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REVIEW ARTICLE

Dynamic Systems and Inferential Information Processing in Human Communication

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Abstract Research in human communication on an ethological basis is almost obsolete. The reasons for this are manifold and lie partially in methodological problems connected to the observation and description of behavior, as well as the nature of human behavior itself. In this chapter, we present a new, non-intrusive, technical approach to the analysis of human non-verbal behavior, which could help to solve the problem of categorization that plagues the traditional approaches. We utilize evolutionary theory to propose a new theory-driven methodological approach to the 'multi-unit multi-channel modulation' problem of human nonverbal communication. Within this concept, communication is seen as context-dependent (the meaning of a signal is adapted to the situation), as a multi-channel and a multi-unit process (a string of many events interrelated in 'communicative' space and time), and as related to the function it serves. Such an approach can be utilized to successfully bridge the gap between evolutionary psychological research, which focuses on social cognition adaptations, and human ethology, which describes every day behavior in an objective, systematic way.

Human communication and information processing

The information processing approach study the nature of human communication uses signal and response, sending and receiving, and encoding and decoding for the structural explanation of interaction between individuals. On the surface, this approach seems quite practical. One organism, the sender, encodes information into a signal. The signal is passed on to another organism, the receiver, who decodes the signal. The receiver is capable of responding appropriately, or not. In this approach a signal is a defined entity, bound within a signal frame. In addition, we can find 'basic trigger signals' which are sent parallel to the actual signal. Trigger signals carry the decoding message. When a 'sender' laughs, for example, his encoded 'signal' of laughter will be decoded by the receiver and interpreted as anything from sexual enticement to ridicule, all depending on the 'trigger signal' of the sender – namely, the sender's body posture [1].

The description of communication from this sequential, information processing level has served as a guideline for communication research for many years, maintaining much of its popularity through the ease of its empirically testable framework. Recent research has shown, however, that this view of communication is most likely too simplified, and that the approach has several flaws. One problematic area is the lack of direct linkage between signals and their causes/effects [2]. A key problem is the assumed 'knowledge' that must accompany signal encoding and decoding. The receiver has to recognize that a signal is present. Then he has to add knowledge in order to be able to decode the meaning of this signal. This means that the receiver has to share knowledge with the sender, and that there have to be signals for the transfer of knowledge. This leads to an infinite regression of definition, a regression that can only be solved when there is a common knowledge that is shared prior to communication [3].

A second problematic area for research based on this approach is the methodology – our attempts to discretely classify a 'signal'. Even if behavior can be categorized in organized single chunks of movement, there is always the feeling that the choice of a particular feature is arbitrary and subjective – a matter of scientific artistry and intuition [4]. This may be one reason, among many, why no catalog of behavioral 'chunks' has yet become a standard across studies. In order for a good catalog to exist (to increase reliability and decrease observer bias), categories would have to be unmistakable, stereotypical, homogeneous and discrete. The result then leads to oversimplification and broad categories. In the typical 'catalog' approach, observers recognize 'movement-Gestalten', put a name on them, and count them – a lexical, language-like process. Finally, categories are not only arbitrary and subjective, but variation in a non-verbal signal (possibly carrying information relevant for communication) might be lost as well as differences in the 'quality' of a behavior [2].

When a continuous behavioral stream is forced into a series of event categories, comparable, but qualitatively distinct, behaviors are subsumed. For example, a 'non-verbal threat signal' can be carried out in many ways – by raising an arm quickly or slowly, with the fist tightly clenched or not, with the movement staying at the maximum flexion for a certain time, or with a slow or quick return to the resting position. Any of these possible movement combinations will produce a different type of 'threat'. Assume the transfer of the movement combination itself to a leg or even a head movement: turning the head quickly towards a target, staring at him, and then slowly looking away. Utilizing various body parts, we can produce 'threat' connotations. The important key for the connotation, however, is the *quality* of the movement itself – an aspect that is typically lost within the categorization.

