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The Representation of Self Reported Affect in Body Posture and Body Posture Simulation

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A B S T R A C T

It is taken for granted that the non-verbal information we acquire from a person's body posture and position affects our perception of others. However, to date human postures have never been described on an empirical level. This study is the first approach to tackle the unexplored topic of human postures. We combined two approaches: traditional behavior observation and modern anthropometric analysis. Photographs of 100 participants were taken, their body postures were transferred to a three dimensional virtual environment and the occurring body angles were measured. The participants were asked to fill in a questionnaire about their current affective state. A principal component analysis with the items of the affect questionnaire (Positive Negative Affect Scales, PANAS) revealed five main factors: aversion, openness, irritation, happiness, and self-confidence. The body angles were then regressed on these factors and the respective postures were reconstructed within a virtual environment. 50 different subjects rated the reconstructed postures from the positive and negative end of the regression. We found the ratings to be valid and accurate in respect to the five factors.

Key words: *nonverbal behavior, communication, affective states, simulation*

Introduction

If one picture tells more than thousand words, how many volumes can be told by a single gesture, posture, or body movement? That most of what we say within a conversation is expressed not only by our words, but also through our body language and nonverbal communication, is a popular scientific finding. Ethological studies of non-linguistic communication in courtship using facial ex-

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pression, gesture, posture, distance, paralanguage, and gaze have established that a universal, culture-free, nonverbal sign-system[1], which is available to all persons for negotiating sexual relationships, may exist. The nonverbal channel, more powerful than the verbal for expressing such fundamental contingencies in social relationships as liking, disliking, superiority, timidity, and emotions such as fear, appears to be rooted firmly in human evolutionary heritage.

But what about the association between body language and a person's affective state? Tomkins[2], Ekman[3] and Izard[4] in their theory of a 'Facial Expression Program' claim a direct connection between internal physiological processes and facial expressions. When an emotion is elicited, neuronal impulses trigger certain physiological changes, as well as distinct facial expressions. According to Ekman[3] the so-called base emotions are always linked to a specific facial expression. Facial expressions are signals of emotions; we assume an evolutionary advantage in signaling one's internal state to others. In contrast to the Facial Expression Program theory Fridlund[5,6] states that facial expressions are social tools, as mimics signal intentions and social motives, which are not essentially linked to emotions and internal states. According to this theory, facial expressions have evolved in order to activate desired reactions and behaviors in interaction partners. There is considerable disagreement whether nonverbal behavior is connected to internal states or not. But if there is a linkage between internal states and facial expressions other forms of nonverbal behavior should be affected as well. Panksepp[7] hypothesized that affective states have neuro-anatomical, physiological, and chemical correlates, which again influence behavior. It is likely that affective feelings may correlate with certain body postures as well as positioning patterns of the upper and lower limbs. In the present study we aimed at investigating the relationship between basic affects and body postures by using a mathematical reconstruction method of body postures.

Argyle[8] points out that posture is an intermediate between gestures and spatial behavior with respect to its intensity and function. Posture frames and defines a period of interaction, which is usually longer than that of a gesture but shorter than that of a spatial position. Therefore it seems obvious that postures are well suited for the expression and communication of affect just because they represent stop-phases in an ongoing behavior stream.

Research on body posture is almost non-existent in on the field of non-verbal behavior analysis. The reasons for this are manifold and lie partially in methodological problems connected to the observation and description of behavior, as well as in the nature of human behavior itself[9,10]. Researchers have tried to describe body postures with a top-down approach by using descriptive categories. However, even if postures can be categorized in organized single chunks, there is always the feeling that the choice of a particular feature is arbitrary and subjective – a matter of scientific artistry and intuition[9].

Affect and attitudes in body postures

Categories used to describe body postures mainly stem from attitudes, and postures are also supposed to signal attitudes. For example, Argyle[8] described a dominance posture as follows: upright standing position, hands on hips, expanded chest; in established hierarchy: relaxation. Mehrabian[11] found that one of the ways in which posture communicates dominance is through relaxation, which is characterized by asymmetrical arm positions, sideways lean, asymmetrical leg positions, hand relaxation, and backwards lean. The relaxed postural style is used towards others with a lower status, more often to females than to males, and also more often to a person of the opposite sex than to a person of the same sex.

Other research has dealt with the communication of affect through body postures. Mehrabian[11] found that openness of arms signals a positive attitude only when expressed by females. Arms akimbo, i.e. arms on hips, were also found to signal a negative attitude, both for the sender and the receiver. It has been observed that interacting persons often adopt postures that are mirror images of each other. Kendon[12] suggested that this might be a sign of good rapport. Dabbs[13] carried out an experiment in which a confederate did or did not mirror the postures and gestures of subjects. When mirroring, subjects considered the confederate more favorably, believed that they agreed on attitudes, and thus identified with him. Graham, Ricci-Bitti, and Argyle[14] found that videotapes of the body could be decoded more accurately than those of the face with respect to five levels of arousal, but less accurately for most of a range of specific emotions, though for English performers anger was communicated better through the body posture.

