 2015; Weege et al., in press). The recordings of two women for which technical problems in post-processing of dance movements occurred were excluded from the rating study.

Dance videos were shown to 50 male and 40 female students at the University of Göttingen (Germany), who were asked to judge the attractiveness of the dancers on a Likert-type scale (1 = 'very unattractive'; 7 = 'very attractive'). Video clips were presented to opposite-sex raters in randomized order on a 15.4'' laptop computer. The judgments of four non-heterosexual raters (by self-report) were excluded prior to analysis, reducing the sample of raters to 49 men aged 19 to 30 years (*M* = 23.71, *SD* = 2.82) and 37 women aged 17 to 46 years (*M* = 23.96, *SD* = 4.82).

Five male dancers were not heterosexual (by self-report) and their reports were excluded prior to analysis. The final sample of dancers was 75 men (aged 18 to 42 years, *M* = 21.76, *SD* = 4.09) and 84 women (aged 18 to 41 years, *M* = 20.61, *SD* = 3.80).

Results

Table 1 presents descriptive statistics of anthropometric measurements (HGS, height, weight) and indices (BMI) of dancers. Female attractiveness ratings of male dancers ranged from 1.86 to 4.78 (M = 3.27, SD = .67) and male attractiveness ratings of female dancers ranged from 1.73 to 5.29 (M = 3.67, SD = .76). There was high inter-rater reliability among raters' attractiveness assessments of dancers (Cronbach's alpha; female raters = .89, male raters = .91).

Lilliefors tests indicated no significant deviation from normal distribution for HGS measurements (Zs < .07, ps > .20) and attractiveness ratings (Zs < .10, ps > .05). BMI of male and female dancers was not normally distributed (Zs > .10, ps < .03) due to outliers identified by visual inspection of histograms. We therefore log (base 10) transformed BMI (into BMI_{log}) for analysis. BMI_{log} showed no significant deviation from normality (Z < .10, p > .07).

Zero-order correlations revealed a positive correlation of HGS with dance attractiveness in men (r = .27, p < .01, one-tailed), but not in women (r = .002, p = .49, one-tailed). HGS correlated positively with BMI_{log} in both male and female dancers (rs > .30, ps < .01). BMI_{log} showed no correlation with dance attractiveness in men (r = .02, p = .42, one-tailed) or women (r = -.009, p = .47, one-tailed). Recalculating the relationships between male and female HGS and attractiveness ratings of their dances by conducting partial correlations (r_p)—thus controlling statistically for the affect of BMI_{log} on HGS—revealed similar results as with zero-order correlations (men: r_p = .27, p < .01; women: r_p = .01, p = .48, both p one-tailed).

Table 1. Descriptive statistics of HGS, body height, weight and BMI of male (n = 75) and female (n = 84) dancers.

	Male dancer			Female dancer		
	Max	Max	Mean (SD)	Min	Max	Mean (SD)
HGS (kgf)	13.88	59.25	37.33 (8.60)	10.75	44	23.25 (5.68)
Height (cm)	163	192.6	176.61 (6.65)	148	176.5	164.32 (6.46)
Weight (kg)	51.7	127.3	77.08 (12.93)	39	102.5	62.14 (10.79)
BMI	17.95	41.57	24.68 (3.81)	16.03	35.68	22.99 (3.53)

Discussion

The results support the hypothesis that men's but not women's dance movements convey information about physical strength (Hugill et al., 2009; McCarty et al., 2013). Women judge physically stronger dancers (measured by HGS) to be more attractive. Previous studies have reported female preferences for male facial and body cues that signal physical strength (Fink et al., 2007; Sell et al., 2009), and geometric morphometric investigation indicates that HGS is related to specific male facial configurations (Windhager et al., 2011). The current results corroborate the finding that men's dance movements provide information about physical strength.

This seems plausible for two reasons. First, male dance may signal information about health—a quality that women prefer in mates. Second, dance may signal information about male competitiveness and strength—a quality that influences male-male fighting ability. Our results on opposite-sex attractiveness assessments of dances do not permit conclusions about male perception of other men's competitiveness (regarding fighting ability), and this is an avenue for future research. However, the two scenarios are not necessarily mutually exclusive, given that women prefer men who have attained status, or those who signal the capacity to achieve status via social dominance. Attractiveness assessments alone do not explain whether women consider a man's dance attractive because attractiveness assessments signal male quality in terms of health and "good genes" or cues of social dominance. Moreover, in the present study we asked only opposite-sex individuals to judge dance attractiveness. It remains to be investigated whether men's assessments of other men's dances follow those of women. Future research should ask both

sexes explicitly about perceptions of, for example, fighting ability, dominance, and masculinity, in addition to attractiveness.

In this context, it is noteworthy that in addition to physical strength, research has documented positive relationships of women's assessments of the attractiveness and assertiveness of men's dances (Hugill et al., 2009) and also positive associations of dance attractiveness and sensation-seeking (Hugill et al., 2011). Given Isen et al.'s (2014) conclusions about stronger genetic and androgenic influences on HGS development in men than in women, information about male dominance and status from dance may also be mediated by androgen action. Fink et al. (2007) reported that digit ratio (2D:4D)—a proxy of prenatal androgenization—correlates with women's attractiveness, masculinity, and dominance assessments of men's dances. Men with lower 2D:4D (high prenatal testosterone) were judged higher on these attribute, suggesting an organizational effect of testosterone on men's dance quality. Likewise, 2D:4D correlates negatively with HGS in men (but not in women) (Fink et al., 2006; Hone et al., 2012). Recent research further shows that HGS correlates positively with gender identification from men's (but not women's) dances (Hufschmidt et al., 2015). In conclusion, these findings suggest that dance movements convey information about male strength through the effects of prenatal androgenization on strength and that such information is not present in women.

Acknowledgements

We thank Nick Neave and Kristofor McCarty for granting us access to the Newcastle Gait Lab at Northumbria University (U.K.). This work was funded by the German Science Foundation (DFG), grant numbers 1450/4-1 and FI 1450/7-1 awarded to B.F.

CHAPTER III

WOMEN'S ATTRACTIVENESS PERCEPTION OF MEN'S DANCE MOVEMENTS IN RELATION TO SELF-REPORTED AND PERCEIVED PERSONALITY

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Evolutionary Psychological Science (2015), 1, Pages 23-27

Abstract

Recent research on women's ratings of men's dance movements indicates that women derive similar cues of male 'quality' (e.g., physical strength) from movement as from faces and bodies. Whether this extends to personality assessments is yet unclear. We recorded dance movements of 80 men using 3D optical motion-capture technology and secured self-reports of men's personality standings. Dance movements were applied to a uniform, shape-standardized virtual humanoid character (avatar) and presented to women as 15 sec. videos for attractiveness and personality ratings. Women's ratings of dance attractiveness correlated negatively with men's self-reports and women's ratings of men's neuroticism, and were positively correlated with men's self-reported extraversion and women's ratings of men's conscientiousness. Men's self-reported personality scores did not correlate with women's ratings of men's personality standings. Findings are discussed with reference to previous research and the social significance of dance movement cues and impression formation.

Keywords: dance, men, personality, attractiveness, stereotype

Introduction

The morphology of the face and body affects social perception (Fink & Penton-Voak, 2002; Gangestad & Scheyd, 2005; Grammer et al., 2003; Rhodes, 2006). Dion et al. (1972) documented that people attribute desirable personality characteristics to attractive people—the 'what is beautiful is good' stereotype. Although this heuristic is often regarded as bias in social perception, people sometimes use such stereotypes to identify prospective romantic partners with personality characteristics they desire (Little et al., 2006; Zhang et al., 2014).

Little et al. (2006) asked men and women to report the personality characteristics they desire in a romantic partner and then rate the attractiveness of composite facial images. Two groups of composite images were created such that blends of the most attractive faces were either based on desired or non-desired personality characteristics. A subsequent test of participants' ability to attribute personality characteristics to these composites documented that participants who desired certain personality characteristics rated faces associated with these characteristics as more attractive. Little et al. suggest that attractiveness is not an unspecific attribution but instead reflects attribution of desired personality characteristics. In short, people may provide higher attractiveness ratings when they perceive – based on facial appearance – that the target has desired personality characteristics. Zhang et al. (2014) arrived at a similar conclusion, when they requested facial attractiveness ratings in the presence or absence of personality information. Faces presented with positive personality information were rated highest on attractiveness, followed by those with no personality information and faces with negative personality information. Zhang et al. concluded that personality trait manipulation influences attractiveness ratings, such that faces reflecting desired traits are rated more attractive.

Gait cues can also affect trait ratings, particularly when making social decisions when cues of facial and body morphology are less visible. For example, Thoresen et al. (2012) presented point-light walking of motion-captured men and women to participants, who were asked to rate them on major personality dimensions. As in previous studies (e.g., Ambady & Rosenthal, 1993; Montepare & Zebrowitz-McArthur, 1988), there was high agreement among raters, although there was no correlation of self-reported with perceived personality. Moreover, there were no associations of motion parameters with self-reported personality. Hence positive relationships between self- and other assessments of personality may hold only for certain stimuli (e.g., faces; Penton-Voak et al., 2006).

In the present study, we investigated women's attractiveness and personality ratings of men's dance movements in relation to self-reported personality of male dancers. Dance is a complex form of human movement, which is observed in courtship situations in almost all human societies (see for review Hanna, 1987, 2010; Hugill et al., 2010). It has been reported that male dance conveys aspects of mate quality such as physical strength (Hugill et al., 2009; McCarty et al., 2013) and sensation seeking (Hugill et al., 2011), with dances of physically strong and risk-taking men rated more attractive by women. Moreover, Fink et al. (2012) reported positive correlations of men's self-reported agreeableness and conscientiousness with women's ratings of men's dance quality. Such studies provide information about women's preferences for the dance movements of men with certain personality characteristics, but it is not known whether women's preferences are linked to the personality of the dancer, which would imply women's ability to accurately assess personality traits from dance. From an evolutionary viewpoint such capacity would have been beneficial when assessing the personality of unfamiliar men, especially in courtship situations, in order to prevent women from male aggression and other cost-inflicting behavior. Accurate personality assessment via dance movements cannot be assumed, given the results of previous research indicating inaccurate personality assessments based on faces and gaits. Hence, inferences about dancer personality via ratings of dance attractiveness may be based on displays expressed in dance that do not match (and are not caused by) self-reported personality.

