their health, strength, size, status, intelligence, or creativity" (Blythe et al., 1999), dance might also be a courtship behavior, indicating one or more aspects of the overall fitness value of the dancing person. This line of reasoning fits with the closely related and much better explored topic 'evolution of music'. Many authors consider music to be an adaptation. Miller, for example, states: "Human music shows all the classic features of a complex biological adaptation." (Miller, 1999, p. 329). In terms of courtship behavior "we may assume that musical tones and rhythm were used by our half-human ancestors, during the season of courtship." (Darwin 1871, p. 880)

In 1998, Miller & Todd posited a two-stage lens model for assessing mate quality by integrating perceived sexual cues (Miller & Todd, 1998). According to this lens model, there are several sexual cues (e.g. waist-hip-ratio) that indicate different actual traits (e.g. fertility). Following this idea, music and dance could also be sexual cues for reproductive success, for instance fertility, health, or neuro-physiological efficiency.

A SHORT HISTORY OF DANCE RESEARCH

Grammer et al. (2003) stated that motion alone can provide a lot of information about a person. For instance, on the basis of motion perception alone, people can identify two of the major aspects of mate-choice which are identified up to now: Youth and gender. This is already well-known in scientific fields dealing with human gait. Hausdorff et al. (2001) showed that stride-to-stride fluctuation in gait patterns changes characteristically with maturation in children and older adults. From point-light display experiments[1], we know that subjects are very good in identifying the sex of walkers without seeing direct bodily cues of sex (e.g., Kozlowski & Cutting, 1977). But that is not all: There are also hints that diseases are reflected in gait patterns (Hausdorff et al., 2001). Additionally, Grammer et al. (1997) report differences in female movement quality during their menstruation cycle: Females were asked to turn around 360° in front of a video camera. They showed slower and more complex movements when they had high estrogen levels and were in the presence of a male experimenter. These findings support the idea that motion conveys a lot of information about a person and that movement quality is an indicator for the fertility of that person.

Additional hints of the importance of movement during courtship come from research of nonverbal courtship behavior. People in zero acquaintance scenarios tend to establish a personality profile (the 'big

[1] A point light display is a reduced visual representation of a moving human or animal body, produced in the dark, with the actor wearing lights on the independently moving body segments (typically on the joints).

five': extroversion, neuroticism, conscientiousness, agreeableness and openness) of a stranger in less than ten minutes (e.g. Borkenau & Liebler, 1992). Considering the very short time necessary for such assessments, this information is very likely to be extracted from behavior such as motion quality rather than from verbal exchange. Intelligence can be accurately accessed within a few minutes as well (e.g., Murphy et al., 2003). Furthermore, Walk & Homan (1984) and Dittrich et al. (1996) report that emotions expressed by educated mimes or dancers and taped as point-light displays are identified with remarkable accuracy. Grammer and others conducted several experiments in which two strangers of the opposite sex met for the first time and had a conversation (e.g., Grammer, 1990; Grammer et al., 1998; Grammer et al., 1999). These strangers show, for example, synchronization of nonverbal behavior with highly complex time structures (Grammer et al., 1998). Furthermore, female movement quality (number of movements, duration, size, speed, and complexity) covaries with female interest in her interlocutor (Grammer et al., 1999), whereas in both sexes a lack of interest is communicated through closed postures (Grammer, 1990). Thus, movement quality seems to indicate not only the mate value, but the interest of a potential partner as well, which could denote the probability of successful mating with this person.

FACIAL AND BODILY ATTRACTIVENESS

Evolutionary principles indicate that the more time or energy an individual invests in a bodily feature, the more reliable the feature is as an indicator for this person's genetic quality (e.g., Skamel, 2003). Since we are a species that has developed very complex language systems, we have generated a simple term for the complex judgment: "I very much enjoy perceiving a feature that indicates a high genetic quality." We call it 'beautiful' or 'attractive'. In other words: Instead of saying that "beautiful bodily features indicate high gene quality", we prefer to say that "high gene quality is manifested in certain bodily features, which we call beautiful".

Thornhill & Grammer (1999) suggested that the attractiveness of female faces and bodies is a reliable indicator of good health, fertility, and immunocompetence. Many female body features develop under the influence of estrogen. Estrogen is not only essential for the functioning of the female reproductive physiology (e.g., Dixson, 1998), but has negative effects on the immune system as well, for example, the promotion of certain hereditary diseases (Service, 1998). Therefore, females who carry bodily indicators of a high estrogen level show that they i) are able to reproduce, and ii) have such a powerful immune system that they can afford having such high estrogen levels. Thus, the simultaneous occurrence of two features, say a particular waist-hip-ratio signaling high estrogen levels, and even skin texture signaling immunological estrogen resistance, should be perceived as extremely attractive. Averageness and symmetry, in contrast, indicate a good immune system per se, because no diseases or parasites were able to disturb the physiological development (Grammer & Thornhill, 1994). The same relation exists for male body features and testosterone. Experiments have shown that female preference for testosterone-related facial characteristics is most apparent during their follicular phase of menstrual cycle, when conception is most likely.