In total, the main virtue of the information processing approach – that signals can be put into simple, empirically testable frameworks ends up being the main vice. When, if at all, the categorizations of signals become standardized, those classifications tend to be arbitrary, broad and over simplified, and tend to remove the variation and movement quality aspects that may be integral to the signal. After nearly two decades of information processing research, we are left with an unfortunate realization. When categories are used for the assessment of non-verbal behavior the results are rarely reproducible. Further, different signals seem to take various meanings. There are two possible conclusions: (1) either we have the wrong theory, or (2) our methods are not adequate; and in any case, both methodology and theory are intertwined. Flaws in one tend to reflect flaws in the other.

Communication as a dynamic system

In a recent approach, Shanker and King [5] present an alternative view to the traditional information processing theory. In their view, communication is conceptualized not as a system of sequentially transferred signals, but rather as a dynamic system of cross modal attunement. Communication is seen as an interaction that includes attention regulation, engagement, intentional affective signaling, reciprocal affective problem solving, affectively mediated creation of ideas, and affectively mediated thinking [6]. This system can be further conceptualized in terms of engagement and disengagement, synchrony and discord, breakdown and repair. All elements are considered to continuously interact and change with respect to one another by forming a mutual aggregate pattern – the so-called 'co-regulated activity'. The key point is that communication is dynamic.

The classic metaphor for this view is the 'dance' metaphor [7]. The steps and flow of an interaction are moderated through a dance of time-modulated synchrony and dynamic accumulation of signals. Synchronization of body movements (to both our own words and the words and movements of others) is a fundamental part of this process. This synchronization dance is what is commonly perceived by the interactants to be 'rapport'. Research shows that such a process can be perceived. When participants view dyads interacting they are able rate the amount of synchrony that is present and assess 'rapport' accordingly [8].

Consequently, a good empirical test of the dynamic systems theory might begin with a detailed analysis of movement and rapport perception. The results of Grammer, Kruck and Magnusson's [9] analysis of these components underscore the importance of synchronization and dynamic transferring of signals within a specific time structure. Analysis of self-reported 'rapport' ratings from male/female dyads interacting in a waiting room context showed that rhythmical patterning of movements alone – and not their content – was responsible for creating positive feelings in interactions. With the help of a search algorithm called THEME [10], significant results were found for a phenomenon the authors describe as 'hierarchically patterned synchronization'. If a female is interested in a male, highly complex behavioral patterns with a constant time struc-

ture emerge. This means that for behavior 'A' (e.g., she moves her arm), behavior 'B' repeatedly follows in a constant time interval (e.g., he moves his leg). But A and B together form a new unit, 'AB', which might create a pattern with behavior C and so on. With such patterns, communicating partners continuously establish and sustain a feeling of shared rhythm and movement. The patterns are pair-specific and independent of behavioral content. Only a few of the patterns occur twice.

An interesting side note, here, is to mention again our foundation for criticizing the traditional information processing 'catalog' approach to the study of communication. In the study cited above, Grammer, Kruck & Magnusson [9] found that patterns in nonverbal behavior could only be identified by their rhythmical structure and not by their content. In addition to analyzing behaviors for movement quality via THEME, they also maintained traditional catalog methodology quantification. Interestingly enough, all behavioral categories that have been previously found by Moore [11] to be 'courtship signals' were not significantly related to rapport. The conclusion for this research is that there may be at least two levels of communication in courtship: one that operates on an information processing system level, with defined signals, and another that operates on a dynamic, more complex level. While defined signals may have communication value, they are not the key components for the creation of interaction rapport. Rapport operates on a dynamic level.

A study that analyzed human body movements and laughter also pointed toward the existence of an underlying dynamic synchronization pattern [12]. Results showed that when comparing body movements and the power (frequency * amplitude) of laughter, there is a cross lag correlation between female laughter and male movements. Interestingly, the number of significant correlations is connected to female interest. When the female's interest is high, the male synchronizes his body movements with the female's sound production on a micro level. Male's body movements reach their apex of movement exactly at the time where the female laughter has its highest power. This occurs throughout the laughter episode itself; throughout the staccato of laughter the male moves rhythmically in unison. Such findings provide some of the first empirical evidence for the dynamic basis of human communication.

