RUNNING HEAD: CEPHALO-CAUDAL PATTERNS IN HUMAN BEHAVIOR

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Simple Cephalo-caudal Patterns Embedded in Complex Human Interpersonal Behavior

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ABSTRACT

A novel model is presented to explain human social behavior. In recent years, a cephalo-caudal directionality to behavior has been reported in a few mammals including rodents, cattle and cats. This model shows how complex human behavior also follows this rule of cephalo-caudal directionality. The positions of the lower motor neurons mediating the specific acts in the cephalo-caudal neural axis are considered to be an important correlate of the act. The model posits that movements that constitute behavior consist of a primary (ereismatic) layer, consisting of four orienting modules – eyes, head, trunk and pelvis; and a secondary (teleokinetic) layer consisting of six transmitting channels – the eyes, facial expression, speech, upper limbs, lower limbs and the pelvic movements. The model proposes that, with increase in intensity, communications occur in a particular sequence – non-contact communications, followed by extremity-contact communications and finally axial-contact communications. The model demonstrates through multiple examples that complex human behavior also follows a cephalo caudal directionality, both in the orienting modules as well as in the transmitting channels. In this paradigm, conciliatory and agonistic communications are examined as prototypes for analysis of more complex dominant and submissive behavior as well as psychiatric conditions such as mania and depression. The model suggests that, with increase in severity of depression, there is progressive shut down of communication caudo-cephalically ; on the other hand, with increase in intensity of mania, there is progressive increase of communication cephalo-caudally. In other words, the cephalo-caudal progress of communication is inhibited in depression and disinhibited in mania. The model is sensitive to the social context of behavior which is without precedent in the literature. Finally, certain issues pertinent to difficulties of behavioral description and model building in human behavior are discussed. The model emphasizes the role of objective behavioral description paradigms that borrow from concepts in comparative psychology and animal behavior. To summarize, a novel model for interpersonal behavior is introduced that describes behavior as a function of proxemic progression in the horizontal dimension and cephalo-caudal progression in the vertical dimension.

Keywords: animal social behavior, interpersonal communication, modeling behavior, non verbal communication, psychopathology.

Simple cephalo-caudal patterns embedded in complex human inter personal behavior

1.0 Introduction

Models of human social behavior have used a variety of approaches. These have suffered from many drawbacks and a satisfactory model has proved elusive (Patterson, 2001). Here a novel model is presented to explain human social behavior. The model is built by examining everyday behavior and incorporating patterns observed into the model. The model is based on the idea that human social behavior does follow patterns and these patterns become apparent on close examination of complex social behavioral sequences. This understanding may allow the formulation of general rules that regulate human behavior. It would then be possible to codify the 'grammar' of nonverbal communication.

2.0 Behavior is locomotion

The functions of the skeletal system could be said to include the maintenance of posture, locomotion and interpersonal behavior. The movements underlying interpersonal behavior are due to the use of the locomotor apparatus for a specialized purpose in the social domain. Thus, interpersonal behavior is a special case of locomotion and, as such, should be bound by the general rules that regulate

locomotion. This assumption is doubly buttressed by the fact that it is not only the expression but also the perception of social information that is intimately connected with locomotion. For example, Scholl & Tremoulet (2000) have demonstrated that people spontaneously perceive physical movements in social terms. It has been

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suggested that motor acts have two identifiable components – a teleokinetic component which is the goal oriented movement and an ereismatic component which provides the postural support for the movement and maintains equilibrium (Massion, 1992). Partly because of the polymorphous or multidimensional nature of behavior, there is, as yet, no single set of satisfactory criteria for defining either single events or complexes of events (Fentress, 1992). Current descriptions of human behavior consider emotions too generically, such as, anger, sadness and so forth. They do not differentiate between various bodily expressions of the same emotion but with differing intensities; for example, frowning, using abusive language and slapping somebody, may all have the same underlying emotion of anger but obviously these behaviors are not the same and vary in form and intensity. Extant models do not accommodate this vital distinction and thus do not faithfully denote actual behaviors in their descriptions. The proposed model attempts to overcome these shortcomings.