Manning et al. (1998) found that the mean male second digit (index finger) to fourth digit (ring finger) ratio (2D:4D) is lower than the mean female ratio. Men tend to have longer ring fingers than index fingers, while in women the index finger is on average as long or even longer than the ring finger (Manning, 2002). Furthermore, Manning et al. (1998) found that in adult subjects lower digit ratios correlate with higher testosterone levels (for both men and women). This relation can also be found in sperm counts, number of offspring, and marital status (Manning et al., 1998, 2000; Manning, 2002). These findings are reflected in the perception of hand attractiveness: Manning & Crone (manuscript) have found that in men long ring fingers were positively associated with perceptions of attractiveness and sexiness.

How can finger digit ratio give us information about fertility? To answer this question, we have to go back to the 'ontogenetical descent of man', to about the seventh week of pregnancy. At this time, the genetically controlled sex differentiation begins by hormone-induced shaping of the sex specific gonad cells (testes in male and ovaries in female embryos) that immediately start to produce sex hormones. In male fetuses, there is a testosterone production peak in week 13 (Migeon & Wisniewski, 1998). Relative digit length, which appears to be fixed by week 14 (Garn et al., 1975), is influenced by the testosterone level via a number of tissues making up the fourth digit that are sensitive to testosterone (Manning, 2002). Manning et al. (1998) also found an insignificant but positive relation between prenatal estrogen level and the growth of the second digit. Therefore, the fetal digit length seems to reflect prenatal levels of sex hormones. The relationship between 2D:4D ratio and fetal hormone levels is of course difficult to measure directly. However, digit length seems to be "an indicator of steroid hormone levels at an important period for brain organization, sexual orientation, and the formation of the heart and major blood vessels and of the breasts." (Manning, 2002, p. xiv)

Sex-specific digit ratios affect not only the number of offspring and the likelihood to get married, but seem as well to be an indicator for musical and athletic ability. Sluming & Manning (2000) found out that there is a negative relationship between high musical ability (measured by the status of 54 men in a British symphony orchestra) and the musician's 2D:4D ratio. The same holds for athletic abilities. Manning & Taylor found in 2001 that professional football players had lower 2D:4D ratios than men of a control group. Football players in the reserve team had higher 2D:4D ratios than players in the first team, and players that had played in the national team had lower 2D:4D ratios than those who had not. Thus, musical ability and sportiness seem to be fertility indicators.

HORMONES AND MOTION

As we have seen above, 2D:4D ratio is negatively correlated to both prenatal and adult testosterone levels (e.g., Manning et al., 2001). Sex hormones control maturation of reproductive cells in both sexes. In males, testosterone is not only essential for spermatogenesis, but it is also known that high levels of testosterone suppress immunocompetence (e.g., Folstad & Karter, 1992). That is to say, only males with high immunocompetence can afford a high testosterone level. Females look for parasite-resistant males to increase their offspring's likelihood of surviving and to increase the probability of male parental care in species where males are involved in breeding. Thus, species-specific hormone markers that indicate high testosterone levels show high immunocompetence as well.

Two examples from the animal world demonstrate what further influence testosterone can have: Parker et al. (2002) showed that testosterone levels in male junglefowls were positively correlated to dominance rank. Individuals that transferred to smaller flocks showed reduced comb growth (a testosterone marker) and decreased testosterone levels. Olsson et al. (2000) treated male sand lizards with testosterone. These lizards showed greater mobility than control males, which resulted in higher mating success.

MOTION: ATTRACTIVENESS AND PERSONALITY

Further data for the connection between movement quality and courtship behavior come from attractiveness ratings of dancing subjects. Grammer et al. (2003) videotaped 71 persons in a dance club performing free dancing movements and transformed these short movies into dynamic quantized displays, which save the information about movement expressiveness, but do not allow identification of any body details. These quantized displays were rated for attractiveness and eroticism. It revealed that the mean rating for each stimulus person was correlated with its movement qualities (speed, emphasis, expressiveness, and complexity) (Grammer et al., 2003). It led the researchers to the conclusion that "movement quality is related to sex and attractiveness, and movement can be used as a stand-alone indicator for attractiveness" (Grammer et al. 2003, p. 316).