Evolutionary based system constraints for communication in humans

How should research on the dynamic level of communication continue or be structured? One way towards the understanding of the communication process is to look at the evolutionary constraints that may influence the way in which the communication 'dance' will be structured. Although we can identify general principles for communication, we would expect that some domain specific constraints exist. An obvious domain to start with – and one we will elaborate here – is deception and human mate selection. Human mate selection is bound to be closely tied with specific communicative needs, especially that of deception.

General constraints on communication: the advantage of deception

When thinking about human behavior, one must keep in mind that both the natural and the social setting are structural elements of our Environment of Evolutionary Adaptedness (EEA) [13]. Adaptation to the social aspects of the EEA would have been important, as a great deal of an organism's well-being, survival, and reproduction prospects depend on its communication with other members of the group. One perpetual facet of group living is deception. Deception is an important element in generating and maintaining one's adaptive communicational advantage over his/her potential competitors. Presenting one's intentions in a communication may be a costly mistake, since the intentions of one organism may be diametrically opposite from the intentions of another organism. Thus, a conflict situation may arise from the presentation of conflicting goals. This presents the seeds for deception. Organisms would have needed to develop a means of concealing their intentions or any psychophysical features that might negatively affect (a) the achievement of a short-term goal and (b) the chances of reproduction in the long run.

Taken in this evolutionary context, we can say that deception in communication is merely an adaptive response to the demands set upon an individual organism by the environment. Just like various species (e.g. *Hyla arenicolor*, the canyon tree frog [14]) develop highly adaptive cryptic coloration to blend with the environment and escape a predator, humans can use communication signals to conceal their intentions and thus bypass potential goal-inhibiting social-interactive obstacles [2]. In the end, this creates a communication dilemma. The manipulative component of a signal aims to force the receiver into a certain state where he or she willingly accepts the goals of the sender, preferably without recognizing consciously that the sender is being manipulative. The presence of this manipulative side to communicative signals is inevitable due to the strength of its adaptive advantage. Humans are evolved to be deceptive.

What implication does this have for either the information processing or dynamic systems approach to communication? Neither approaches preclude the presence of deception. Organisms are able to falsify a single signal and its meaning, or they might also be able to manipulate the dance-like structure (and mutual influencing) of a dynamic system communication. However, it may be speculated that falsifying a single signal might be more obvious for detection than the more subtle dance like structure. Dynamic communication, then, can be a likely candidate for honest signaling. Coming from a constraints perspective, it seems likely that the study of deception from the dynamic systems approach might be an important addition to our understanding of the communication process.

Domain specific constraints on communication: asymmetric investment

The expectations for signaling and deception in signaling can then be applied to specific domains. Constraints on communication are also likely to stem, for example, from evolutionary differences in the reproductive capabilities of males and females. Since females invest more per offspring, their potential fertility is lower than that of males, and subsequent risk within male-female interactions is higher. Females, as the limiting factor in reproduction, are thus the 'choosers' in courtship, and males have to compete for their accessibility.

The specific consequences of male/female asymmetrical investment can clearly be seen in mate selection preferences [15, 16]. Men's socioeconomic status is the most important choice criterion of women, with social position, prestige, wealth etc. being used as indicators for the available investment. In contrast, women's physical attractiveness is the most important choice criterion for men, as attractiveness, healthiness and youth are all cues linked to reproductive capacity. Further, men are more inclined to multiple short-term mating (e.g., philandering), whereas women are more interested in few, long-term bonds [16]. The differences in evolutionary needs will lead again to a central problem relevant to communication parameters: males and females have different intentions. Whenever conflicting intentions – especially those from a biological, evolved basis – are present, deceptive signaling can be predicted. These interest conflicts between the sexes are central to understanding why efforts to find a mate are fraught with ambivalent signals and deception.