In our view any functional interpretation of body posture remains critical because it just describes a single posture and it is not possible to interpolate the function on all possible variations. Furthermore most of the research seems fairly vague. For example, given all the variability that is present in human posturing, relaxation and upright position will be hard to operationalize. According to Hewes[15], who has studied the human postures used in different human cultures, the range of stable postures is apparently large (i.e. about 1000). Variability can be further increased by definite social rules. Japanese recognize three levels of deference in bowing, up to 45°. Kudoh & Matsumoto[16] asked Japanese students to rate forty verbally described postures on sixteen scales and found three factors. The main factor was dominance vs. submissiveness including postures such as thrusting out the chest and leaning back, in contrast to shrinking the body and lowering the head.

Besides the difficulties in operationalizing postures, research has demonstrated that attitudes and affect are clearly expressed and communicated by body posturing. However, two questions remain to be answered. First, how does communication through body posture actually work, and second, how to set up an appropriate analysis system that can deal with the variance in body posture?

Communication of affect through body posture

The behavior of a conspecific seems to be assessed constantly in order to detect one's action tendencies and internal state[9]. However, the major problem in communication between a sender and a receiver is the possibility of deception. Thus acting agents are either forced to impose costs for signaling to the conspecific[17] or to look for unforgeable signals. To date the possible mechanism of this type of communication remains somewhat unknown.

Gallese and Goldmann[18] suggest that human mind-reading abilities rely on the capacity to adopt simulation. This capacity might have evolved from an action-execution-observation matching system whose neural substrate are the so-called mirror neurons (MNs), which have only recently been discovered in the macaque monkey pre-motor cortex.

Mirror neurons are a particular class of visuo-motor neurons, originally discovered in the area F5 of the ventral pre-motor cortex of monkeys[19,20]. Area F5 is characterized by the presence of neurons that guide goal-related motor acts such as hand and mouth grasping[21–23].

A possible function of these neurons could be the promotion of learning by imitation[24]. Another suggestion is that the MNs underlie the process of »mind-reading« or at least serve as precursors to such a process. Mind reading is the activity of representing specific mental states of others, for example, their perceptions, goals, beliefs, and expectations. Evidence is now accumulating that humans develop the capacity to represent mental states in others, similar to monkeys. Neuro-physiological experiments[25] clearly demonstrate that action observation is related to activation of cortical areas that are involved in human motor control. In addition, they also indicate that the observation of actions might produce an activation of the motor cortex.

Based on these findings Rizzolatti, Fogassi and Gallese[25] derived the »direct-matching hypothesis«, which proposes that humans understand actions when they map a visual representation of any observed action onto their own area of motor representation of exactly the same action. According to this view, an action can be »read« when its observation causes the motor system of the observer to »resonate«. For example, when we observe a hand grasping an apple, the same neurons that control the execution of grasping movements become active in the observer's motor areas. When only parts of a motion are perceived visually the mirror neurons complete the motion by firing in the correct patterns. By this approach, the »motor knowledge« of the observer is used to represent the observed action. In other words, we »understand« an action because the motor representation of that action is activated in our brain. Detecting another agent's goals and/or inner state can be valuable for an observer for the anticipation of this agent's future actions, which may be cooperative, non-cooperative, or even threatening. An accurate understanding and anticipation enables the observer to adjust his responses appropriately.

We speculate that these findings represent a pathway of simulation that enables an observer to assess his opponent directly and constantly. Postures can be characterized as a hold period between an onset and an offset movement. Therefore, we assume that postures can trigger a response of the mirror neurons based on their ability to complete fragmentary motions. In light of such a system every learning system that assesses postures through social categorizing seems to be superfluous. MN activity causes a state in the observer that matches the one of the target constantly. This hypothesis further suggests that categorizing actions of others in order to understand them is not required. Moreover we propose a rigorous bottom up approach.

Analyzing body postures

According to Krämer[26] current research methods and also the results of research on non-verbal behavior are in a confusing condition. In a thorough review of research findings, she concludes that there have only been few developments during the last 25 years. She suggests introducing new methods, which should avoid global categorization and rely on low-level empirical data[27]. Non-verbal behavior research should focus on a very basic non-interpretative level. This would avoid the necessity to create more than 1000 categories[15] for the description of body postures. Hence, quantitative measures of body posture are seen as dependent on the assignment of a set of numerical values to the positions that is being analyzed. Such an approach could be carried out by using an automatic system with reflective markers and the respective cameras. We suppose that this procedure will tend to foster reactive effects in the observed subjects, especially when focusing on the representation of affect in postures.