We hypothesized that women's attractiveness ratings of men's dances would correlate positively with women's ratings of men's extraversion, openness, agreeableness, and conscientiousness, and would correlate negatively with ratings of men's neuroticism. Despite reports of positive relationships of women's ratings of men's dance quality with men's self-reported agreeableness and conscientiousness (Fink et al., 2012), our expectations about the relationships of men's self-reported personality with women's dance attractiveness ratings are less certain. Fink et al. had women rate men's dances on quality (good vs. bad), and quality assessments may differ from attractiveness assessments. In addition, Fink et al. reported a positive correlation of men's self-reported extraversion and a negative correlation of men's self-reported neuroticism with women's ratings of men's dance quality, but both correlations were non-significant, perhaps because of low statistical power (n = 48 men). However, considering these findings together with the fact that the present study investigated a larger sample of male dancers, we hypothesized that dance attractiveness ratings would show similar relationships with self-reported personality to

those with personality ratings. Finally, based on previous research reviewed above, we did not expect significant correlations between male dancers' self-reported personality and women's ratings of dancers' personality.

Materials and Methods

Participants

Eighty men aged 18 to 42 years (*M* = 21.61, *SD* = 4.01) participated. Participants were recruited from the student population at Northumbria University (UK). Participants were not professional dancers and had not experienced injuries that might affect their natural movement. Five men were not heterosexual (by self-report) and were excluded from statistical analyses. The age of the final sample of 75 heterosexual male dancers ranged from 18 to 42 years (*M* = 21.76, *SD* = 4.09).

Self-reported personality

Prior to dance recordings, each participant completed the 60-item NEO-FFI personality inventory, which is widely used to measure the five major dimensions of adult personality (neuroticism, extraversion, openness to experience, conscientiousness and agreeableness) (Costa & McCrae, 1985, 1992). Scores for each dimension range from 0 to 4.

Dance movements

Dance movements of each participant were recorded using a 3D-optical motion capture system comprising 12 near-infrared cameras (T20 Pentax lenses, Vicon, Oxford, UK) and running Nexus Software (Vicon Nexus 1.5.1 & 1.7.1). Following the Plug-in-gait marker placement set, 39 reflective markers were affixed to participant's major joints and body parts and movement of these markers was recorded at a rate of 200 frames per second. Participants were instructed to dance for 30 sec in the way they would usually move in a nightclub. To control for music preferences, the same 125 bpm repeated drum pattern was played to each participant. As described in Fink et al. (2012), dance movements were then applied to virtual, gender-neutral, form-standardized humanoid figures (avatars) using Autodesk Motionbuilder 2011 (Autodesk Inc., San Rafael, CA, USA). For dance ratings, 15 sec clips were selected from the middle of each participant's dance recording and presented as 24 fps, 773 x 632 (attractiveness) / 400 x 328 (personality) pixel sized videos, without audio.

Attractiveness ratings

Forty female volunteers were recruited from the student population of the University of Göttingen. On 15.4'' laptop computers they were randomly presented all 80 dance videos and asked to judge each dance on attractiveness using a 7-point Likert scale anchored by 1 = 'very unattractive' and 7 = 'very attractive'. After eliminating ratings provided by three self-reported non-heterosexuals, the responses of 37 heterosexual females (17 to 46 years; *M* = 23.96, *SD* = 4.82) were included in the analysis.

Personality

A total of 227 participants (men and women) were recruited from the student population of the University of Göttingen. Fifty-one participants did not complete the ratings and their data were therefore excluded. With respect to sexual orientation, data from a further six participants were excluded. For the present study we considered women only. Thus our final sample comprised 102 heterosexual women (18 to 57 years; *M* = 25.10; *SD* = 7.63). Using Qualtrics online survey software on 15.4'' Laptop computers, each participant viewed 20 randomly selected dances and was asked to assess the personality traits of the dancer. Judgments were made on five bipolar scales [with scores ranging from 1 (low on dimension) to 5 (high on dimension)] representing the five major dimensions of personality. Two pairs of traits described each dimension (one pair appearing left and the other right from the scale on the screen). Items were taken from the German version of the Ten-Item Personality Inventory (TIPI; Gosling et al., 2003; Muck et al., 2007). The order of scales was randomly arranged across participants.

Results

One-sample Kolmogorov-Smirnov tests for goodness of fit revealed no deviations from normality for men's self-reported personality scores, dance attractiveness ratings, or women's personality attributions (all *Z*s < 1.15, all *p*s > .15). Calculated means of dance attractiveness ratings ranged from 1.86 to 4.78 (*M* = 3.27, *SD* = .67) and there was high agreement across judges (Cronbach's alpha = .89).

Women's dance attractiveness ratings correlated negatively with men's self-reported neuroticism (*r* = -.23) and positively with men's self-reported extraversion (*r* = .22) (both *p*s < .05, these and subsequent *p*s are one-tailed). Self-reported openness to experience, conscientiousness, and agreeableness of dancers did not correlate with attractiveness ratings (all *r*s < .13, all *p*s > .13). In addition, dance attractiveness ratings correlated negatively with women's ratings of dancer neuroticism (*r* = -.28, *p* < .01),

positively with women's ratings of dancer conscientiousness (r = .35, p < .01), but were not correlated with women's ratings of the three other dancer personality dimensions (all rs < .11, all ps > .18).

Men's self-reported personality scores did not correlate with women's ratings of dancer personality scores (all rs < .18, all ps > .07). Table 1 reports inter-correlations of men's self-reports and women's ratings of personality. The following relationships were significant after Bonferroni corrections. Self-reported neuroticism correlated negatively with self-reports on extraversion, conscientiousness and agreeableness, and self-reported agreeableness.

Women's personality ratings based on men's dance movements revealed negative correlations of neuroticism with extraversion and openness. Extraversion correlated positively with openness and negatively with conscientiousness.

Finally, we did not detect any significant correlation of dancers' age and self-reported personality (all rs < .19, all ps > .05) and perceived personality (all rs < .10, all ps > .20).

Table 1. Inter-correlations of men's self-reports and women's ratings of personality from dance movements.

	1	2	3	4	5
	Self-reported personality				
1. Neuroticism	--	**-.45****	-.21*	**-.28****	**-.28****
2. Extraversion		--	.05	.17	.23*
3. Openness			--	-.06	.24*
4. Conscientiousness				--	.24*
5. Agreeableness					--
	Rated personality				
1. Neuroticism	--	**-.88****	**-.89****	.08	.25*
2. Extraversion		--	**.97****	**-.35****	.08
3. Openness			--	-.26*	.17
4. Conscientiousness				--	.28**
5. Agreeableness					--

* p <.05, ** p < .01 (one-tailed); Note: Correlations in bold were significant after Bonferroni correction.

Discussion

Women derive quality cues (e.g., physical strength) from men's dance movements and rate these cues as attractive (see for review Hanna, 2010; Hugill et al., 2010; Fink et al., 2014). Comparably little is known about the relationship of men's personality and women's assessments of dance attractiveness, although some research suggests that aspects of personality are conveyed through dance movements (Fink et al., 2012; Hugill et al., 2011). The current research failed to find relationships between men's self-reported personality and women's ratings of men's personality from men's dance movements. Thus, women were not able to accurately assess men's personality from dance movements - a result that corroborates research investigating relationships of self-reported personality with observer-reports of personality based on gait (Thoresen et al., 2012).

Although research on personality perception from faces suggests there is a 'kernel of truth' in trait impression (e.g., Berry, 1990; Penton-Voak et al., 2006), accurate trait ratings may not be derivable from body movement. Thoresen et al. concluded that reliability of trait ratings in point-light walkers is driven by impressions of emotion, attractiveness and masculinity rather than raters' abilities to accurately derive personality from motion cues. In other words, agreement in assessments of others at first impression may be driven by other cognitive mechanisms, which then produces agreement in assessments of, for example, attractiveness.

Studies using facial stimuli indicate that personality attributions are affected by raters' valuations of personality (Little et al., 2006; Zhang et al., 2014). We did not ask our female participants to report desired personality characteristics before they rated male dancers on attractiveness and personality. However, our findings on associations of perceived attractiveness and personality (conscientiousness and neuroticism) suggest that these ratings were not independent. These correlations per se do not identify causal relationships: Did women rate a dancer as attractive because they responded positively to personality cues derived from body movements, or did they rate a dancer as attractive for other reasons and – in consequence – assign 'positive personality' to them?

Our finding of a negative correlation of men's self-reported neuroticism and a positive correlation of men's self-reported extraversion with women's ratings of dance attractiveness suggests that men scoring low on neuroticism and high on extraversion perform attractive dance movements. But these findings do not mean that women perceive these traits as such when being prompted for personality attributions. There may be certain male movements associated with particular personality traits, such as extraversion and

neuroticism, and women perceive these movements as attractive. Alternatively, women may perceive certain dance movements as attractive and then associate positive or negative personality traits with these movements in the sense of the attractiveness stereotype (Dion et al., 1972). Finally, assessments of dance attractiveness may be produced by combination of both cognitive processes. In this context, it is interesting that dance attractiveness ratings were correlated with both men's self-reported neuroticism of women's ratings of men's neuroticism. This could indicate that men's dance movements linked to neuroticism are particularly important in women's dance attractiveness assessments. Sensitivity to movement cues that signal neuroticism suggests a mechanism of dance attractiveness assessments similar to what has been reported for assessments of face and body attractiveness assessments (Grammer et al., 2001).