Coming from a constraints perspective, specific predictions about communication parameters can be made. During courtship, especially in its beginning phase, deception is expected to be numerous, e.g. men will exaggerate their status and long-term willingness to invest, and women embellish their physique or feign interest in order to discover men's 'real' attributes. Men, due to their lower reproductive investment, will be expected to be quickly interested in a woman and tend to overtly signal both sexual interest and commitment. The higher investment of women, in contrast, will predispose females to utilize coyness displays and subtle, non-committing and ambivalent signals – an act that serves to lengthen interaction and thereby extend their chance to correctly evaluate a man's real intentions and qualities. As soon as a male gets a clear signal of a female's interest, his tendency to deceive may increase. This is the case because the possible costs of deception are lowered continuously the more she shows her interest – he will not get rejected. Indeed, more than 60% of males report using deception in courtship situations [17]. This constraint (i.e., that females need to avoid showing interest) will have a direct impact on communication: When communicating, women will need to use non-obvious and non-binding channels. Nonverbal communication, in contrast to speech, is said to be just unobtrusive, indirect, subtle and non-committing ([7], see below).

This prediction may also have been derived from folk-psychology and cliché-like knowledge on women's 'natural emotionality'. However, it is also solidly corroborated by data. From earliest childhood onwards, women exhibit more (expressive) nonverbal behavior than men (e.g., facial expressions and touching [7, 18]). To quote DePaulo [19]: *'Differences in ability, motivation, and spontaneous expressiveness all converge to produce what may be one of the most pervasive and important of all individual differences in the use of nonverbal behavior for self-presentational purposes: Sex differences... [women's] body movements are more involved and more expressive'* (p. 222–223).

How does information about such mate selection constraints fit into our approach to communication? We hypothesize that sequential, direct signaling plays a minimal role especially in the opening phase of courtship interaction. When individuals begin verbally communicating, the most important signals are likely to be on the nonverbal dynamic level, since individual signals could be falsified more easily. The dance like structure, on the other hand, is more likely to be an honest signal. We propose that dynamic movement – or, more specifically, movement *quality* – is a likely to be a crucial and important part of the courtship process. Why? Dynamic movement quality allows an observer to make accurate inferences about the internal state of the target. In the next section we will elaborate on the previous research on movement quality affordances, provide a possible methodology for measuring the dynamic movement – inference relationship, and discuss an impetus in the brain-behavior relationship, which might provide for such a system.

The key to dynamic body movement: inferential communication

In Austrian expression psychology, the assessment of movement quality has played an important role as early as the beginning of the 20th century. Fischer [20] introduced an objective movement analysis method based on filmed behavior, where the coordinates of joints in every film picture were measured. Flach [21] postulated, *'A symbol alone, a gesture…is ambiguous. In contrast, the dynamics of a movement are unambiguous and convincing'* (author's translation). Fifty years later, Johansson [22, 23] fixed point-light displays to the joints of participants and filmed their movements in the dark. When the point-light films were shown to observers, they were able to recognize sex, age and movement patterns (e.g., walking) of the filmed participants, but when point-light displays were presented as fixed images, they were rated as randomly distributed [24, 25]. Similar results were also found by Berry and his colleagues [26], whose quantized videos showed that observers are able to detect effort, intention and deception from body movements alone.

Facial and head movements are also rich sources of information. Kempter [27, 28] used short video-clips of politicians that were then rated by observers on 15 personality dimensions. The movements of the politi-

cians were then extracted with the BERN-Coding-System [29] by hand, and transferred to computer avatars. Although all avatars looked alike, they were rated in their personality dimensions exactly like the original politicians that they had imitated. Following these results, Kempter [27, 28] concludes that personality is encoded in body movement. Kempter [27, 28] uses the term 'inferential communication' to describe the fact that movements allow an observer to make inferences about the personality of the moving person.

When it comes to person perception and movement, attractiveness of the communicating agents are expected to play a role. Such a finding would be directly predicted from the evolutionary constraints – spoken about earlier in the paper – of human mate selection. Indeed, facially attractive people (and people with voices rated as nice by others) tend to be more accurate senders of nonverbal emotion information, especially for controlled, posed expressions [30]. This effect is particularly enhanced in females [31].