Recording postures in social interactions, where one would expect that affect is expressed, requires different methods. Dierssen, Lorenc and Spitaleri[28] used a transparent grid attached to a movie screen and x and y coordinates that were plotted for various points of the body to record postures. This two dimensional system was extended to a three dimensional approach by Trochim[29]. In his method the resulting posture is represented as a three-dimensional graph. This graph can be described as a vector of coordinates of joints, which has one disadvantage– it does not cover rotations of limbs. Bente[30–32] and later Kempter[33] developed a method that continuously translated angles between limbs into a three dimensional computer representation of a person from movies. With this method they where able to show that the three dimensional representations were rated validly by observers on several personality dimensions. In addition, they compared the original movie with the three dimensional representations and found no significant differences. Thus, this seems to be a valid method for a description of a person as a three dimensional graph. Moreover the representation of a posture as an n-dimensional vector provides the opportunity for the use of more sophisticated mathematical methods.

Landmark based geometric morphometrics offers several tools for visualizing shape changes such as thin-plate-spline deformation grids, landmark displacement

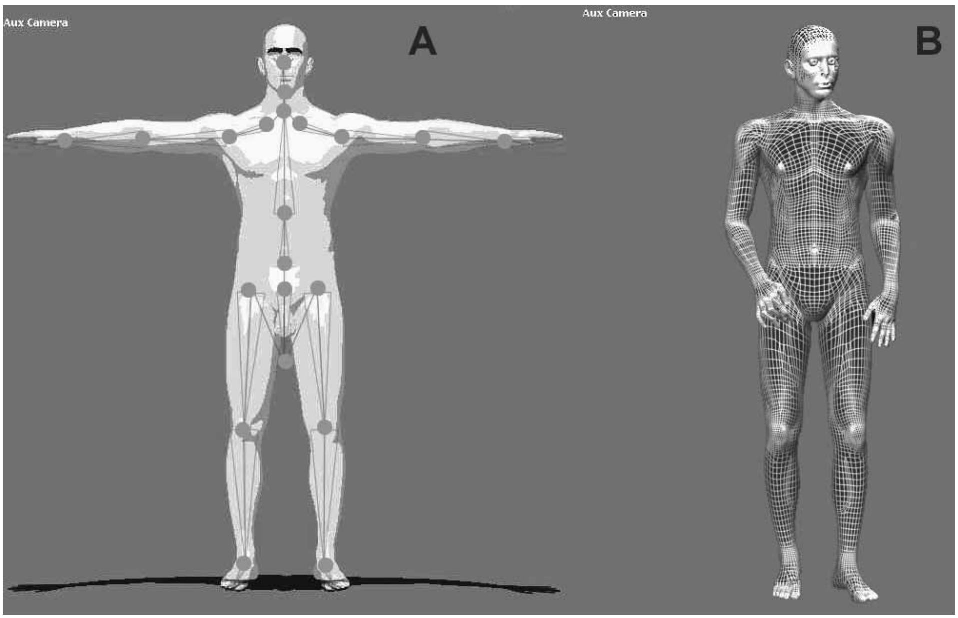

Fig. 1. A) depicts the bones system of the avatar used in this study. Note that the joints connecting the head to the body are divided into three joints. In this study only two were used, which were kinematically chained. The same was done for the connection of chest to hip, where the abdominal joint is chained and for the connection of hip to thigh where the upper leg is chained. B) shows the wire frame model used for the body form calculation.

vectors, or series of different shapes[34–37]. In some sense postures are shapes represented through landmarks in a three dimensional space. Multivariate statistical outcomes such as group difference vectors, shape regression vectors, or principal components can directly be graphed as morphological changes. The most appealing method for the present kind of study is creating a series of shapes by adding different multiples of such a vector to the mean form or another kind of appropriate starting form. A set of landmark coordinates, for example, can be regressed on some factor like observers ratings and the resulting vector of regression slopes be multiplied by different (positive and negative) values and added to the mean configuration. These shapes can then be shown as a continuous series of pictures to represent the pure influence of the particular factor on shape[38,39]. Similar methods can be applied to forms in motion as well[40,41]. These methods allow visualizing postures generated from low-level data and relate them to self-reports or observer ratings without using a categorical posture classification system for observation. The approach suggested here is that any posture can be seen as a result of a finite number of joint angles. Thus any quantitative description (either self description of internal states or description by observers) can be regressed on the values of the angles in a given posture. The resulting slopes of the regression can then be used to visualize the results by adding the calculated values of each angle to the average posture.