Indeed there are two studies which show a direct relation of body build and hormones to the attractiveness of dance. Brown et al. (2005) found in a Jamaican sample — using motion captured dances on neutral stick figures as stimuli — that bodily symmetry, one of the indicators of physical attractiveness, predicted perceived attractiveness of dance motions. The second study by Fink et al. (2007) shows that male saliva testosterone levels also predicted the attractiveness of male dancing motions. Both studies are thus able to link attractiveness and body motion via two crucial factors which link mate-quality and body motion.

But there are other factors than mere attractiveness ratings which could be conveyed by dancing. Bechinie & Grammer (2003) were able to use motion energy[2] data in training time delayed neural networks (TDNN, Waibel et al., 1989) to recognize personality traits (Big-Five, Costa, 1985) from male and female dancing motions. Koppensteiner & Grammer (2010) showed that personality can be decoded reliably from body and head motions of politicians which were transferred on stick figures. In this research also motion parameters were identified which lead to the decoding of the big five personality traits.

Personality also might function as a mate selection criterion because personality predicts the lines of action a person can take (Buss & Craik, 1983). Moreover on a proximate level, personality controls levels of cognitive functioning and is aimed at attaining or avoiding affective states central to a person. On an ultimate level, personality would allow predictability for self and others. It could serve as a social resource marker which facilitates ecological and social niche finding which matches a continuous distribution of viable strategies. McDonald (1999) thus concludes that personality is an evolved motivational system which has an affective core and its variance is maintained by frequency dependent selection. Studies of twins reared apart have also shown that the core of personality traits might be highly heritable (Pervin, 2003).

The high agreement among observers regarding the personality of a target has been demonstrated in several studies. Albright et al. (1988) assume that any impact of the stimulus target can be attributed to the physical features of the target. But they are not able to indicate which physical stimuli carry which information. Among researchers it is completely unclear how such a consensus might be reached and what information is used to assess the targets.

Previously, these finding have been explained by a social constructivist hypothesis which rests upon the assumption that there is no true association between appearance and personality, rather the consensus might reflect a commonly accepted covariation between certain facial features. This would reflect culturally acquired stereotypes about these links (cf. McArthur, 1982).

We will argue here that personality predicts the bandwidth of affect and affect then becomes visible in the quality of motion. This would make

[2] For a definition of motion energy see section on methodological issues (below).

the communication of personality possible in real time and allow a spectator to assess action tendencies in a potential mate via the 'shared manifold' (Gallese, 2001). Indeed our brain seems to be able to simulate motion in real time with the help of the so-called F-5 neurons which can be found in the prefrontal cortex. This could provide the pathway for the perception of dance by simulation in the brain.

BODY MOTION AND DYNAMIC SYSTEMS

Although we find some links between potential mate quality and dance — the signal which humans use for its assessment is less than clear. Here we propose that there has to be a relationship between cognition, the general construction of the body and the resulting body motion. This relation also might be called embodiment (Wachsmuth et al., 2008)

The actual intelligence of motion becomes visible through its expression by the body construction (Pfeiffer, 2007). In this view the body itself is a dynamical system with a limited number of degrees of freedom — in a simplified way this can be regarded as a number of joint pendulums which are controlled by the physical construction. In a simplified model (using head, arms, trunk, and legs) we would get a 12-dimensional dynamic system.

Thus, an organism's actual behavior is not only the outcome of internal control (brain) but also morphology, materials, and interaction with the environment. In this view the neurological structures exploit physical constraints in order to achieve robust movement and induce statistical regularities through sensor-motor activity. As a result motion ability is not only a result of motor control strategies, but the physical construction characteristics of the body, like length of levers, tendons, muscles and their weight, which determine the ability to move.

If this is the case we can suggest that prenatal sex hormone levels will determine the relative growth of brain regions in the two sexes (Goldstein et al., 2001). Relative differences caused by hormone exposure could be responsible for gender identification and moreover for different personalities. DeYoung et al. (2010) indeed were able to show in an fMRI study that the 'big five' personality dimensions are associated with the relative size of brain structures.

Following this line of thought — at the same time sex hormones create the blue print for later body development and affect differential growth of brain regions — it is at hand to expect a relation between personality, body build and body motion (Fig. 1). In terms of evolutionary biology (Oberzaucher & Grammer, 2008) body motion would consequently be an unfalsifiable signal and thus paramount to mate selection.