Gigerenzer and Goldstein (1996) have argued that humans make inferences about uncertain aspects of the world under limited time and knowledge, following cognitive heuristics. Grammer et al. (2001) tested these "fast and frugal" algorithms by applying them to attractiveness assessments of female faces and bodies and found that "avoid the worst" best describes how humans arrive at attractiveness assessments. From an evolutionary perspective, attractiveness assessments may follow such an algorithm, which would widen the pool of potential partners. According to this logic, first impressions about the attractiveness of an individual are not made by identifying highly attractive features but by being sensitive to the worst features (Cyrus, 2010). The dance attractiveness and neuroticism link, in men's self-reports and women's attributions of dance, may be produced by just such cognitive mechanisms, i.e., sensitivity to neuroticism cues in men's dance movements may be advantageous for women to attend to, given possible links of neuroticism with aggression and other cost-inflicting behavior (Hines & Saudino, 2008; Moeller et al., 2010).

The present study did not investigate the biomechanical characteristics linked to personality. This is an avenue for future research. A recent study (Neave et al., 2011) reported that good dancers display larger and more variable movements in relation to bending and twisting of their head/neck and torso. These authors concluded that certain aspects of movement amplitude, speed, and variability are also important for female perceptions of male dancing ability. In the classic Heider and Simmel (1944) study, participants attributed intentional movement and goal-directed interactions to shapes, despite the absence of explicit social cues. Basic features of these objects, together with movement were sufficient to cause social attributions (Barrett et al., 2005; Dittrich & Lea,

1994; Runeson & Frykholm, 1983). These fundamental movement characteristics may also affect perceptions of human dance such that people who associate elements of a dance with desirable personality characteristics as a consequence rate that dance as more attractive.

Finally, one limitation of this study could be the sample size (75 male dancers). Personality relationships with physical and behavioral traits are typically low. Significant associations are typically difficult to detect in small samples and if present they could be due to sampling effects. Thus the reported significant correlations of women's attractiveness judgments with men's self-reported personality and perceived personality from dances certainly require further investigation and replication in larger samples.

In conclusion, the present study documents that women's attractiveness assessments of men's dance movements are related to aspects of male personality, although men's self-reported personality did not correlate with women's ratings of men's personality. Our data indicate that neuroticism, in particular, is associated with certain dance movements, and this may affect women's assessments of men's dance attractiveness. Future research should test explicitly whether female psychology includes sensitivity to displays of neuroticism in an effort to avoid such men, rather than preferences for men that display high quality through dance movements. Another extension of this present study is certainly a test for possible sex differences in the accuracy of personality perception from dance, including the possibility that men perceive dance movements of other men differently than women in the context of male rivalry. We speculate that men do not necessarily share the female sensitivity to detect negative personality from dance movements but rather attend to cues signalling extraversion in believing that women admire extraverted men, though again, this needs to be confirmed in future research.

Acknowledgements

We thank Nick Neave and Kristofor McCarty for granting us access to the Newcastle Gait Lab at Northumbria University (U.K.). This work was funded by the German Science Foundation (DFG), grant numbers 1450/4-1 and FI 1450/7-1 awarded to B.F.

GENERAL DISCUSSION

Mate selection has always been an important adaptive problem that many species, including humans, have to solve. Evolutionary psychologists argue that human social perception is to some extent driven by mental adaptations that have been shaped by selection pressure. Preference for certain features in physical appearance is thought to be one of the evolved cognitive mechanisms that drive our perception of attractiveness and thus facilitates mate related motives (e.g., Buss, 2008; Grammer et al., 2003). Evidence for this assumption is based on investigations of static representations of the face and body. Given social perception involves dynamic interaction, the signalling value of body movements is comparably understudied. The aim of this work was therefore to investigate the role of human body movements in social perception using the example of women's perception of mate quality cues from male dance movements.

The first study **(Chapter I; Weege et al., 2012)** addressed whether women pay more visual attention - in terms of number of fixation and dwell time - to "good" dancers compared to "bad" dancers, and whether they evaluate them as more attractive. The data suggest that women selectively process male dance movements for which they show a preference.

The second study **(Chapter II; Weege et al., 2015b)** tested the association between attraction to the opposite sex based on dance movements and physical strength (as measured via HGS), as a measure for a dancer's health and fitness. As expected, the study found that the attractiveness perception of men's but not women's dance movements was positively correlated with physical strength.

The third study **(Chapter III; Weege et al., 2015a)** aimed to investigate the role of men's personality on women's perception of male dance movements. Although research on the perception of gait has not provided evidence for trait attribution (Thoresen, Vuong, & Atkinson, 2012), it remains unknown whether this finding can also be extended to the perception of dance movements. The present study's outcome is in line with Thoresen et al.'s findings, as women were not able to accurately judge male personality from motion cues alone. Nevertheless, it was found that women's ratings of male dancer's attractiveness correlated negatively with men's neuroticism and positively with men's extraversion. Additionally, women's perception of male dancer's attractiveness correlated negatively with

women's ratings of dancer's neuroticism and positively with women's ratings of male dancer's conscientiousness.

The findings of this thesis corroborate the assumption that women are sensitive to variation in male dance movements and derive certain physical aspects from male dances similar to what was found for faces and bodies. This does not extend to the perception of male personality characteristics, although women seem to stereotypically assess personality from dance for the purpose to avoid neurotic men. Therefore body movements seem to play an important role in social perception.

People constantly form impressions of others and make decisions based on them in social situations. Often these assessments of others are imperfect in their accuracy, but they serve a simplification of the complexity in social perception. The basis of such mental processes is the selective attention to relevant information. Relevance is context-dependent but the ultimate function of selective attention and cognitive processing is problem solving at various endpoints. One of the central adaptive problems of all sexually reproducing animals including humans is mate acquisition. The identification of potential partners with desirable mate qualities is crucial to the enhancement of an individual's reproductive fitness. Evolutionary approaches to investigate mating related behaviour usually focus on superior mental processes (e.g., judgements on attractiveness) rather than early stages of social perception. The eye is the first instance visual input impinges on. Social signals relevant for mating decisions are diverse, but attentional capacity is limited. Information therefore competes for representation, analysis or control in the downstream cortical areas (Desimone & Duncan, 1995). It is suggested that the focus of eye gaze reflects the process the cognitive system selectively evaluates in a given moment (Maner et al., 2003). In other words, what is of immediate interest to the observer (Langton, Watt, & Bruce, 2000). However, visual attention and judgement of select stimuli are two distinct processes.

The first study of this thesis **(Chapter I; Weege et al., 2012)** combined both processes. Eye-tracking technology was applied to study women's visual attention to male dance movements and their associated attractiveness evaluations. Thus, the study added ecologic validity to dance movement perception. The study investigated a typical dynamic setting that occurs in many social situations, such as nightclubs or public festivals, while keeping cues other than motion constant. The findings suggest that women are sensitive to variation in male dance movements, and selectively attend to what they subsequently perceive as attractive. This is in line with research proposing that humans have a cognitive

bias towards attractiveness ("beauty captures the mind of the beholder" theory; Maner et al., 2003), in that men and women selectively attend to attractive faces rather average looking faces. Why do women attend more strongly to what they perceive as attractive (here "good" dancers), and not to dance moves that are especially odd, quirky or very "bad"? Considering the "negativity bias" - the general tendency of humans to be drawn to "bad" news (Trussler & Soroka, 2014) - women's gaze also could have been captured by dances that are curious rather than attractive. This was not the case. Women's selective attention to "good dancers" and mental processes of attractiveness perception seem to underlie evolutionary constrains, in the sense of directing attention automatically to what is "good" for them. Only the information that receives attention can subsequently be processed by adaptive mechanisms that guide mating-related decisions and actions. The study in **Chapter I (Weege et al., 2012)** supports the findings that come from facial stimuli, showing that a perceptual bias towards what is attractive also exists for dance movements. Whether they like it or not, women automatically make a distinction between attractive or unattractive already at early perceptual levels. Although this process seems to be bounded, the selective attunement to what is "good" is sensible in evolutionary terms, given that "good" may be indicative for potential mate qualities.

In a biomechanical assessment of male dancers, Neave et al. (2011) found that variable and large movements of the head, neck and trunk characterize a "good" male dancer. The authors speculated that dance movements may signal a men's physical fitness and health, following the logic that movements high in amplitude, variability and speed can only be displayed by individuals that possess certain physical condition and overall quality, including strength and flexibility. Evidence for this assertion may be derived from the observation that complex male motor displays play an important role for female mate choice in many species, such as birds (Barske et al., 2011; Coleman, Patricelli, & Borgia, 2004; Williams, 2001), spiders (Clark & Morjan, 2001; Singer et al., 2000), even flies (Maynard-Smith, 1956)(see for review Byers et al., 2010). One of the rare examples for dance-like courtship displays in mammals comes from the closest living relatives to humans, the Chimpanzees (*Pan troglodytes*). Van Lawick-Goodall (1968) observed that male Chimpanzees perform a ritualized form of bipedal locomotion - the so-called "bipedal swagger" - to attract females, by standing upright with slightly hunched shoulders and arms sidewise away from the body, swaying rhythmically from foot to foot. Although the term "dance" is not well defined, complex male motor behaviours that do not primarily serve locomotion seem to have evolved through sexual selection pressures. Dance might

therefore be a costly and sophisticated male trait that females use to base their mate decisions on. Based on literature on courtship dances in animals, it is suggested that human dance may also have a long evolutionary history (Sheets-Johnstone, 2005). Darwin (1871) suggested that dance displays play an important role in human social interaction, operating in behalf of sexual selection processes. However, until today, not much is known about the signalling qualities of human dance movements, possibly due to its complexity and involvement of many bodily structures and mental processes (such as coordinating control). But if sexual selection pressure acts on the perception of dance, it should have signalling character in terms of the dancer's physical or genetic qualities (Hugill, Fink, & Neave, 2010).