The method is also free from subjective interpretation and does not use any assumptions on the structure and organization of non-verbal behavior as claimed by Grammer et al.[10]. Further, the results can also be visualized. Body angles can be transformed into three-dimensional models of persons and a realistic representation of a body posture from any view-

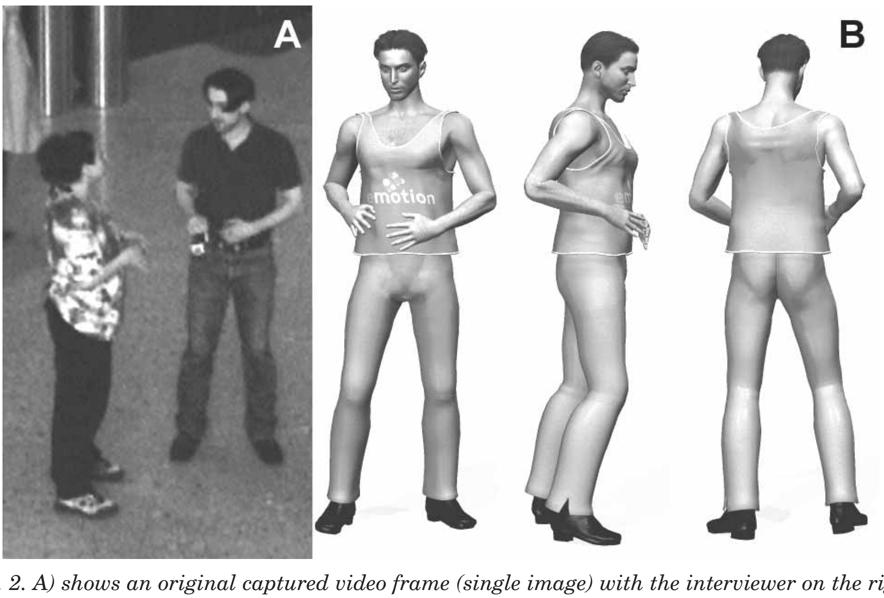

Fig. 2. A) shows an original captured video frame (single image) with the interviewer on the right side and the subject on the left side. B) shows the result of the three dimensional transcription with Poser 4.0 from different viewpoints.

point. It allows to change sex, age and ethnicity for a model and opens completely new possibilities in non-verbal behavior research.

Hypotheses

Based on the theoretical considerations mentioned above we hypothesized that the encryption of affect in body posture is likely and that it should be possible to analyze it on a low level (non-categorical) data set. We supposed that the human brain also uses simulation and not categories for the depiction of affect in body posture. In particular we predicted that (1) the description of affect in body posture is possible by using low-level data combined with the appropriate mathematical methods, (2) postures can be understood in respect to affective state on this level, and (3) in order to validate this approach observers can decode affect from artificial body postures which are reconstructed from the descriptions above.

Method

Coding of postures

A hidden digital video camera (Sony DCR-VX700E) was used to record videos from 100 subjects (females: n = 56, mean age = 22.5, SD = 4.85; males: n = 44, mean age = 23.4, SD = 3.95) when a confederate interviewer approached them. Subjects were randomly assigned to either a male or a female interviewer. As subjects passed by, the interviewer asked them to fill in the PANAS (Positive-Affect-Negative-Affect-Scales[42]) inventory for the assessment of affect state. In order to keep the participants' privacy we took out 5 questions from the original inventory so that our modified version consisted of 15 items.

From the video recordings, a stop motion image was taken of each subject exactly at the moment he/she came to rest (standing) while speaking to the interviewer. The body posture of each participant was then transferred onto a three dimensional avatar (i.e. a virtual human figure) by means of Poser 4.0 (Curious Labs, Santa Cruz). On the avatar, 55 angles within three or two movement directions were utilized to re-create the body posture of the subjects (see Table 1). All movements were constraint in their directions corresponding to the anatomical construction of human joints with four exceptions (head-neck, chest-abdomen, left buttock-left thigh, right buttock-right thigh). The avatar we used did not match exactly the anatomy of the human skeleton. This is due to the fact that the wireframe meshes we used have seams at the limbs. The gaps between the limbs have to be linked for rendering according to the limb movement by using a dynamic fill procedure. In order to avoid folding, the following joints between the limbs are separated in two parts: head-neck, shoulder-arm, chest abdomen and buttock-thigh. Corresponding parts are constraint with respect to their movement directions. For the analysis the angles were added to form a single category. Postures were created starting with the positioning the axis of the hip. Then we proceeded to create the avatar up to the head and down to the feet. Body orientation of the avatar towards the interviewer was adjusted to the camera plane. In order to ensure reliability of coding, two experimenters created the initial posture. Additionally, two different experimenters controlled the resulting postures, and in a third run the first author re-checked all postures.