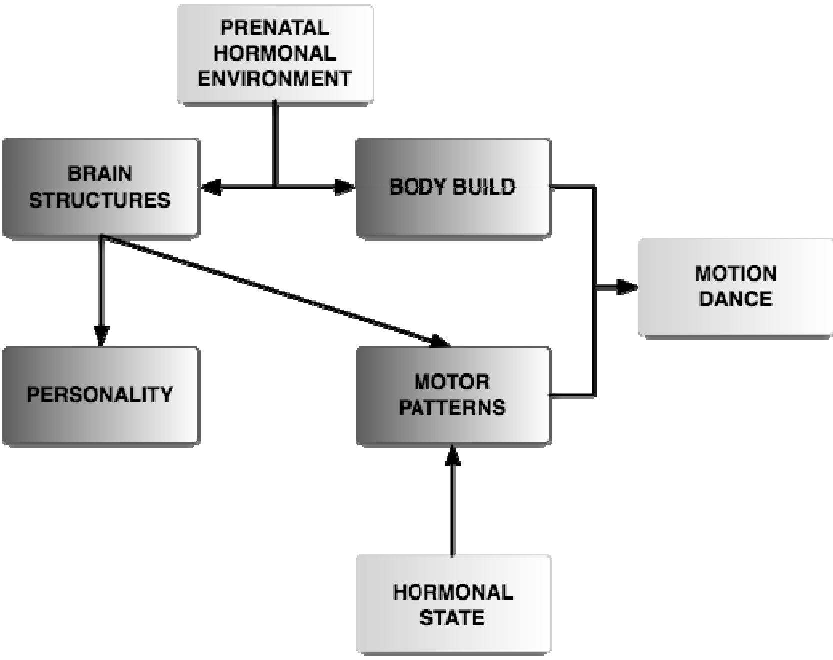

Fig. 1: Hormonal influences on differential growth and functioning of body regions. The prenatal hormonal environment affects the growth of brain structures and body proportions. Brain structures and body proportions affect motion quality, which is also affected by current hormonal state.

One problem for mate selection is that the cues which are used for assessing mate quality have to be honest and non-falsifiable. Body construction is the basis for motion and the influence of sex-hormones is difficult to falsify. Thus individuals should rely on the signals they see in movement, for example in dancing.

Early sex hormone levels are expressed in 2D:4D ratios — this measure would reflect the basic quality of brain build, body build and dancing. In addition we find relations between 2D:4D and the expression of personality (Fink et al. 2004). Thus the logical conclusion would be that these features are interrelated.

We will test our concept on data of a preliminary study we conducted on dancing, 2D:4D and personality. The methodological approach consists of the assessment of personality, 2D:4D ratios as a cue for prenatal hormonal environment, anthropological measurements which are associated with attractiveness to the opposite sex, and finally the analysis of the dynamic features of dance. These relations should be sex specific and allow us to identify the signal which people use for the assessment of the attractiveness of dance.

METHODOLOGICAL ISSUES AND ANALYSIS PROCEDURE

DATASET

The dataset consisted of 50 male (mean age 21) and 50 female students (mean age 20) who were recruited at the University of Vienna. They were instructed to dance for 30 seconds without music in presences of spectators of the same and opposite sex. This dance was videotaped (Fig. 2). In addition the subjects filled out a general demographic questionnaire and the German version of the NEO-FFI short version (Costa & McCrae, 1989).

After the dancing we measured finger length and took several anthropometric measures like body height, weight, breast, waist and hip circumference. Body fat was measured with a body fat analyzer (Tanita TBF-105). Finger length for the determination of the 2D:4D ratio was measured with a caliper from the distal crest to the finger tip (Fig. 3). Finger length is the sum of all four fingers measured (2D-5D). In addition we measured body symmetry by comparing the elbow, wrist, knee and ankle circumference of the left and right body side. All anthropometric measures were taken twice and averaged.

Fig. 2: Setup for videotaping dance motions.

Fig. 3: Measuring of digit length

MOTION ANALYSIS

The videotaped dances were analyzed with Motion Energy Detection (MED, Bechinie & Grammer, 2003). MED basically is the first derivate of the video stream which actually produces one value for the amount of motion for each video frame. This method can be used to estimate the change of motion on a frame to frame basis (Fig. 4).