A major component of the 'what is beautiful is good' stereotype is the belief that attractive people are more socially skillful. However, expressiveness and beauty research then shows that this stereotype has a 'kernel of truth'. Several researchers have suggested that this attractiveness/communication skill link can be readily explained by environmental contingencies, that attractive people (1) receive more favorable expectations from others, (2) enjoy better social exchanges, (3) develop more positive self images, and (4) have more confident interpersonal behavior patterns [32]. As a result of such environmental contingencies, attractive people will logically be better senders than unattractive people.

The movement quality hypothesis, when combined with evolutionary theory, would offer an additional explanation: perhaps attractive people are better communicators because they have a physiognomy (e.g., symmetry) that better supports the encoding of information. A recent study by Grammer *et al*. [33] that analyzed movement quality (dancing) and independent movement attractiveness ratings argues for this view: attractiveness signals good genes and the perception of certain facial qualities as attractive might have evolved as an adaptation to the problem of choosing a high quality mate. It seems likely that also the quality of body movements is directly connected to symmetry and averageness – markers of developmental stability and heterozygosity. When it comes to movement quality, it may be speculated that more or less symmetrical bodies will move differently because of their limb length and mass distribution of muscles. The same argument might also hold for averageness – average bodies, as they represent the population mean, are less likely to have extreme features that might hinder movement ability. This should be detectable in movement quality. Thus, like the inferences that movement quality allows for about demographic information [22], social intentions [26]and personality variables [27, 28], it is possible that movement cues could also provide inferences about a person's internal status, developmental or genetic history.

Several research endeavors have provided evidence that movement quality can also be used as a cue for the inference of internal physiological states. Grammer *et al*. [2] showed that the quality of female body movements (e.g., speed, emphasis and complexity), and not their content, changes with female estrogen levels, and that males react to these changes accordingly with higher excitement, i.e. they start to move more. Studies of menstrual cycle and female reveal similar findings [33]. In a forthcoming paper [33] we will also show that this is the case for movement quality and testosterone in males. This is important research, as the assessment of internal states would be expected to be crucial to interaction. Inference about honest, unfalsifiable signals would be of great advantage. Again, dynamic movement quality seems to be a likely candidate.

Movement quality analysis – an new methodology

A great deal of information might be encoded in movement quality. Actual communication does not only rely on simple signals, however, any 'signal' can do, depending on the way it is performed. In answer to the persuasiveness of the findings mentioned in this paper, we have developed a new analysis technique for the assessment of human movement, which is independent of an observer, dispenses with movement categorization, and circumvents problems with many (different) behaviors cumulating their effects simultaneously and successively. This new approach is based on automatic analysis of body contour changes recorded on digitized films (Automatic Movie Analysis – AMA). AMA subtracts successive video frames from each other and thus determines the total amount of change occurring within a given time span (Motion Energy Detection – MED). Thus, AMA cumulates all movements in the picture into one measure of total picture change. There is no distinction between particular movement patterns. With a thresholding method, it is possible to determine when a movement starts and ends within a series of video frames. This allows for quantitative assessment of movement qualities (e.g., duration, speed, size, etc.; see [2] for a more detailed description) independently of their Gestalt. Besides objectivity, automatic analysis yields high speed and high reliability. AMA procedure is validated by the fact that it is analogous to the organization of human visual perception in two ways: (1) neither color nor depth nor form are necessary to perceptually process movement [34], and (2) movement detection is essentially a processing of contour changes [34]. Thus, if humans assess the qualities of movement, they probably do it in a way that is similar to the way AMA does. With this method we analyzed communication in dyads of the opposite sex in Germany and Japan [35].

In both cultures, when the frequencies 'cataloged' behavior codes were compared to male and female interest, no significant correlations were found. When the

movements were analyzed for quality (AMA) instead of content, however, significant results were found across both samples. Females changed the quality of their behavior when they had high interest in the male. These qualitative changes were not due to mere agitation or excitement – the females actually moved more, but showed smaller and slower movements. These qualitative changes give an impression of slow and determined movements, where the single parts were accentuated. Further, results show that males react to these qualitative modifications positively and rate the situation as more pleasant (although their interest in the partner is not affected). In addition, males who perceive the situation positively talk more.