Questionnaire analysis and regression of self reported affect on joint angles

A principal component analysis with questionnaire items resulted in five principal components. Then a regression analysis was used to determine the influence of affect on body positioning. The 55 joint angles were linearly regressed on each of

TABLE 1
JOINT ANGLE IMPLEMENTATION AND ROTATION LIMITS

Joint	Movement	Limits in degrees
Head	Bend	–35 to 17
	Twist	–12 to 12
	Side-side	–15 to 15
Neck[1]	Bend	–20 to 20
	Twist	–25 to 25
	Side-side	–10 to 10
Shoulder	Up-down	–12 to 31
	Front-back	–30 to 30
Upper Arm	Bend	–85 to 45
	Front-back	–45 to 35
	Twist	–30 to 35
Underarm	Bend	–130 to 15
	Twist	–85 to 45
Hand	Bend	–70 to 80
	Side-side	–20 to 20
Chest	Bend	–40 to 27
	Twist	–20 to 20
	Side-side	–20 to 20
Abdomen[1]	Bend	–25 to 45
	Twist	–25 to 25
	Side-side	–20 to 20
Hip	X-Rotate	–360 to 360
	Y-Rotate	–360 to 360
	Z-Rotate	–360 to 360
Buttock	Bend	–35 to 10
	Twist	–15 to 15
	Side-side	–5 to 30
Thigh[1]	Bend	–65 to 30
	Twist	–45 to 48
	Side-side	–15 to 45
Lower Leg	Bend	–3 to 150
	Twist	–15 to 15
Foot	Bend	–25 to 35
	Twist	–15 to 19
	Side-side	–16 to 22

[1] Kinematically chained to joint above

the five factors, resulting in five vectors of regression slopes. The 55 slopes of such a vector represent the multivariate pattern of dependencies of the bending variables on the particular factor. The effect of one factor can be visualized by adding an arbitrary multiple of the corresponding slope vector to the mean vector. Even a 'negative' factor (e.g. *sadness* as the opposite of *happiness*) can be visualized by applying a negative multiple for the slope vector before adding it to the mean vector. With these data 25 postures were created.

Rating of simulated postures by third party observers

Ten postures that represented the upper and lower end of the regression were rated on a five point Likert scale (1 = very slightly, 5 = extremely) for the five principal components of the PANAS analysis (males: n = 25, mean age = 23.4, SD = 4.07; females: n = 25, mean age = 23.6, SD = 3.07). The stimuli were presented in random order. This experiment was supposed to serve as an indicator of the validity and accuracy of the simulated body postures with respect to self reported affect.

Results

Sex differences

A test for sex differences in the joint angles revealed that male and female postures differ only marginally. As there are 55 body angles we refrain from presenting the non-significant t-tests statistics. None of the angles differed significantly after Bonferroni correction. Therefore we did not split the data by gender for the further analyses. If our hypothesis is correct and body postures do indeed signal affective states, there should be no sex differences, neither in the production, nor in the perception of postures, because affective states and their communication should be independent from sex of the sender.

Principle component analyses of the PANAS items (self report)

The adjectives from PANAS were subjected to a factor analysis. The factors are presented in Table 2. A five-factor solution explained 73 % of variance. The factors were labeled as follows: factor 1 = social aversion, received the rating label »Dismissive« (»ablehnend«); factor 2 = social openness was assigned »Open« (»aufgeschlossen«); factor 3 = happiness was named »Happy« (»glücklich«); factor 4 = irritation was assigned »Irritated« (»genervt«); and factor 5 = self-confidence was translated into »Self confident« (»selbstbewusst«). These labels were then used in the rating study.

Posture reconstruction, and validity (third party rating)

In order to analyze the association between body posture and affect, the body angles were regressed on the regression scores of the PANAS analysis. The resulting five slope vectors (one for each factor) were then used to reconstruct the postures (see Figure 3). The resulting four sets of scores were added to the mean posture (positive factor) and subtracted from the mean posture (opposite of the positive factor). These two sets of scores for each factor from the PANAS principal component analysis were then applied to the avatar and linearly interpolated. At a distance of 1 from the mean (the factor itself) and 1.5, which shows the exaggerated posture.

We calculated inter-rater reliability for each factor over all pictures in order to see if there was agreement on the judgments. For social aversion we found a Cronbach's Alpha of 0.86. The average measure intra-class correlation (ICC) was 0.85 ($F(9,490) = 6.83$, $p = 0.0000$). Com-

TABLE 2
FACTOR LOADINGS OF PANAS ITEMS (N = 100)

	Factors				
	Social aversion	Social openness	Happiness	Irritation	Self confidence
Hostile	**0.83**	–0.18	0.09	0.16	0.02
Upset	**0.80**	–0.07	–0.16	0.26	0.04
Irritable	**0.75**	–0.11	–0.22	0.15	0.14
Scared	**0.73**	–0.29	0.16	0.15	–0.19
Attentive	–0.14	**0.83**	0.19	–0.21	–0.01
Determined	–0.15	**0.83**	0.10	–0.06	–0.09
Active	–0.13	**0.81**	0.10	–0.05	0.21
Interested	–0.31	**0.46**	0.16	–0.16	0.41
Excited	–0.03	0.09	**0.98**	–0.11	0.12
Inspired	0.05	0.22	**0.83**	0.07	0.15
Jittery	0.30	–0.13	–0.04	**0.83**	0.06
Afraid	0.53	–0.14	0.11	**0.58**	–0.28
Happy	–0.30	0.21	**0.53**	**–0.55**	0.08
Proud	0.20	0.10	0.15	–0.05	**0.85**
Strong	–0.34	0.38	0.34	–0.10	**0.54**