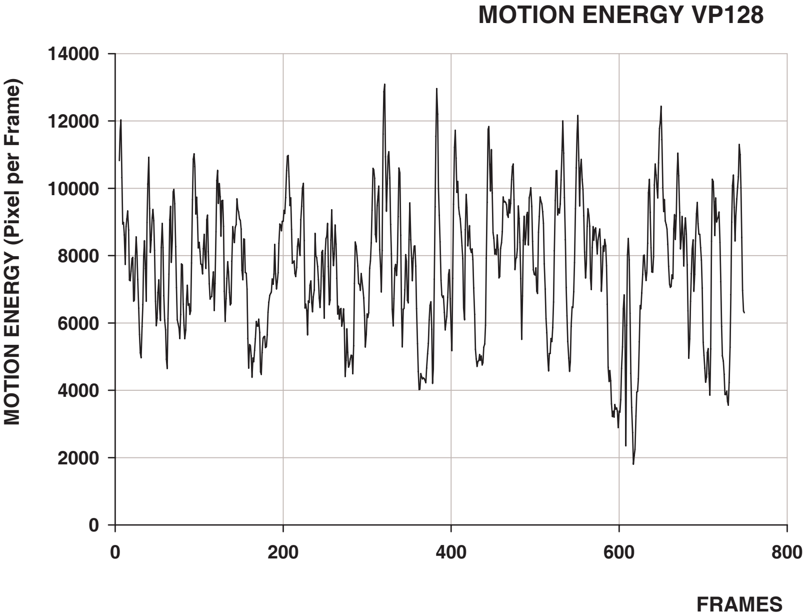

Fig. 4: The motion energy is based on the first derivate of a movie. It corresponds to the number of pixels that have changed their grey value.

RECURRENCE QUANTIFICATION ANALYSIS (RQA)

For the analysis of the dynamic properties of the motion energy curves we applied recurrence quantification analysis. Recurrence plots refer to the fact that deterministic dynamical systems diverge and converge in their patterns over time. Recurrence plots (RP) were introduced by Eckman et al. (1987). In such a plot all values of the time line are plotted against each other value. In a random series no patterns occur, but in more deterministic series patterns will form. A recurrence plot reveals distant correlations in a time series. RPs make it instantly apparent whether a system has periodic elements or is completely chaotic.

The measures introduced for the RQA were developed heuristically between 1992 and 2002 (Zbilut & Webber, 1992; Webber & Zbilut, 1994; Marwan et al., 2002). They are actually measures of complexity. The main advantage of the recurrence quantification analysis is that it can provide useful information even for short and non-stationary data, where other methods fail. RQA can be applied to almost every kind of data. It is widely used in physiology, but was also successfully applied on problems from engineering, chemistry and earth sciences (see Marvan et al, 2002). Here we will describe only the nature of the measures (for a mathematical outline see Marvan et al., 2002).

The dynamic features which can be assessed from an RP are:

Recurrence. Recurrence is the density of the recurrence points in an RP. This is the probability that a specific state will recur. In terms of dancing it will indicate that the same motion energy will occur again with a high probability — this would mean that the dancing motions are fluent and stereotypical.

Determinism. This measure is related to the predictability of the dynamic system — in terms of dancing it could be interpreted that no erratic or additional single elements are added.

Laminarity. Laminarity is related to the amount of linear phases in the system or its intermittency. In dynamical systems intermittency is the alternation of phases of apparently periodic and chaotic dynamics. In terms of dancing this would mean the fraction of time the dance is uncoordinated and turbulent.

Trapping Time. This measure indicates how long a system stays in a certain state — in dancing this would be how long a person holds a steady rhythm, for instance.

Divergence is the maximal diagonal line length, and as such a measure of the determinism of the system.

Entropy. This reflects the complexity of the deterministic structure in the system — and it is a measure of uncertainty — in terms of dancing with unpredictable motions.

Trend. This measure provides information about the stationarity of the system.

The recurrence analysis was done in the program Visual Recurrence Analysis by A. Koronov[3]. In Fig. 5 we show a recurrence plot of the dance data from Fig. 4. It shows that the moving body indeed is a dynamical system, which in dancing movements undergoes different recurrence states.