The second study **(Chapter II; Weege et al., 2015b)** investigated physical strength as one factor that influences social perception. Studies on face and body have demonstrated that certain morphological structures of a man's face (such as round faces, wide eyebrows and a prominent jaw outline; Windhager et al., 2011) and body (Fink et al., 2007b; Sell et al., 2009) signal physical strength. It has been proposed that the perception of physical strength is relevant for mate selection purposes, as it may facilitate the assessment of an individual's health (e.g., Fredericksen et al., 2002; Kritz-Silverstein & Barrett-Connor, 1994; Rantanen et al., 2000; Vaara et al., 2012), developmental stability (Fink et al., 2014b) or fighting ability (Sell et al., 2009). The present study **(Chapter II; Weege et al., 2015b)** supports the assertion that physical strength plays an important role in the perception of body movements, such as dance. This is in line with previous research documenting a positive relationship between male dance attractiveness/quality and physical strength (as measured via HGS). Hugill et al. (2009) obtained dance recordings of 40 men by using a 2D video approach. Male body movements were blurred for presentation to female judges so that movement was the predominant information accessible to perceivers. Hugill et al. standardized body height by scaling the videos. However, even though the blurring of videos presented a highly degraded representation of dance movements, some information about male body morphology might have retained in the videos. This issue has been addressed in the present work **(Chapter II; Weege et al., 2015b)**, as the 3D optical motion capture approach and the application of movements to a gender-neutral virtual character removes any variation in male body morphology. In addition, virtual characters do not have a specific height (this is defined by the designer); as height can be set to any standard that applies to all characters. It is interesting that both Hugill et al. and the present study **(Chapter II; Weege et al., 2015b)** arrive at the same conclusion on the relationship of dance attractiveness and physical strength, given the different approaches used in the two studies. One could

speculate that the strength of the signal conveyed in male dance movements (i.e., physical strength in this context), is significant enough so that it allows different methodologies to detect this effect. Recent reports on strength generally conclude that physical strength is a relatively robust signal, which affects both static and dynamic representations of the male physique. McCarty et al. (2013) investigated the relationship between men's physical strength and male and female perceptions of their dance quality using motion capture technology. The authors acknowledge that their results cannot be interpreted in terms of different mating strategies, as they only collect dance quality assessments. McCarty et al. suggest asking females about their preferences and males about their evaluation of dominance and/or fighting ability. The present study **(Chapter II; Weege et al., 2015b)** asked women for their preferences (as assessed via attractiveness) for one or the other male dancer. In corroborating the statement on male strength and dance attractiveness relationships, it is also noteworthy that the present study goes beyond previous reports in terms of statistical power. Hugill et al. had 40 male dancers and McCarty et al. 30 male dancers in their samples. The present sample was more than twice this size (n=80) and extended the study of a dance attractiveness/physical strength relationship in men to women, for which dances of 86 women were recorded.

The association between physical strength and dance attractiveness seems to be quite robust in men, but non-existent in women, which suggests that men's dances signal information about their mate quality to women (Fink et al., 2014a; Hugill et al., 2009; McCarty et al., 2013). Women's preference for dances of physically stronger men could be interpreted in different ways, given the associations of HGS with health related parameters (e.g., Fredericksen et al., 2002; Rantanen et al., 2000) and fighting ability (e.g., Sell et al., 2009). Following evolutionary logic, women would directly and/or indirectly benefit from either choosing a healthy man who is equipped with "good genes" (dance could be seen as a handicap, sensu Zahavi, 1975) and/or a man with competitive abilities who likely succeed in male-male contests, consequentially offer protection and resources. At the present, there is more support for a relationship between women's adaptive development towards finding dances of men with high competitive abilities in terms of fighting ability attractive, as this may be a signal of social dominance and status. Hugill et al. (2009, 2011) reported an association between women's attractiveness perception of men's dances with women's evaluations of assertiveness and men's self-reported risk-taking behaviour. The authors concluded that testosterone might act as moderating factor between men's physical strength and the perception of their dances. Physical strength has been shown to negatively

correlate with digit ratio (2D:4D; the relative length of the second and fourth finger) - a putative proxy for testosterone exposure in utero - (Fink et al., 2006a). Digit ratio in men has also been found to correlate with physical fitness and athletic abilities (Hönekopp, Manning, & Müller, 2006; Manning, 2002), cardiovascular efficiency (Longman, Stock, & Wells, 2011; Manning, Morris, & Caswell, 2007), male physical aggression (Bailey & Hurd, 2005), male physical competitiveness (Manning & Taylor, 2001) and reproductive success and dominance (Manning & Fink, 2008). Hence, prenatal androgenisation could possibly affect men's dancing abilities, which consequently influence women's preferences for certain male dance movements. Indeed, women judge dances of men with lower 2D:4D (high exposure to testosterone in utero) in contrast to high 2D:4D men as more attractive, masculine and dominant (Fink et al., 2007a).

The present study **(Chapter II; Weege et al., 2015b)** corroborates the findings of a positive association between men's physical strength with women's attractiveness perception of their dances, whereas this effect was absent in women. Recently, Hufschmidt et al. (2015) showed that physical strength (as measured via HGS) is positively correlated with gender identification performance from male (but not female) dance avatars. Both male and female judges accurately determine the strength and gender of male dance movements, which supports the assertion that physical strength is a quality trait of significance in men, but not in women. Physical strength is suggested to indicate a men's formidability, which is related to men's potential status, survival and ability of resource acquisition and maintenance (Lassek & Gaulin, 2009; Puts, 2010). Both men and women benefit from accurately identifying a male's physical qualities; men evaluating a potential opponent's fighting ability in intrasexual competition (Puts, 2010; Sell et al., 2009) and women increasing their reproductive success by choosing a healthy, dominant male with high resource-holding potential (Buss & Schmitt, 1993; Sell et al., 2009). The focus of the present study **(Chapter II; Weege et al., 2015b)** was on women's attractiveness perception of male dance movements. This does not allow interpretations in terms of whether perceived competiveness (e.g., fighting ability), health or ability to provide recourses are components of women's attractiveness assessments. Whether male judges derive cues to physical strength and associated traits (such as aggression or dominance) from male dance movements is also not clear. However, Sell et al. (2009) reported that men and women can accurately judge physical strength from facial and body images that is associated with their perception of formidability (e.g., fighting ability). Given the assertion that the perception of male body movements underlies the same distinct perceptual mechanisms and evolutionary

principles as those that have been shown for the perception of physical appearance (e.g., Fink et al., 2015; Grammer et al., 2003; Rhodes et al., 2006), this may include the physical strength/fighting ability relationship (Sell et al., 2009).

In summary, physical strength is a trait that has been identified as being a potential cue to male quality in the context of intra- and intersexual selection, across taxa (Andersson, 1994). In humans, it affects social perception of male physical appearance, and there is accumulating evidence that this also applies to male body movements.

Physical strength has been shown to correlate with body symmetry in human males (Fink et al., 2014b). The authors argue that males that are better able to resist developmental stress also might develop higher muscularity despite immunosuppressive effects of testosterone. Studies in animals show that females prefer males with the most symmetrical secondary sexual characteristics. It is argued that symmetry serves females as a reliable cue to a potential mate's overall health and genetic constitution, as only males in good condition can develop highly symmetrical features (Møller, 1992a; Møller & Pomiankowski, 1993; Swaddle & Cuthill 1994a; for meta-analysis see Møller & Thornhill, 1998). In birds, for example, female swallows (*Hirundo rustica*) choose males with the most symmetrical tail (Møller, 1992b), female zebra finches (*Taeniopygia guttata*) preferentially mate with the most symmetrical leg-banded and chest plumage males (Swaddle & Cuthill, 1994a,b) and peahens (*Pavo cristatus*) prefer males with symmetrical ocellus numbers in their tails (Manning & Hartley, 1991). A similar link between symmetry and sexual selection relevant features has been found for Japanese scorpion flies (*Panorpa japonica*)(Thornhill, 1992), antlered mammals (Bowyer, Stewart, Kie, & Gasaway, 2001; Lagesen, & Folstad, 1998) and primates (Manning & Chamberlain, 1993), with asymmetric males being less successful in male contests than symmetric counterparts, the consequence being that the latter is more likely to be chosen as a mate. It is hypothesized that fluctuating asymmetry is a trait used in inter- and intra-sexual selection (e.g., Møller & Pomiankowski, 1993), ultimately serving individuals' reproductive fitness by passing on "good genes" to their offspring (sensu Zahavi, 1975).

Based on the observation that in many animals symmetry is found to be attractive and of reproductive advantage (see for review: Møller & Thornhill, 1998), one of the most extensively studied traits in attractiveness research is fluctuating asymmetry (FA). Symmetry is thought to influence the attractiveness and health perception of faces (e.g., Fink et al., 2006b; Grammer & Thornhill, 1994; Jones et al., 2001; for review see Little et al., 2011; Rhodes et al., 2006) and bodies (W.M. Brown et al., 2008; Tovée et al., 2000), reflecting an

evolutionary adaptation to identify and select mates of high quality. W.M. Brown et al. (2005) investigated the relationship between FA and the perception of male dance movements in a rural Jamaican sample. They found that low FA males were rated higher on dance quality than high FA males. However, reanalyses (see Trivers, Palestis, & Zataari, 2009) were not able to replicate the associations between perceived dance quality and body symmetry (also see "the case of symmetry and dance" in Fink et al., 2014a). After a yearlong controversy, the publication was retracted by the end of 2013. Although clear evidence is lacking, the idea of an association between FA and perceived dance quality is not *per se* absurd. Findings on the association between developmental stability (as measured via FA) and certain sport performances suggest that low body-FA male middle-distance runners have better running abilities (Manning & Pickup, 1998), and that running speed in elite sprinters is predicted by knee symmetry (Trivers et al., 2014).