2.2 Behavior is communication

As mentioned above, defining and measuring communication has been a particular difficulty because of the polymorphous nature of behavior. We realize that without a proper definition of behavior, any model that aims to capture the dynamics of complex behavior is doomed to fail. Thus, we look at the entity of 'behavior' through the paradigm of communication. A fundamental assumption of this model is that all human interpersonal behavior can be looked at as communications of various sorts (Goethals, 2005), that is, behavior by the communicator tells the recipient something about the communicator's intentions. Thus, we define behavior as a set of either single or multiple communicatory events occurring in succession. Each communicatory event has an orienting component and a transmitting component. This

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approach to defining a communicatory event is directly derived from the components of locomotion mentioned above. Thus, each communicatory event consists of an ereismatic component and a teleokinetic component. The ereismatic component orients the sensori motor apparatus towards the stimulus of interest (interpersonal partner). The teleokinetic component transmits specific messages to the interpersonal partner. Further details of what exactly constitutes the ereismatic machinery and the teleokinetic machinery, are described below.

3.1 The model: orienting modules and transmitting channels

According to the model, the machinery to receive and transmit communications is arranged around the neural axis. There are two layers of behavior-movements (Table 1). The primary layer consists of the eyes, head, trunk and pelvis, which form the orienting modules. The primary layer orients the sensory and motor apparatus to the appropriate stimulus. The secondary layer consists of six transmitting channels which make the specific communication. These are the eye movements, facial expression, speech, upper limb movements, lower limb movements and pelvic movements. The orienting modules orient the channels embedded in the modules towards the stimulus of interest. Thus, the first orienting module, the eyes, carries the first channel - the eye movements; the second orienting module, the head, carries the three channels - eye movements, facial expression and speech; the third orienting module, the trunk, carries the upper limb movements and lower limb movements and the fourth module, the pelvis, carries the pelvic movements. Naturally, the movements of the secondary layer (transmission) can be appropriate only after the movements of the primary layer (orientation) are achieved. Montpare et al. have noted that human bodies are large objects possessing multiple degrees of freedom which are ideal channels for emotional communication (Montepare, Koff, Zaitchik & Albert, 1999). The model is guided by the principle of 'kinematic specification of dynamics' (Runeson & Frykholm, 1983), which states that the spatio-temporal patterns observed in an event specify the underlying causes of that event. In other words, the kinematics of an event directly specify the dynamics that constrain and determine them. However, descriptions of these movements and what the dynamic constraints on social interaction are, are not found in the literature. Here, the model attempts to do just that. The other function of the primary layer is to indicate the position in the social hierarchy. Downcast eyes (Ellyson, Dovidio & Brown, 1992) and head- down (Mignault & Chaudhri, 2003) are signs of submission in asymmetric contexts. Bowing and prostration (trunk down) are well known submissive gestures. The dual role of the primary layer in mediating both orienting behavior and hierarchy-indicative function is not surprising as orienting behavior itself has hierarchy-indicative functions; for example, among both human and nonhuman primates, submissives tend to orient themselves so as to always face the dominant (Chance, 1967).

3.2 Lower motor neurons

The model describes the pattern of activity that occurs over the neural axis during the expression of interpersonal communications. The model starts by considering the cephalo-caudal position of the 'lower motor neurons' in the neural axis mediating the specific acts in the interpersonal communications. Each channel has its corresponding set of 'lower motor neurons' that control the activity in that channel (table 1). 'Lower motor neurons' refers to the neurons that supply the musculature of the animal and thus are directly responsible for the movements of the animal. These originate from the spinal cord (spinal nerves) and the brain stem (cranial nerves). These in turn are supplied by higher centers in the brain (upper motor neurons). The 'lower' in 'lower motor neurons' refers to the position of these neurons in the brain stem and the spinal cord vis a vis the 'upper motor neurons' that are situated in the cerebral hemispheres (Fig. 1). This differentiation between the 'upper motor neurons' and the 'lower motor neurons' is a routine clinical practice in the assessment of neurological disorders like stroke (Brazis, Masdeu & Biller, 2012). It is immediately apparent from table 1, that the root values of the channels in the secondary layer show a cephalo-caudal progression. The analysis of interpersonal behavior in terms of superimposed modules and channels finds support in the organization of posture control. Human posture involves superimposed modules from the feet to the head, each with its own specific central and peripheral regulation, which can be controlled more or less independently (Massion, 1992). As mentioned above, interpersonal behavior is a special case of locomotion, and as such, the organization of the neuromuscular apparatus regulating both locomotion and interpersonal behavior, is expected to be similar.