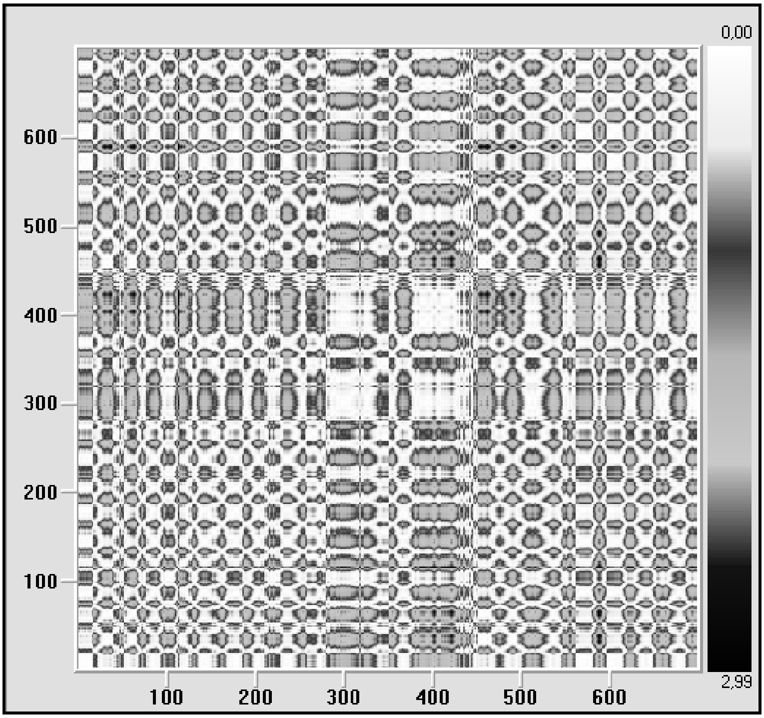

Fig. 5: Recurrence Plot on the motion energy of a dancer. The visible pattern shows the high degree of determinism in the dancing movements.

DYNAMICS OF DANCE

Prenatal hormonal environment

The 2D:4D relation is significantly different between the sexes in the predicted direction. The difference for both hands in males is -4.3 mm and for females it is -1.3 mm (ANOVA, $F = 7.3$, $p = 0.008$). The results do not change when corrected for body height (ANOVA, $F = 6.2$, $p = 0.015$). Independent of body height, male 2D:4D is lower than female 2D:4D. This indicates a pronounced sex difference in early hormonal environment.

[3] http://nonlinear.110mb.com/vra/

Body Measurements

For the body measurements we found the expected sex differences. Males are significantly taller and heavier than females and have more muscle mass and less fat than females. Their body mass index and their waist to hip ratio is higher than in females, whereas there are no differences in shoulder to hip ratio and body symmetry.

The question is how early hormonal development relates to body build. Weight (n = 45, r = -.32, p = 0.03), hip circumference (n = 45, r = -.42, p = 0.004), body fat (n = 26, r = -.48, p = 0.01) and finger length (n = 45, r = -.30, p = 0.04) correlate negatively with 2D:4D — this implies that the absence of prenatal testosterone correlates with a more feminine body build in males — for females no relations emerge.

Table 1: Sex differences in body build

	male		female	
	Mean	SD	Mean	SD
Height	180.09_a	5.44	166.46_b	5.75
Breast	93.0_a	8.6	87.8_b	6.2
Waist	82.8_a	7.9	71.3_b	6.9
Hip	94.6_a	7.1	89.4_b	7.5
Finger length	307.90_a	17.72	279.88_b	16.55
Weight	74.4_a	11.3	58.5_b	7.6
Percentage body fat	11.97_a	6.84	17.19_b	7.10
Muscle mass	63.09_a	6.06	42.68_b	3.12
Body Mass Index	$.23_a$	0.03	$.21_b$	0.03
Waist to Hip Ratio	$.88_a$	0.06	$.80_b$	0.05
Shoulder to Hip Ratio	$.99_a$	0.08	$.99_a$	0.07
Body Symmetry	$.821_a$	0.072	$.822_a$	0.092

Note: Values in the same row and subtable not sharing the same subscript are significantly different at $p < 0.05$ in the two-sided test of equality for column means.

Personality

Personality traits were analyzed with the standard procedure of the NEO-FFI (which measures the 'big five'). Sex differences were found as follows: Females show higher scores on neuroticism (n = 50, mean = 2.0, SD = 0.7) than males (n = 50, mean = 1.6, SD = 0.5, ANOVA F = 12.4, p = 0.001) and females score higher (n = 50, mean = 2.7, SD = 0.5) than males (n = 50, mean = 2.4, SD = 0.4) in agreeableness (ANOVA F = 4.3, p = 0.039).

Prenatal hormonal environment (2D:4D) correlates only with extraversion in males (n = 44, r = -.33, p = 0.02). Extraversion further shows a correlation with body fat (n = 25, r = .41 p = 0.04), waist to hip ratio (n = 45, r = .36 p = 0.02), and shoulder to hip ratio (n = 45, r = .33, p = 0.02). Openness correlates with finger length (n = 45, r = .34, p = 0.02). Conscientiousness correlates with shoulder to hip ratio (n = 45, r = 0.30, p = 0.04). In females no significant correlations between body build and personality traits were found.