Extraction method: Principal component analysis, Rotation method: Varimax with Kaiser normalization. Total variance explained: 73.0%

parable results hold for social openness. Cronbach's Alpha was 0.87 and the average measure intra-class correlation was 0.85 (F (9,490) = 7.04, p = 0.0000). Happiness had a Cronbach's Alpha of 0.80 and the average measure intra-class correlation was 0.77 (F (9,490) = 4.4205, p = 0.0000). Social irritation scored with a Cronbach's Alpha of 0.89 and the average measure intra-class correlation was 0.8760 (F (9,490) = 8.07, p = 0.0000). The last item, social confidence, showed the lowest Cronbach's Alpha with 0.69 and the average measure intra-class correlation was 0.91 (F (9,490) = 3.19, p = 0.0009). We concluded that the ratings of the reconstructed postures were valid because the raters showed a high inter-rater reliability. In order to find out whether there is an overlap between the semantic domains of the adjectives, we correlated the average ratings over all pictures. It turned out that the rating domain of »Dismissive« was correlated positively with »Irritated«, and »Open« correlated positively with »Happy«. This means that a posture that is rated as dismissive might also be rated as irritated, and a posture rated as open might also be happy. This overlap has to be taken into account when analyzing the rating profiles of the single pictures.

Another validity check appeared even more sophisticated and straightforward with respect to our overall hypothesis. If our assumption, that the reconstructed postures comprise the information about scores on the PANAS factors, was right, then the opposite of the positive factor should score significantly lower on the rating dimension. This was tested with paired t-tests (social aversion: positive 3.48 SD = 1.09, negative 2.59 SD = 1.35, f = 5.99, df = 98 p = 0.001; social openness: positive 3.18 SD = 0.89, negative 2.64 SD = 1.22, f = 5.64, df = 98 p = 0.014; happiness: positive 2.56 SD = 0.81, negative 2.05, SD = 0.99, f = 3.72, df = 98 p = 0.007; irritation: positive 2.88 SD = 1.30, negative 2.68, SD = 1.16, f = 1.16, df = 98 n.s.; self-confidence: positive 3.58, SD = 1.23, negative 3.12 SD = 1.23, f = 1.17, df = 98 p = 0.055). These results show that the reconstructed »negative« posture might indeed be perceived as the opposite of the observed »positive« factor. Note that the »negative« postures are constructed and not observed, which underlines the validity of our procedure.

After we had shown that observers agree on the ratings of the affective state of a posture, the last step of our analysis was to see whether and how the postures are related to the differences in ratings. At this point one should keep in mind that the postures are constructs from the regression analysis.

In addition to this analysis each posture should score higher on its own dimension if positive and lower if negative than all other postures that were rated by the observers. In order to analyze this we tested if the ratings for the single pictures in their own domain differed signif-

TABLE 3
CORRELATIONS BETWEEN RATING ITEMS IN THE PICTURES (N = 10)

	Open	Happy	Irritated	Self confident
Dismissive	–0.922*	–0.842*	0.872*	–0.331
Open		0.860*	–0.911*	0.542
Happy			–0.885*	0.585
Irritated				–0.590