Compared to walking and running, dance movements involve a different interplay of morphological structures and physiological requirements, but the quality of either display should still be comparable, as being based on the same bodily constitution. Indeed, women's attractiveness perception of different male body movements (e.g., running and dancing) seems to be comparable (Fink et al., 2014a). Considering the relationship between men's body FA and women's evaluations of male dance attractiveness, the present work looked at 12 male bodily traits (2^{nd} to 5^{th} finger length (2D to 5D), width of hand, wrist, elbow, knee, ankle, foot and the length and width of the ear)(unpublished data), and women's perception of men's dance movements. Ideal FA of 5 male body traits (4D, 5D, ankle, ear length, ear width; 7 traits showed directional asymmetry and were excluded) showed no association with women's attractiveness perception of men's dances. The results are in accordance with Trivers et al.'s (2009) reanalysis, suggesting that FA may play a tangential role for women's perception and evaluation of male quality from dance movements. Similar results come from the study on gait perception. J.R. Brown, van der Zwan, and Brooks (2011) found that judges were not able to discriminate between symmetrical and asymmetrical point-light walkers (PL-walkers), and symmetrical PL-walkers were not perceived as more attractive and healthy than asymmetrical ones. When the same motion information was presented in a static motion path image, judges could readily discern symmetrical PL-walkers, which they perceived as attractive and healthy. Hence, symmetry seems to be important in evaluating individuals' qualities, but it seems to be a trait that is expressed rather through static appearance than dynamic cues, such as gait or dance.

Although research has documented that humans derive a variety of information of an individual's qualities from static and dynamic cues (e.g., physical strength; Fink et al., 2007b; Hugill et al., 2009; Sell et al., 2009; **Chapter II; Weege et al., 2015b**), anthropometric characteristics only can explain some proportion of human social perception and mating behaviour. Humans are complex in their cognitive abilities and also highly social with diverse interpersonal behaviours. It is therefore proposed that sexual selection has shaped psychological characteristics and preferences for such alike. Indeed, personality plays a critical role in mate selection (e.g., Botwin, Buss, & Shackelford, 1997). Studies on the perception of faces (e.g., Berry, 1990; Penton-Voak et al., 2006) and video clips (Borkenau, Mauer, Riemann, Spinath, & Angleitner, 2004) suggest a "kernel of truth" in personality attribution, whether this extends to the perception of body movements is not well understood. Results from the third study of this work **(Chapter III; Weege et al., 2015a)** indicate that women are not able to discern basic personality traits from motion cues alone. In fact, women's personality attributions on the basis of male dance movements did not correlate with men's self-reported personality scores. The results are in line with findings on the perception of general personality descriptors from PL-walkers (Thoresen et al., 2012). The authors found that trait attributions did not correspond to self-reports of the walkers. They concluded that consensus of personality attributions might be produced indirectly through first (unconscious) impressions of emotions, attractiveness and masculinity that in turn affect evaluations of e.g. personality. This is reminiscent of selective processing mechanisms, such as the attractiveness stereotype. Initial perception of attractiveness is also associated with positive personality traits and social characteristics (Dion et al., 1972; Eagly et al., 1991; Feingold, 1992). Women might desire certain personality traits in men (such as being conscientious but not neurotic; **Chapter III; Weege et al., 2015a**), and attribute such traits to the dance movements they have evaluated as attractive. The study focused on the relationship between perceived and self-reported personality, but did not assess the desired personality of a potential partner. Findings on personality attributions of facial photographs revealed a strong influence of rater's desired personality in a potential romantic partner (Little et al., 2006; Zhang et al., 2014). This might also be the case for the personality perception of dances.

However, personality seems to be important in judging others, as women's perception of male dancers attractiveness correlated both with perceived personality traits (neuroticism (-), conscientiousness (+)) and men's self-reported personality (neuroticism (-), extraversion (+)). Support comes from studies that found a relationship between men's

personality and women's evaluations of their dance movements, in that dancers were perceived as attractive/high in dance quality who scored high on sensation seeking (Hugill et al., 2011)/conscientiousness and agreeableness (Fink et al., 2012a). The present study **(Chapter III; Weege et al., 2015a)** revealed slightly different results to Fink and colleagues. Women perceived dances of men who scored high on extraversion and low on neuroticism as most attractive. Fink et al. found women's perceptions of male dancers dance quality being positively correlated with extraversion and negatively correlated with neuroticism, but the findings failed to reach statistical significance. The almost twice as high sample size of male dancers used in the present study **(Chapter III; Weege et al., 2015a)** suggests that Fink et al.'s results come out as a sampling effect. Additionally, the present study evaluated women's preference (assessed as attractiveness), which could be influenced by traits other than dance quality. Considering previous findings, it is not clear whether women judge certain male dance movements more positively than others due to personality characteristics they desire or whether they can accurately assess men's personality. The present work **(Chapter III; Weege et al., 2015a)** suggests that an assessment of global dimensions of personality is not possible from dance movements. However, this may be different for specific personality traits such as sensation seeking (Hugill et al., 2011).

Interestingly, neuroticism seems to be especially important in judging men's body movements, as women's attractiveness perceptions were both related to men's self-reported neuroticism and women's ratings of neuroticism **(Chapter III; Weege et al., 2015a).** Neuroticism has been shown to be associated with aggression and other cost-inflicting behaviours (Hines & Saudino, 2008; Moeller, Robinson, & Bresin, 2010). Thus, being sensitive to cues indicative for neuroticism may be beneficial for women in many aspects, but especially for their reproductive fitness. McArthur and Baron (1983) argue that social perception gives certain attributes, such as anger, fear or dominance, context-dependent priority, as a quick detection and impression formation is essential for survival and environmental adaptations. Bar, Neta, & Linz (2006) reported that subjects based consistent first impressions of whether a facial stimulus indicates a threatening personality or not within the first 39 ms of exposure, but not on judgments on intelligence, supporting the view that survival-related cues are judged more quickly. Such evolutionary advantageous cognitive mechanisms, those that allow humans to make functional inferences about the world under limited time and knowledge, have been associated with "fast and frugal" heuristics – algorithms that neither look up nor integrate all information, but successfully guide humans through decision-making processes (Gigerenzer & Goldstein,

1996). Applying cognitive heuristics, Grammer, Fink, Juette, Ronzal, and Thornhill (2001) found that humans ground their attractiveness judgments of female faces and bodies primarily on an "avoid the worst" principle, arguing that this strategy would leave more potential partner than a strategy that aims for the most attractive individuals. This finding might also apply to the attractiveness perception of male body movements, as women perceive neurotic dancers as less attractive and perceive less attractive dancers as being more neurotic **(Chapter III; Weege et al., 2015a).** Although women had no conscious information about men's personality, motion cues in male dance movements may activate other relevant impressions that are on grounds of a personality - dance relationship. Certain body movements seem to reveal more neuroticism than others, and women use male dances to associate positive or negative male characteristics. This is reminiscent of a classic study by Heider and Simmel (1944), who demonstrated that even moving geometrical symbols (a large triangle, a small triangle, and a circle) are associated with intentional actions of animated beings, without any social context given initially. People derive personality and intentions from non-human motion cues and assign social meaning to abstract movements. Koppensteiner (2011) found that people associate different motion patters of an animated ball with certain personality traits, similar to motion cues relating to high values of trembling and frequency that express high levels of neuroticism. This finding is similar to what was found in a study on speakers' motion patterns during a speech; jerky movements that were high in velocity were rated high on neuroticism (Koppensteiner & Grammer, 2010).

The present study suggests that dance movements of men scoring low on neuroticism are perceived as attractive. Which movement parameters drive perceptions of attractiveness and personality is not clear. The next logical step would therefore be to objectively describe dance movements by linking biomechanical characteristic with dancer's personality and perceived attractiveness. Additionally, women's desired personality in a potential partner and their ability to assess e.g. physical strength and measures of competitiveness (e.g., fighting ability) from motion cues would add valuable insights into the evaluation of dance as male quality trait. Neave at al. (2011) showed that dance quality is associated with variable and large movements of the head, neck and trunk, but also with right knee movements, the latter being most likely due to the dancers' footedness. Hence, selecting certain movement characteristics that account for social perception and especially mating related decisions is not trivial. This also applies to the perception of females dance movements. There is evidence that women alter the way they move in relation to their

menstrual cycle phase, and that men seem to be sensitive to these changes. Men judge gaits and dances of women in their fertile phase as more attractive (Fink, Hugill, & Lange, 2012) and female lap dancers report significantly higher earnings in their fertile phase compared to their non-fertile phase (Haselton & Gildersleeve, 2011). Hence, a step towards investigating the signalling value of female body movements could include a biomechanical analysis of those kinematic features that cause such subtle but effective changes across a women's menstrual cycle.

In conclusion, human cognitive mechanisms selectively process relevant information to solve adaptive problems such as mate selection (e.g., identify mates with good qualities - related to fertility, parental abilities or genetic constitution) to enhance their reproductive fitness. Attractiveness research has relied on static cues investigating individuals' characteristics that influence social perception. This may be due to the complexity of dynamic signals that come from a variety of single features. New technologies such as motion capturing facilitate the investigation of dynamic aspects by isolating e.g., body movements from physical appearance.

The present thesis emphasises the role of body movements in social perception. Results indicate that women are visually sensitive to subtle variation in male dance movements. This selective processing of male dancing ability is associated with women's preferences for those dances that signal certain male quality characteristics relevant for mating decisions. Physical strength seems to be one of the traits that is conveyed through male (but not female) male dance movements, as women prefer dances of physically stronger men. Following evolutionary logic, women benefit from identifying physical strength in potential mates, as associated traits such as health, dominance, fighting ability and resource holding potential enhance their reproductive fitness. Evolutionary psychologists argue that physical strength is a male typical trait relevant to intra- and intersexual selection. The findings of this thesis support this assertion in that a dance attractiveness/physical strength relationship was found in men, but not in women.

The role of men's personality for women's attractiveness assessments of their dance movements is less clear. This thesis suggests that women's attractiveness assessments of male dance movements are affected by certain male personality traits, although they were not able to accurately judge men's personality. Women seem to be endued with cognitive mechanisms that are sensitive to cues of neuroticism, as they found dances of those men attractive, which they perceived to be less neurotic and which were, by self-report, less neurotic. This suggests a similar algorithm of "avoid the worst" when judging on a men's

attractiveness that was reported for attractiveness judgements of faces and bodies (Grammer et al., 2001). Avoiding neurotic men may ultimately be beneficial for women's safety and reproductive fitness, given the findings on associations between aggression and other cost-inflicting behaviour with neuroticism (Hines & Saudino, 2008; Moeller et al., 2010). Women may perceive more than is literally present in male dance movements, make trait inferences and activate social stereotypes, but this allows fast decisions in social situations, aiming for what is "good", and avoiding what is "bad".