Motion dynamics

As males and females differ considerably in body build, we should be able to show that the dynamic features from the RQA differ — if the argument holds true that body build indeed affects motion quality. Indeed recurrence rate (males 15.4, SD = 33, females 27.8, SD = 24, t-test, p = .04), determinism (males 31.9, SD = 24, females 45.1, SD = 28, t-test, p = .01), and laminarity (males 18.2, SD = 27, females 31.6, SD = 37, t-test, p = .05) are significantly higher in males than in females. The female dance is less chaotic and shows more fluent motions with continuous repetitions.

In order to reduce the data we applied a Principal Component Analysis to the motion quality variables. The resulting three factors explained 78.5% of the variance. 1) The rhythmic dancer shows high recurrences of specific states and high intermittency along with high levels of determinism and predictability of the occurrence of elements. The motion system stays in the same state for a long time and the deterministic structure is highly complex. 2) The smooth and slow dancer's style is a low dimensional dynamic system with high divergence of the trajectories. And finally 3) the wild dancer shows high determinism, low recurrence and low stationarity with high trends in motion changes (turns body around). Prevalence of dancing styles is not significantly different between the sexes.

Motion, body measurements and personality

The final part of the analysis will now deal with motion, personality and prenatal hormonal environment. Agreeable males use the slow dancer style (n = 45, r = .37, p = 0.02) and conscientious males use the rhythmic dancer style (n = 45, r = .31, p = 0.04). Agreeable females in contrast avoid the slow dancer style (n = 45, r = -.28, p = 0.05) and conscientious females also avoid the rhythmic dancing style (n = 45, r = -.32, p = 0.03) but prefer the wild dancer style (n = 45, r = .28, p = 0.05). This is also reflected in correlations of prenatal hormonal environment and dancing style. In males there is a positive correlation between 2D:4D and rhythmic dancing (n = 45, r = .35, p = 0.02) while no such relationships are found in females.

When we take a look at the body measurements themselves we find that rhythmic male dancers (n = 45) are symmetric (r = .38, p = 0.01), show a high waist to hip ratio (r = .35, p = 0.02), a high shoulder to hip ratio (r = .41, p = 0.006), and have shorter fingers (r = -.32, p = 0.04). The last two relations hold also true for female finger length ($r = -.30$, $p = 0.05$) and shoulder to hip ratio ($r = .33$, $p = 0.03$). Females who dance with the wild style usually have small breasts ($r = -.30$, $p = 0.04$).

RÉSUMÉ: THE BODY AS A DYNAMIC SYSTEM

We believe that dance is one of the last unexplored mysteries of human behavior. After carefully reviewing past research, we think we have identified useful methods for revealing evolutionary explanations for this mysterious motion pattern. Correlations of movement quality with selected cues that are known to indicate reproductive success (2D:4D ratio, personality and body features) only partially support our hypothesis that dance quality is used as one of many cues for mate choice. In this first exploratory study our hypothesis was that prenatal environment influences both personality and body build and then finds its expression in dancing could not be fully supported.

Kretschmer (1921, 1961) and later Sheldon (1940) tried to find correlational relationships between body build and personality or temperament. Both assumed a causal relationship — but later it became clear that the results were artifacts originated in methodological shortcomings. The more serious problem was that this type of research in all its naïveté discredited psychological analysis of human gestalt. But newer work by Borkenau & Liebler (1995) suggests a link between appearance and personality. A second problem is that the assumed somatotypes as such are not supported by empirical data when analyzed with modern statistical methods. This is why we concentrated on sex differences. Our model is completely different in that we assume a common variable, which is only partially genetic, i.e. sex hormone levels during early ontogeny.

Our basic idea was that both personality and body build are determined by prenatal sex hormones and — when dancing is embodied — personality could find its embodied expression. A complete model for this hypothesis could not be established in the course of this project. But we find a row of interesting isolated results, which still prevail after correction for the amount of statistical tests. Therefore the reason why TDNNs can be trained to assess personality from dancing movements remains still unveiled. One basic problem of this study is the small number of subjects — we will try to increase this in future studies.

The interactions between 2D:4D and personality is weak — as has been shown in other research. One reason for that could be that the NEO-FFI questionnaire does not cover the dimensions of personality which are affected by prenatal concentrations of sex hormones. Only male extraversion can be related to 2D:4D.

In contrast, 2D:4D is correlated to a high number of bodily features — in males, but not in females. It seems that prenatal testosterone is not responsible for variations in bodily features in the female sex. The lack of relations between 2D:4D and other measures in women could be due to the basic female mechanism. Whereas the construction of a male organism requires the presence of sex hormones, female organisms develop in the absence of sex hormones (Panksepp, 1998). Consequently, positive relations between 2D:4D and other variables are more likely to occur in males, where higher sex hormone concentrations are present. Nevertheless we find profound sex-differences in body build and in the dynamic features of dancing. Females dance recurrently and apparently with smoother motions, whereas heavier males dance not so smooth — it seems that heavier bodies cannot be exploited as well for dancing moves.