* p < 0.01

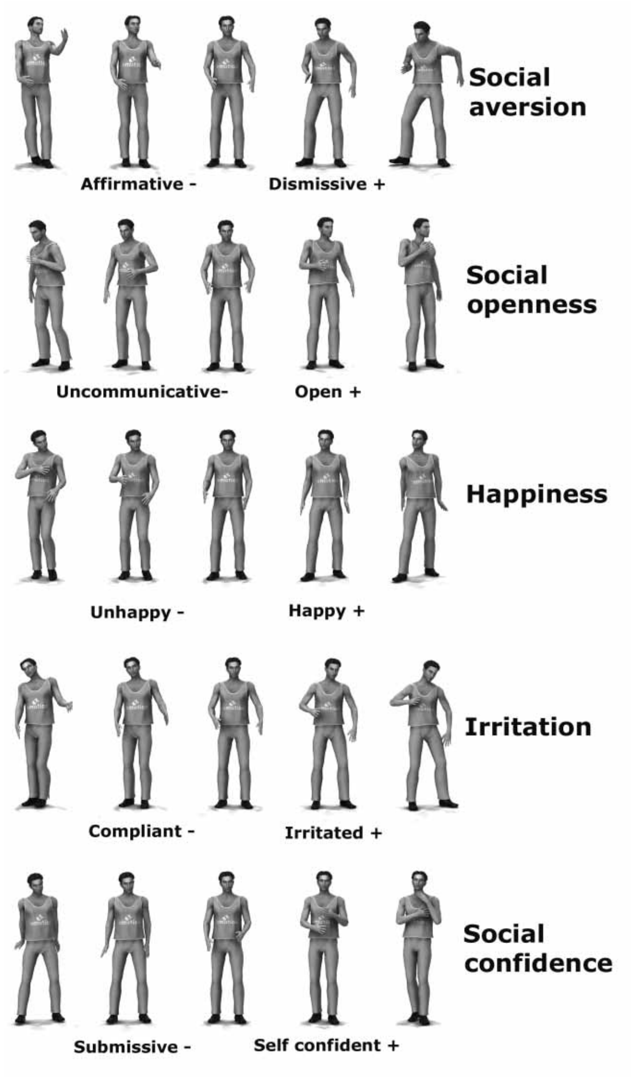

Fig. 3. These figures visualize the results of the regression analysis of PANAS principal components on body angles as follows from top to bottom: social aversion, social openness, happiness, irritation and self-confidence. On the right of each panel the positive axis is depicted and on the left the negative axis. The figure in the middle shows the average for each panel. Each panel was calculated the following: The second figure from the right is the result when the regression is calculated with the slope and a distance of 1. The figure at the utmost right is a factor of 1.5. This method allows the exaggeration of a posture in either direction. For the rating study of the negative pole the second picture from the right was used, and for the positive pole the second picture from the left was used. This picture is marked with the adjective used in the rating study. The picture on the left is marked with the reconstructed dimension. Note that these postures are reconstructions from the principal components of the PANAS scores. Thus they are completely artificial, but nevertheless reach the correct ratings by observers.

TABLE 4
DIFFERENCES IN RATINGS BETWEEN POSTURES (MEAN PICTURE: N = 50, CONTROL: N = 450)

Factor	Picture	Mean picture	SD	Mean control	SD	Expec.*	Observ.*	t	p
Aversion	Dismissive +	3.48	1.092	2.85	1.200	>	>	–3.53	0.000
	Affirmative –	2.58	1.341	2.95	1.183	<	<	1.88	0.064
Openness	Open +	3.16	1.235	2.96	1.159	>	>	–1.15	0.251
	Uncommunicative –	2.64	0.898	3.02	1.188	<	<	2.72	0.008
Happiness	Happy +	2.56	0.993	2.38	0.936	>	>	–1.29	0.195
	Unhappy –	2.06	0.818	2.43	0.949	<	<	3.00	0.004
Irritation	Irritated +	2.88	1.304	2.95	1.250	>	<	0.36	0.713
	Compliant –	2.68	1.168	2.97	1.262	<	<	1.55	0.120
Confidence	Self confident +	3.58	1.230	3.31	1.131	>	>	–1.59	0.112
	Submissive –	3.12	1.136	3.36	1.142	<	<	1.41	0.159

*For the »expected« and »observed« columns, signs should point in the same direction for a correct classification.

icantly form all others. For instance the picture depicting »Unhappiness« should be rated as being unhappier than all other pictures. This is indeed the case for most of the pictures (see Table 3). The table shows that with the exception of the posture »Irritated +« all differences are in the expected direction. Three of the differences »Dismissive +«, »Uncommunicative –« and »Unhappy –« are significant. In these cases the rating scores are significantly different from the same rating scores for the rest of pictures and the differences go in the predicted direction. Although this result is not overwhelming, it shows there is at least some accuracy in our procedure. As shown above there seems to be considerable overlap for the categories in the raters' perception.

Discussion

Most human behavior can be described as dynamic changes in the surface and location of the human body. This is even true for postures because movements, which are used to assume and to form a certain body posture, frame them. This is certainly also true for speech and its prosodic features like voice pitch and loudness, which also are produced dynamically. In this way, human communication can be seen as a multi-channel process. Functionally, the expressiveness of the human body is bound with communication and speech, and should convey information about the personality, gender identification, intentions, emotions and internal states of a person. Mehrabian[43] concluded that non-verbal channels (i.e., movements in the above sense) might dominate speech content. He assumed that only about 7% of the meaning in a message is created by the content of the message, whereas 38% comes from vocal prosodic cues, and 55% is generated by the visual impression of non-verbal behavior.