Interesting connections to these findings comes from other research. Bechinie and Grammer [36] interviewed males and females suffering from the 'broken heart syndrome'. A lover had left all of them within the last three months. A movement quality analysis showed that increasing depression (measured with Beck's depression inventory, BDI) correlated exactly with the same parameters as the courtship study, namely short and slow movements. This means that high depression is manifested behaviorally, creating behaviors that are normally perceived as 'helpless'. If non-depressed females tend to take on the same movement patterns when talking to males in which they are interested, it may be speculated that females are also attempting to communicate a sort of helplessness through their body movements. The function then could be an appeasing one on males, inducing mate bonding or comforting behaviors. We are currently conducting further research to explore the possibility of these connections.

Mirror neurons, allomimesis and the shared manifold

But how can such an inferential communication system work with respect to brain-behavior relationship? The recently discovered 'mirror neurons' could be an answer. Mirror neurons in monkeys [37] appear to form a cortical system that matches observation and execution of goal-related motor action. These also called F5 neurons fire, for instance, when the monkey sees another monkey or human moving his hands to grasp for an object. Fadiga *et al*. [38] was the first to research this system in humans. While testing the excitability of the human motor cortex, they found that motor potentials evoked from the hand muscle area markedly increased when a participant merely watched a person grasping an object. Furthermore, the increase of excitability was present only in those muscles that were used by the subjects when actively performing the observed movements. Similar results were also found by Cochin *et al.'s* [39], EEG analysis of the mirror system. Participants observed movies where human movements were displayed. As a control, objects in movement and still objects were presented. Results showed that the observation of human movements, but not that of objects, desynchronizes the EEG pattern of the precentral motor cortex.

Such findings suggest that humans have a 'mirror matching system'. Whenever we are looking at someone performing an action, there is a concurrent activation of the motor circuits that are recruited when we ourselves perform that action. Although we do not overtly reproduce the observed action, our motor system becomes nevertheless active – as if we were executing that very same action. A mental simulation of a target's actions is of great adaptive benefit. It allows us to build a theory of mind and intention for the observed person. Such a system may provide a necessary bridge from 'doing to 'communicating', as the link between actor and observer becomes a link between the sender and the receiver of a message.

The mirroring itself seems to be movement-related, and the tie between producer and receiver seems to be the goal directedness of the movement. Thus the receiver would not have only a theory of the intentions of what other people will do or enact – we also would have a direct link to the internal states of these people. The fascinating part is that such a system will work in real time without the need for further cognition, and would provide solid basis for empathy, such as that which may be implied from the results of our depression/movement quality findings.

Gallese [40] proposes that motor neurons functionality results in a communicative situation that he calls 'the shared manifold'. The shared manifold would hold information about movement intentions of others, but its presence will also enable an observer to assess a target's emotions, feelings and thus their behavioral tendencies, intentions and goals. In this view the mirror system is crucial to establish an empathic link between different individuals. The shared manifold enables inter-subjective communication. The existence of mirror neurons also sheds new light on a row of previous findings. Mirror neurons could be responsible for a neonates' ability to reflexively imitate facial expressions of adults [41] or the transfer of physiological changes between sender and receiver when seeing a smile [42]. Moreover, the existence of mirror neurons could be a simple explanation for the fact that making voluntarily facial expressions leads to the same physiological changes that one experiences when the emotion is actually felt [42]. Mirror neurons thus might provide the neurophysiological basis of inferential communication.

The dynamic nature of communication

The development of mirror neuron research, when combined with theoretical assumptions about human EEA, and the possible dynamic nature of signals, provides a new approach to communication. Mirror neuron research implies that whenever a stimulus is per-

ceived a hard-wired response is immediately provided. Therefore, honest communication as well as deception may be achieved more successfully by initially bypassing conscious, cortical-cognitive processing and triggering unconscious, limbic-affective processing, and subsequently pairing signals of both direct sequential information transfer and dynamic communication systems. The sequential information transfer could be used when there is shared knowledge about the signals themselves and the situation calls for communication that is direct and unmistakable. But the shared manifold could also contribute to the dynamic decoding process by providing a window to the internal states of the sender and thus reducing the search spaces for the eventual meanings of the signal. Imagine: when I can feel what you mean by observing the quality of your movement, I will be better able to understand the signal meaning itself.