The present thesis corroborates the assumption that body movements, like physical appearance, influence social perception. Dynamic cues should therefore be integrated in attractiveness research, in search for those traits – whether these are based on static, dynamic or a combination of both cues – that account for how we perceive others in an initial encounter. Applying evolutionary concepts to the study of social signals may help understanding the mechanism behind decision-making and reactions in everyday social interactions.

SUMMARY

Bees do it, birds do it, and humans do it too – they dance. But what is the function of dance? The answer to this question is not trivial and has kept researchers busy for decades. It is certainly premature to conclude that the puzzle around the signalling quality of dance has yet been resolved, but there is corroborating evidence for the assertion that individuals communicate aspects of their condition as potential mating partners through dance movements. Evolutionary psychologists argue that dance conveys similar aspects of an individual's quality as it has been reported for facial and body morphology. Like in animals it has been stated that men display elaborate dance movements that inform about strength and vigor, and may therefore be regarded as health cues. Women have indeed reported preferences for male dance movements that are physically demanding; whether dance movements also inform about male personality is yet unclear. The present thesis reports three studies on women's perception of men's dance movements, showing that i) women spend higher visual attention to "good" male dancers as compared to "bad" male dancers, ii) dance conveys aspects of male physical strength – a relationship that is absent in women, and iii) although male personality is not accurately assessed from dance movements, women tend to prefer dancers who signal low neuroticism to them. Men's dance movements were motion-captured and applied onto a featureless, gender-neutral, virtual character (avatar). In a series of visual perception studies women's visual attention, attractiveness, and personality assessments were obtained and related to measures of strength and self-reported personality of male dancers. Together the results support the hypothesis that women are visually sensitive to variation in male dance and tend to prefer those dancers who signal qualities, which may be beneficial in pursuing mate-related motives. Strength seems to be one of these features, but personality information does not seem to be encoded in male dance movements. However, the quality of certain movements may lead women to perceive them in a way that causes them to exhibit little preference for moves they suppose to be linked to male neuroticism. A detailed mathematical and biomechanical breakdown of objective movement characteristics and their relationships with perception is clearly an avenue for future research.

ZUSAMMENFASSUNG

Bienen tun es, Vögel tun es, und Menschen tun es auch – sie tanzen. Doch welche Funktion hat Tanz? Die Beantwortung der Frage ist nicht trivial und beschäftigt Wissenschaftler seit Jahrzehnten. Es wäre sicherlich verfrüht zu behaupten, dass das Puzzle um die Signalwirkung von Tanz bereits gelöst ist, es gibt jedoch unterstützende Beweise für die Annahme, dass Individuen Aspekte ihrer Partnerqualität über ihre Tanzbewegungen kommunizieren. Evolutionspsychologen argumentieren, dass Tanz ähnliche Qualitätsmerkmale eines Menschen vermittelt, wie sie auch für Gesichts- und Körpermorphologie berichtet werden. Ähnlich wie bei Tieren, wird auch bei Männern davon ausgegangen, dass aufwendige Tanzbewegungen Stärke und Elan anzeigen und daher als Hinweis für Gesundheit dienen können. Frauen zeigen tatsächlich Präferenzen für Männer, die physisch anspruchsvolle Tanzbewegungen ausführen; ob jene Tanzbewegungen auch Persönlichkeitsinformationen vermitteln, ist noch unklar. Die vorliegende Arbeit stellt drei Studien über die weibliche Wahrnehmung von Männertänzen vor und zeigt, dass i) Frauen gegenüber „guten“ männlichen Tänzern visuell aufmerksamer sind, im Gegensatz zu „schlechten“ männlichen Tänzern, ii) Tanz Aspekte von physischer Stärke eines Mannes vermittelt – ein Zusammenhang, der bei Frauen nicht beobachtet wurde, und iii) wenn auch die Persönlichkeit eines Mannes nicht akkurat aus Tanzbewegungen abgelesen werden kann, so neigen Frauen dazu jene Männer zu bevorzugen, die geringen Neurotizismus signalisieren. Tanzbewegungen von Männern wurden mittels Motion-Capture Technologie aufgenommen und auf strukturlose, geschlechtsneutrale, virtuelle Charaktere (Avatar) übertragen. In einer Reihe von Studien zur visuellen Wahrnehmung von jenen Tanzcharakteren wurden die visuelle Aufmerksamkeit von Frauen und deren Beurteilungen zu Attraktivität und Persönlichkeit erfasst und in Beziehung zu physischer Kraft und selbstberichteter Persönlichkeit der Tänzer gebracht. Die Ergebnisse unterstützen die Hypothese, dass Frauen sensibel gegenüber Variation in männlichen Tänzen sind und dazu neigen jene Tänzer zu bevorzugen, die Qualitäten vermitteln, die von Vorteil im Bezug auf die Partnerwahl sind. Kraft scheint eines der Merkmale zu sein, generelle Persönlichkeitseigenschaften scheinen jedoch nicht in männlichen Tanzbewegungen verschlüsselt zu sein. Jedoch könnten gewisse Bewegungsqualitäten von Frauen auf eine Art wahrgenommen werden, die in einer geringen Bevorzugung jener Bewegungen resultieren, die sie mit Neurotizismus in Verbindung bringen. Eine detaillierte mathematische und biomechanische Untersuchung

objektiver Bewegungsmerkmale in Bezug zur Wahrnehmung von Tanz ist sicherlich ein Weg für zukünftige Forschung.

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APPENDIX

Motion Capture is described as “the process of recording a live motion event and translating it into usable mathematical terms by tracking a number of key points in space over time and combining them to obtain a single three-dimensional representation of the performance” (Albert Menache, as cited in Noack 2007).

In course of a larger-scale project on human body movements in relation to anthropometric and personality characteristics, body movements of 80 men and 86 women (volunteers, mostly from the student population) were recorded during a period of a total of 21 weeks, using a sophisticated 12- (near-infrared) camera optical motion-capture system (Vicon, Oxford, UK) at the Newcastle Gait Lab, in collaboration with British colleagues from Northumbria University (UK). Additionally to body movements (dance, gait and running), participants provided a set of standard demographic information, gave psychological and health (self-) assessments, anthropometric and physical measures were taken as well as facial and bodily photographs and saliva samples.

From motion data, a set of male and female virtual dance characters were created in an extensive and important two-part process. First, post-processing (realized with Vicon Nexus software), that includes 3D-reconstruction of motion trajectories of 2D data from all cameras as well as cleanup and gap filling of motion data, as marker misrepresentations or disappearances due to e.g., occlusions, crossovers usually occur. Second, data-processing (using MotionBuilder, Autodesk Inc., San Rafael, CA, USA), that involves a step-by-step allocation of all captured marker to an anatomical model (actor), resembling the stature of the captured performer, and the subsequent mapping to the skeleton of a 3D-humanoid character. The fitting process has to be as accurate as possible in order to attain an avatar that displays the individual movement characteristics of each performer true to the original.

In the following figures, I present the Gait Lab at Northumbria University and the most important steps of capturing movements to the final avatar. I won’t go into detail regarding the calibration procedure of the cameras, which is a crucial step prior to all capturing, as it is the basis of high quality recordings.

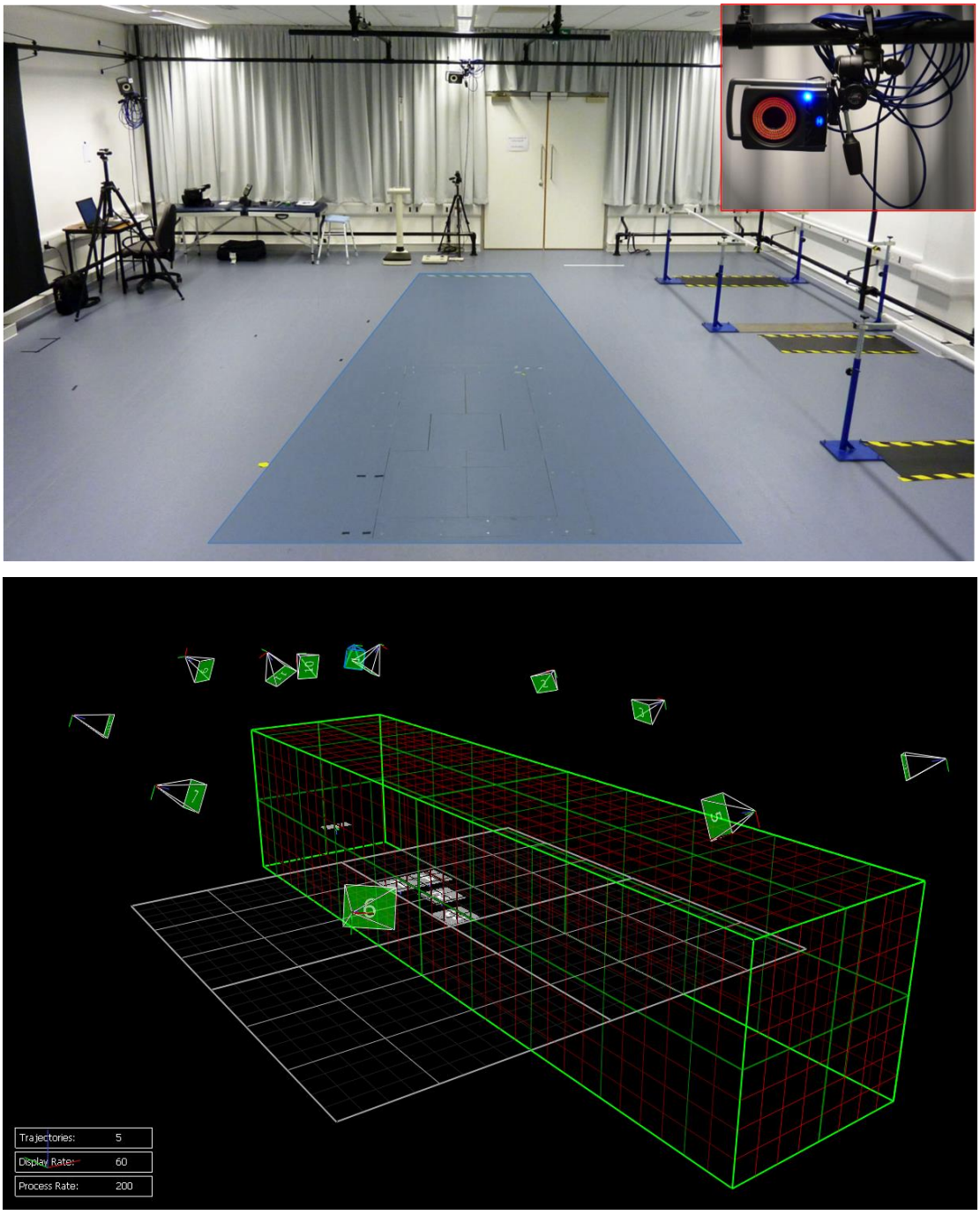

Figure 1. Photo of the gait lab with a close-up (top right corner) of one of the 12 near-infrared cameras (Vicon, Oxford, UK), each capturing at a rate of 200 frames per second. Blue selection illustrates the approximate range in which participant's movements were captured, with some 7m of lengths and 2.5m of width (picture at the top). Capture volume of the calibrated cameras (picture at the bottom).