In this article we present a new methodology for the analysis of human body posture, which is one of the core elements in nonverbal communication. Body posture was rarely subject to empirical research so far. The combination of behavior observation and anthropometric measures can yield new insights. In our view this will mark a major break-through in non-verbal behavior analysis. We investigated the relation between real life body postures and self-reported affect and created mathematical reconstructions for the main factors and their opposites of self-rated affect in a three dimensional environment. Since the negative postures were constructed mathematically, they do not represent a natural posture per se. Ratings of these figures were found to be reliable and in most cases accurate. As predicted reported affect seems to be encoded in body posture and is understood by observers, even from reconstructed postures. The fact that even the reconstructed negative postures show a high degree of raters' reliability and accuracy emphasizes the signal quality of body angles as opposed to posture categories. The fact that postures can be regarded as continuous vectors of body angles and that there is no further need for categories is probably the most interesting aspect of this study. If this were true, learning of social prototypes for social communication would be unnecessary because the affect embedded in these vectors could be simulated by the mirror neurons. If this is the case there is considerable need for an updated communication theory. We can conclude at this point that body postures contain information about self-reported affect, and perceivers can correctly assess the affective value of body postures

Since social categorization and the use of stereotypes could never be able to explain the variance and the complexity of all possible body postures we assume that self reported affect is communicated via the mirror neuron system. This research also indicates that behavior can be described as an n-dimensional vector – based on three dimensional – landmarks, or as in our case, body angles – independent from categorization. The fact that the raters understand even the constructed negative postures implies that any communication theory that uses categories is incorrect, but communication via mirror neurons is quite likely. Behavior research using such an extreme bottom-up approach, can lead to considerable insights in the very quality of social communication, to which research using categories would inevitably remain ignorant. The new anthropometric methods allow reconstructing meaningful elements, and hence provide a solution for the dilemma bottom-up-research was facing so far. However, for the final proof of the proposed communication via mirror neurons additional research is required: Brain-imaging studies, such as fMRI-studies would cast further light on the role of body postures in communication. If the change of body angles elicits activity in the F5-neurons this would be the final proof for such a low-level communication system.

The method we applied generates usable results. There are yet several reservations to the current approach. The present study implies that there is a relation between affective state and body posture, whereas it was not as strong as expected. The ratings of the positive and negative dimensions of the reconstructed postures showed no significant differences in irritation and self-confidence. This might be due to the uncertainty whether the affective states derived from PANAS and the resulting factors represent valid dimensions of human communication. Further studies should also test different dimensions and semantic differentials based on evolutionary psychology. The semantic differentials to be used should represent valid dimensions for the communication of affect. Another problem and possibly a source of artifacts in this procedure is the re-translation of the PANAS principal components into rating adjectives. This problem becomes apparent in the overlap between the rating items. For a human observer it is obvious that somebody who is open should also be happy. Orthogonal rating items would be better for such a procedure.

For the current approach the use of categories for the description of affect and a low-level approach for the description of body postures might appear contradictory. This is certainly a shortcoming of the present study. Either psycho-physiological measures or fMRI-studies would be able to provide more appropriate data for these questions.

Besides the insight into the organization of non-verbal behavior this approach can be used for simulating affect in body postures in embodied systems. The actual simulation engine used will depend on the semantic differentials used for rating, however. In any case the simulation of affect in posture can probably be made more realistic and even valid if the procedure we propose is applied.

We think that this approach is a first step towards an understanding of the role of body posture in social communication. However, as stated above, there are several open questions to be answered.

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IZRAŽAVANJE OSJEĆAJA POLOŽAJEM TIJELA I SIMULACIJA POLOŽAJA TIJELA

S A Ž E T A K

Uzima se zdravo za gotovo da neverbalna informacija koju daje položaj tijela druge osobe utječe na naš doživljaj drugog. Međutim, položaj tijela nije do danas nikad bio opisan na empirijskoj razini, te je ova studija prvi pokušaj bavljenja ovim problemom. Kombinirali smo dva pristupa: tradicionalno promatranje ponašanja te modernu antropometrijsku analizu. Fotografirano je 100 učesnika studije te su slike položaja njihovih tijela prenesene u trodimenzionalno virtualno okruženje a potom su izmjereni svi kutovi tijela koji su se mogli zamijetiti. Učesnici su ispunili upitnik o njihovim trenutačnim osjećajima. Analiza glavne komponente (PCA) odgovora na upitnik o osjećajnom stanju (pozitivno-negativna ljestvica osjećaja, PANAS) izlučila je 5 glavnih faktora: odbijanje/prihvaćanje, zatvorenost/otvorenost, nepopustljivost/popustljivost, osjećaj nesreće/sreće i podložnost/samopouzdanje. Napravljena je regresijska analiza ovih faktora i kutova tijela te je za svaki faktor rekonstruiran odgovarajući stav tijela unutar virtualnog okruženja. Potom je 50 različitih osoba ocjenjivalo rekonstruirane položaje tijela na ljestvici od pozitivnog do negativnog kraja regresije. Pokazalo se da je njihova ocjena bila pouzdana i točna u odnosu na 5 ispitivanih faktora.