Another question is whether traits, which are responsible for bodily attractiveness, covary with dancing style. In males apparently shoulder to hip ratio might depend on sex hormones as expressed in 2D:4D, moreover high shoulder to hip ratio correlates with the loading on rhythmic dancing style in both sexes. Finger length shows the same pattern in both sexes: The longer the fingers, the higher the degree of rhythmic dancing. The mechanism of action suggests that sex steroids exert both an indirect and a direct effect on longitudinal bone growth. Sex steroids influence growth hormone secretion in humans (Frantz & Raben, 1965; Illig & Prader, 1970), which is responsible for bone length growth. If this is the case, we have to take the length of long bones and the resulting proportional differences between subjects and the sexes into account. On the level of the assumption that the human body is a combination of pendulums (at least when dancing) this relation between bone lengths and motion patterns would make perfect sense in terms of physics.

Interestingly enough female breast size, probably because of the inertia moment produced by their weight seems to prohibit the wild dancing. Moreover dancers using the rhythmic stile show a higher body symmetry which is clearly a trait in mate selection.

As we can show the human body can be described as a dynamic system in its motion. The dynamic system is partially sex specific — with respect to body build, and relates, at least in males, to early hormonal environment. In the next step of our research we will try to determine how motion attractiveness fits into the whole picture.

The problem with this study is that the number of subjects apparently is too small so we could not control for spectator effects, which can play a considerable role in the emergence of the typical dance styles. Another problem is that Motion Energy Detection and / or RQA do not pick up the signal completely. And a last, but serious problem could be that the NEO-FFI items are not the personality traits which play a role in mate choice. Besides sex-differences in personality we also find correlations between body build and personality within males and females. This gives rise to the question which variable causes both, within and between sex effects.

A final problem is an analytical problem — some of the bodily traits do not behave in a linear way, like i.e. waist to hip ratio, where an average female waist to hip ratio is attractive rather than a minimum or a maximum. This might be the case for many body measurements and should receive attention in our future research.

In this research area it seems too early to accede to Knight Dunlap's statement from 1928:

> At the present time many so called character analysts, consultants, and experts are presenting both plausibly and earnestly methods of judging character based on physical criteria, such as head measurements. Respectably psychology almost without exception repudiates such methods and its foundations on physiological and neurological grounds. The futility of character judgments by any form of phrenology is refuted theoretically to the queen's taste in a conclusive onslaught. (Cleeton & Knight, 1928, p.255).

They conclude that the physical measurements which underlie character analysis agree neither with themselves nor with other measures of character. These authors at this point in time (1928) set an end to a hype in society where everybody believed that personal character is encoded in bodily and facial appearance. Physiognomy and phrenology were based on the assumption that different traits and abilities of an individual were manifested in the shape and form of the skull and the face. And indeed no scientific evidence was found to support the ideas of physiognomy (Alley, 1988) and the proposed links between character and appearance are mystical (Brandt, 1980).

However, in recent research a new paradigm has arisen, which creates surprising results: The zero acquaintance paradigm is a condition were one person observes another, but the two have never engaged in social interaction before. Surprisingly it seems that people's first impressions of a stranger are remarkably similar regarding some traits. Borkenau & Liebler (1993) showed short 90 second video clips of participants to strangers who assessed the stimulus persons on Big Five Personality Scales (Costa & McCrae, 1985). They also obtained ratings by the target's cohabiting partners. There were significant acquaintance-partner-stranger correlations for extraversion and openness dimensions. Berry (1990) found significant acquaintance-stranger correlations based on static facial photographs for impressions of warmth, honesty and social power.

These results have been replicated over and over under various conditions. Norman & Goldberg (1966) report statistically significant self-stranger correlations for the big five (openness, conscientiousness, neuroticism, extraversion, and openness) when strangers meet for 20 minutes in a waiting room. This finding was replicated by Watson (1989). Borkenau & Liebler (1993) manipulated the amount of information presented to strangers (video and sound) and found high self-strangers correlations for extraversion and conscientiousness. Correlations were highest in the video and sound condition. We are currently pursuing this line of research in social interactions and dancing.

Whereas we are still cautious with the conclusions about the relation between hormones, body build and personality, we think that this line of research is worth further effort. The picture is far from being complete, but each study casts a little more light on the complex developmental and functional processes involved in the creation of such signals.

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