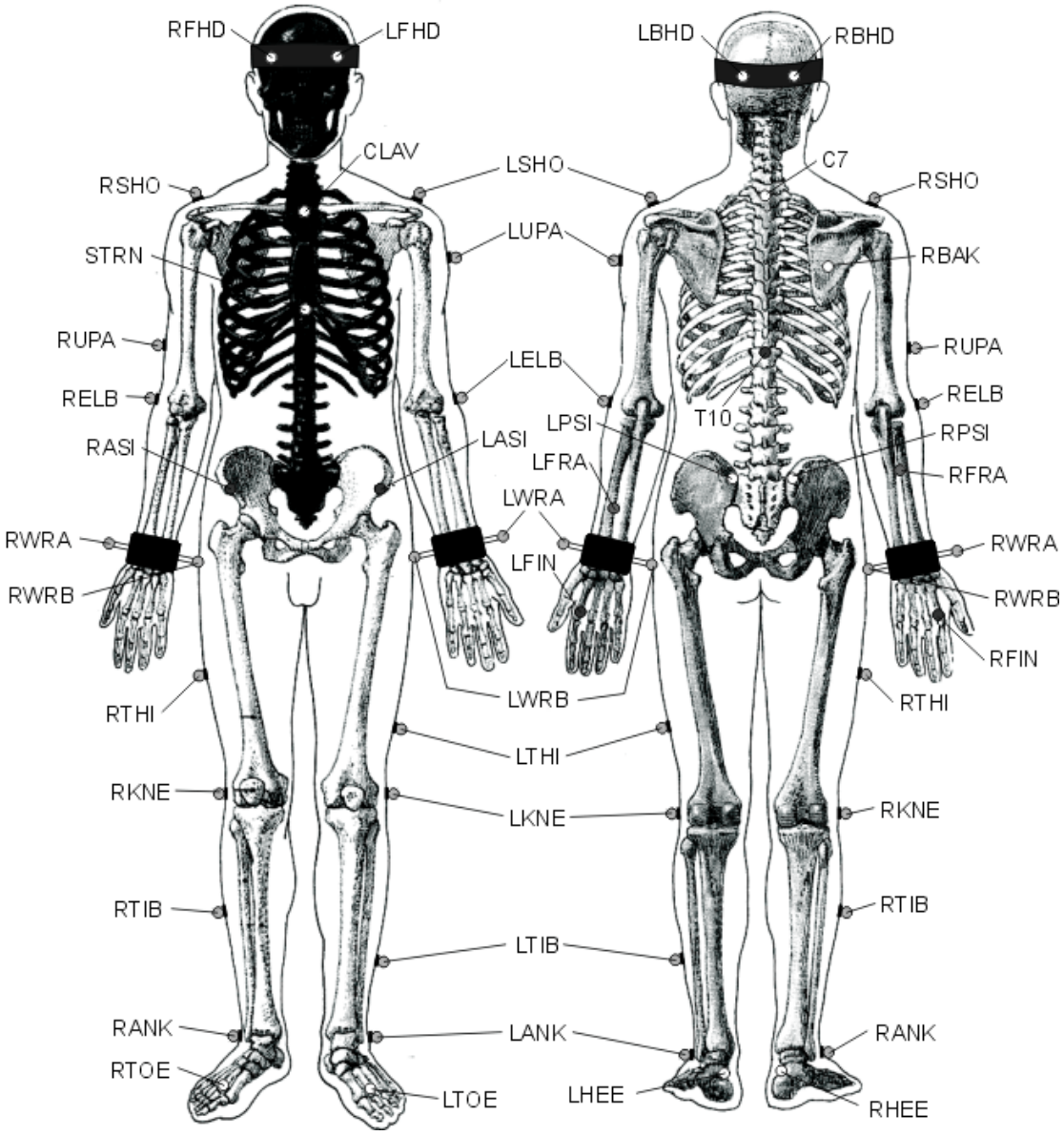

Figure 2. Plug-in-Gait marker set (Vicon, Oxford, UK), the guideline for exact placement of 39 reflective markers to capture and accurately represent all major structures of the full body. Source: Vicon Plug-in-Gait manual.

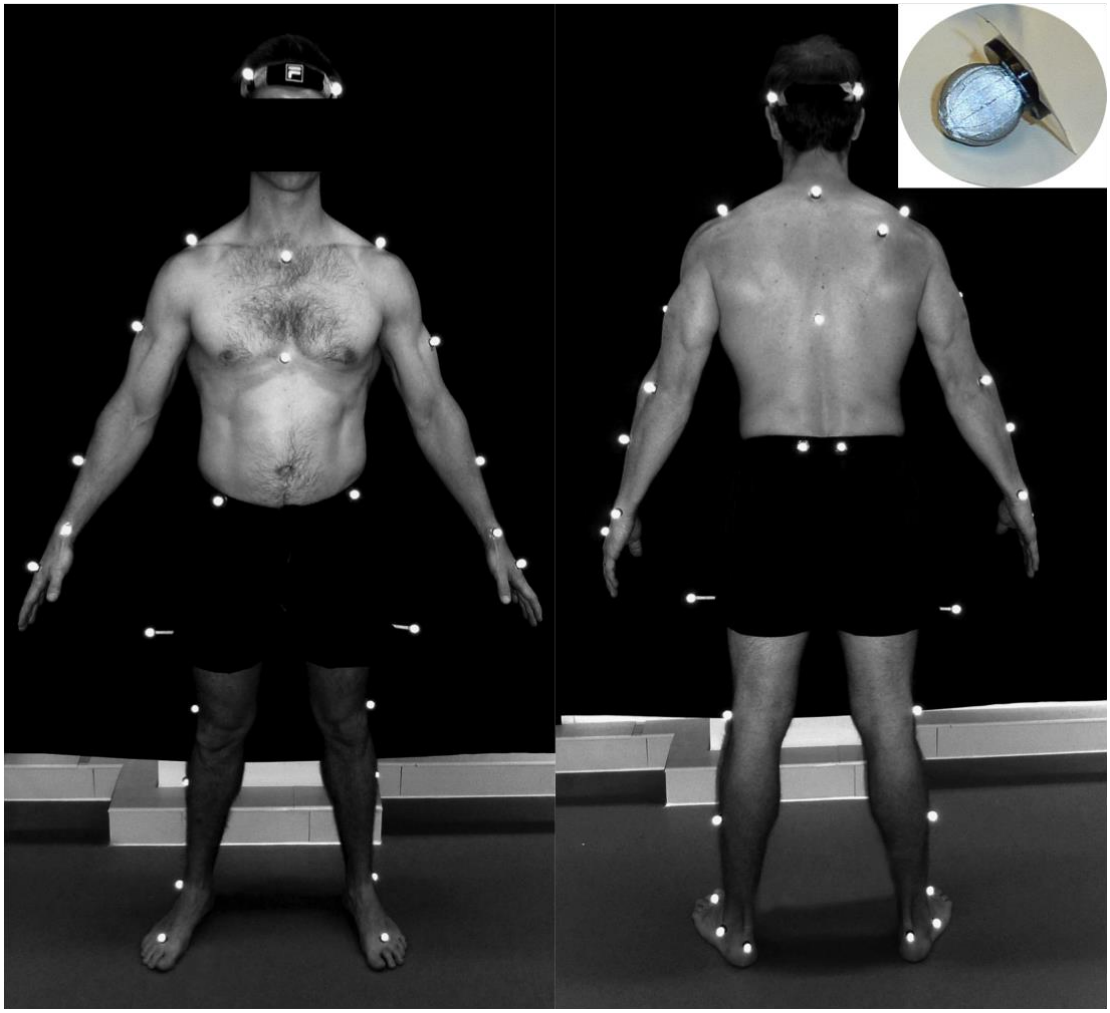

Figure 3. Front and back view of the marker placement, with a close-up (top right corner) of one of the 39 reflective markers (diameter of 14mm).