The next step for research in our field is to reintroduce the concept of the adapted mind and the co-evolution of communication. We have demonstrated that the high-risk situation of human mate choice should lead to certain adaptations in communication, which try to avoid deception because of possible loss of investment. The shared manifold itself is a system that seems to protect against deception. The reading of movement quality via the mirror neurons could lead to a reading of a target's internal state – an unfalsifiable signal. Internal states, which change the quality of motions, cannot be produced voluntarily.

When it comes to deception, relatively few countermeasures then remain. Miller [43] identifies three possible counter strategies against deception (a) hiding of intentions ('poker face strategy') (b) tactical deception and misinformation ('KGB-strategy') and (c) adaptive unpredictability ('protean strategy'). The latter concept was developed by Chance [44] and elaborated by Humphries and Driver [45] who called unpredictable behavior 'protean' after the Greek river-god who eluded capture by continually, unpredictably changing form. The adaptive logic of protean behavior lies in the fact that animals generally evolve perceptual and cognitive capacities to entrain, track and predict the movement of other biologically relevant animals such as prey, predators and potential mates. Such predictive abilities mean that unpredictable behavior will often be favored in many natural pursuit-evasion predator-prey situations. Usually, hostile animals or conspecifics capable of correct prediction punish predictability. However, characteristics that cannot be predicted by an opponent can enhance the effectiveness of almost any behavioral tactic. As outlined above – human courtship is one situation where deception and mind reading will play a role [43]. A co-evolutionary arms race in courtship between social prediction and social proteanism can be predicted [43]. In the analysis of a stranger meets stranger situation, Grammer *et al*. [46] were indeed able to show that female interest in the male promotes proteanism and unpredictability in her behavior.

Only such a system could 'fool' the shared manifold by inducing contradicting information in the receiver. But the sender still has a possibility of deception, although it seems costly to falsify internal states. Trivers [47] postulated that self-deception might play a crucial role in communication – somebody who does not know that he/she is deceptive will perform honest signals. On the basis of the shared manifold this makes more than sense.

Such a dynamic system approach in conjunction with the shared manifold offers many advantages over a sequential information processing approach in the explanation and research on human communication. The main advantage is that this system does not need discrete categorical signals. Nevertheless it can explain how the quality of signals can induce different meanings and the communicators also do not need a shared knowledge about signals. Every type of meaning can be inferred by self-inspection at any time in real time. Moreover, such a dynamic system can explain a variety of constraints in human communication.

Yet there are still many problems with this approach. For instance dynamic systems tend to destabilize and become chaotic. This might be solved in two ways. As we have seen in the synchronization between strangers 'signals' are not part of this system. Thus we propose that discrete categorical signals are used in communication in order to stabilize the dynamic system and set it on track. Another possible stabilization factor is the time difference between processes involved in communication. The shared manifold is a fast continuous process. Internal states (e.g., those based on hormones) are slowly running systems. Thus we can hypothesize that the slower running system stabilizes the faster running systems. Besides internal states, attitudes like friendship, dominance, or affects and finally stable and genetically inherited personality traits could serve as stabilizing elements.

Communication research is at the point where human ethology and evolutionary psychology can complete one another. One basic problem connected to this evolutionary psychology approach is that it remains focused on social cognition. The systematic observation of actual behavior, however, might well be used to analyze the impact of social cognition on real life everyday behavior. It is only logical that there had to be a co-evolution of the adapted mind and communication, because under any circumstances the adapted mind must become visible at one point and declare itself communicatively. An approach which combines dynamic and sequential systems, evolutionary social cognition thinking, and methods which allow for the objective quantification of movement quality will bring us one step closer to understanding the complexity of the human communication process.

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