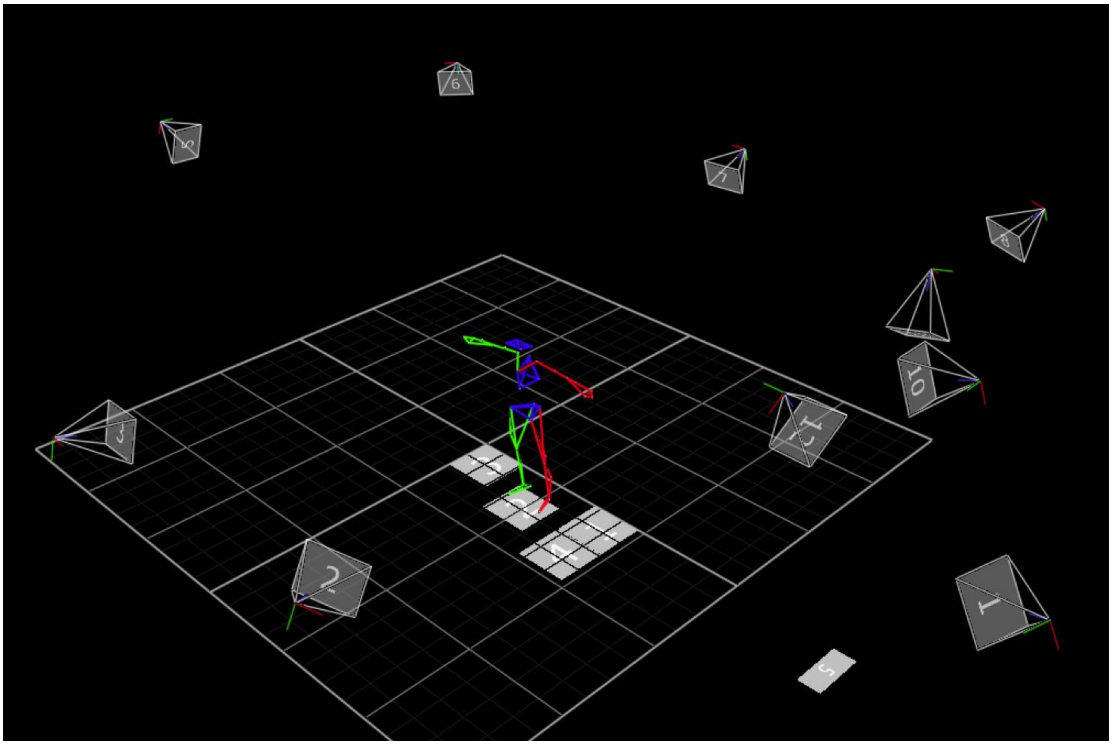

Figure 4. Snapshot of the 3D perspective of all cameras and the "stick figure" of the participant performing the initial T-Pose for subject calibration and subsequent data processing, all markers being correctly assigned to the corresponding body parts.

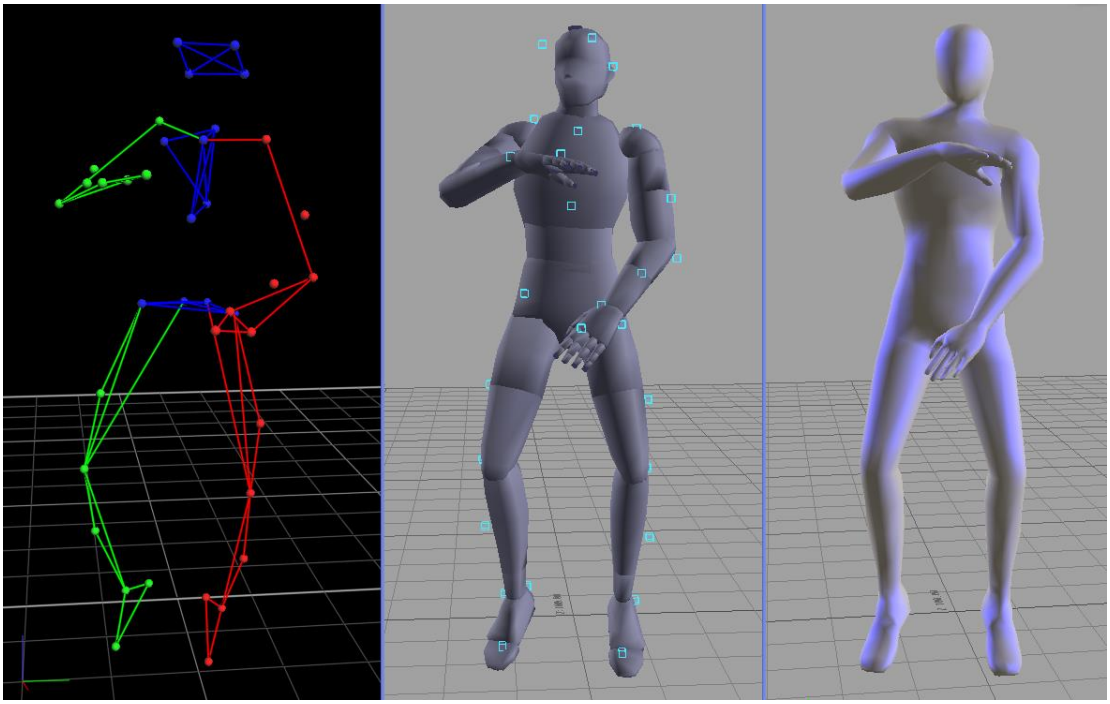

Figure 5. Snapshots of the process of creating a virtual dance character (Avatar). The initial stick figure with all 39 captured markers labelled (left), application of the reconstructed 3D-motion data to the actor (middle) and the final avatar for presentation (right).

ACKNOWLEDGEMENTS

I am very grateful to my “Doktorvater” Bernhard Fink, for walking with me through this long journey; for sharing his knowledge of science and of other aspects of life. I am thankful for his continuous support, encouragement and guidance, as well as for bringing me back on track in times of chaos. With his help, patience and vision for the essential, these last years, I was able to grow on a scientific and personal level.

I would also like to thank my collaborators and friends in Newcastle upon Tyne, who welcomed my colleagues and me with great kindness and helped us, make the most out of the visits. Thanks as well to the people who are directly connected to the work at the Gait Lab at Northumbria University for helping to make the study a success, including my German colleagues who travelled with me.

Thanks to all past members of the Emmy-Noether-Research Group and all the interested and committed students for valuable discussions and for helping with participant recruitment, and all the British and German volunteers who participated in the studies.

I also want to thank the German Science Foundation (DFG), the UNESCO-L’Oréal Support Programme and the Faculty of Biology and Psychology, University of Göttingen for financial support.

Thanks also to Lars Penke for acting as my second supervisor and thesis reviewer, and the other members of my examination board - Antje Engelhardt, Julia Ostner, Margarete Boos, Michael Waldmann - for their interest and time.

Special thanks goes to my parents for accompanying und supporting me throughout the path of obtaining my doctorate.

I deeply thank the grown-up one, the little one and the four-legged one who are my family and my light.

CURRICULUM VITAE

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EDUCATION & WORK

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2009	Scientific assistant *MPI for Experimental Medicine (Department of Neurogenetics)*
2008	Diploma thesis *MPI for Experimental Medicine (Department of Neurogenetics)* Thesis title: Analysis of ectopic myelination of cerebellar parallel fibers by using a mouse model for the human Lhermitte-Duclos-Disease (LDD)
2007	Student assistant *MPI for Experimental Medicine (Department of Neurogenetics)*
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PUBLICATIONS

- Fink, B., Weege, B., Pham, M. N., & Shackelford, T. K. (in press). Handgrip strength and the big five personality factors in men and women. ***Personality and Individual Differences.***
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PRESENTATIONS

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- Cappelle, T.*, Dupp, S., Weege, B., & Fink, B. (2014**). Men's attractiveness perceptions of women's dance movements with and without dance instruction.** 26th Annual Conference of the Human Behavior and Evolution Society (HBES), July 30-August 02, Natal, Brazil. (Talk)
- Weege, B.* (2014). **Women's perception of physical and personality characteristics from men's dance movements.** Symposium: Courant Research Centre 'Evolution of Social Behaviour', June 19th - 20th, Göttingen, Germany. (Talk)
- Hufschmidt, C.*, Fink, B., Weege, B., & Röder, S. (2014**). Effect of digit ratio and circulating sex steroids on gender identification of human dancers**. Symposium: Courant Research Centre 'Evolution of Social Behaviour', June 19th - 20th, Göttingen, Germany. (Poster)
- Cappelle,T.*, Dupp, S., Weege, B., & Fink, B. (2014). **Men's attractiveness perceptions of women's dances with and without dance instruction**. Symposium: Courant Research Centre 'Evolution of Social Behaviour', June 19th - 20th, Göttingen, Germany. (Poster)
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the Human Behavior and Evolution Society, June 29th - July 3rd, Montpellier, France. (Poster)

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DECLARATION

Declaration

I hereby declare that I have written this thesis entitled “Social perception of dance movements – Investigating the signalling value of male body movements using motion-capture technology“ independently and with no aids or sources than quoted.

Bettina Weege’s contributions to the published papers in Chapter I-III are as follows:

Chapter I - **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.

Bernhard Fink and Bettina Weege desinged the study. Bettina Weege collected the data and did the editing, created the stimuli and experiments, and prepared the manuscript. Benjamin P. Lange provided valuable support for the implementation of the eye-tracking experiment and the subsequent rating study. Bernhard Fink and Benjamin P. Lange contributed to the data analysis and finalisation of the manuscript.

Chapter II - **Weege, B., Pham, M. N., Shackelford, T. K., & Fink, B**. (2015). Physical strength and dance attractiveness: further evidence for an association in men, but not in women. *American Journal of Human Biology, 27(5), 728-730*.

Bernhard Fink and Bettina Weege desinged the study. Bettina Weege collected the data and did the editing, created the stimuli and experiments, and prepared the manuscript. Bernhard Fink contributed to the data analysis and finalisation of the manuscript. Todd K. Shackelford and Michael N. Pham provided valuable feedback to the finalisation of the manuscript.

Chapter III - **Weege, B., Barges, L., Pham, M. N., Shackelford, T. K., & Fink, B.** (2015). Women’s attractiveness perception of men’s dance movements in relation to self-reported and perceived personality. *Evolutionary Psychological Science, 1*, 23-27.

Bernhard Fink and Bettina Weege desinged the study. Bettina Weege collected the data and did the editing, created the stimuli and experiments, and prepared the manuscript. Lena Barges provided valuable support for the rating study. Bernhard Fink contributed to the data analysis and finalisation of the manuscript. Todd K. Shackelford and Michael N. Pham provided valuable feedback to the finalisation of the manuscript.

_____ Göttingen, 04.06.2015

Bettina Weege