3.3 the core of the model ; contact and non contact communications

The model suggests that interpersonal behavior consists of continuous sequences of orientation of a particular module followed by transmission in the communication channels situated in that particular orienting module. Both orientation and transmission follow a cephalo-caudal pattern (see below). We examine the model in the context of the prototypes of extremes of social behavior – conciliatory and agonistic. The word 'agonistic' is used here in the ethological sense, which means 'aggressive' in the animal behavior literature. The cephalo-caudal pattern is

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applicable to both conciliatory and agonistic communications. Transmission of communications can be either contact or non-contact – according to whether physical contact is established between the partners in communication. Contact communications are again divided into extremity-contact and axial-contact communications. The model proposes that, with increase in intensity, communications occur in a particular sequence – non-contact communications, followed by extremity-contact communications and finally axial-contact communications(Fig 2). Within each qualitative type of communication, the cephalic channels will be recruited before the caudal channels (figures 3 & 4).This 'progressive proxemic approach' is a direct consequence of the territoriality displayed by animals and humans, and correlates roughly to Hall's characterization of proxemics (Hall, 1963). Thus, with some overlap at the boundaries, non-contact communication occurs within the 'social distance – 4 to 12 ft', extremity-contact communication within the 'personal distance – 1.5 to 4 ft' and axial-contact communication within the 'intimate distance – less than 1.5 ft', as described in Hall. This is demonstrated in fig. 6.

von Cranach (1976) has suggested that hierarchically ordered sequence of orienting movements signal progress in communicatory intent : gaze, head and body. Unfortunately, this important piece of observation was ignored by workers in human behavior in the subsequent decades and was not incorporated into any of the major models of communicatory behaviour. However, it is known that in animals, stimulation of the superior colliculus results in an orienting response towards or away from a target, as an integrated movement across the oculomotor, cephalomotor and the skelotomotor affectors (Gandhi & Katnami, 2011).The current model suggests that the hierarchic sequential ordering is seen not just in the orienting movements but also in the transmitting movements. Irrespective of the type of communication (either conciliatory or agonistic, see below), the activation and recruitment of the channels proceeds in a cephalo-caudal direction. Activity in the cephalic channels occurs before the onset of activity in the caudal channels. With progression in expression of the communication, progressively more caudal channels are recruited. The prototypes of conciliatory and agonistic communications are used below to exemplify the working of the model (figures 3 & 4).

3.4 Stimulus-gratification and stimulus-frustration

We assume that interpersonal communications can only be either conciliatory or agonistic in nature. Seemingly neutral communications, on further progression of interaction, inevitably become either conciliatory or agonistic. Thus the above assumption is actually valid. After each communication, the results of that communication are evaluated by the communicator and this determines the ‘need’ for further communication. Affective reactions stem from the perceiver's goals colliding with the outside world (Mandler, 1975). These affective reactions can be called stimulus-gratification and stimulus-frustration. Stimulus-gratification implies that the intended goals of the particular communication are achieved, that is, the recipient behaves in accordance with the expectations of the communicator. Stimulus-frustration implies that the intended goals of that particular communication are not achieved, that is, the recipient does not behave in accordance with the communicator’s expectations. Assuming that the two participants in the communication are at the same hierarchic level, behaving in accordance with the communicator’s expectations (stimulus-gratification) encourages the conciliatory communicator to proceed further. If at any point in time, the recipient rebuffs the communicator (stimulus-frustration), the conciliatory communication is terminated at

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that level or is reverted to more cephal-wards channels (fig. 3). Typically, defiance (stimulus-frustration) makes the aggressive communicator proceed further with his aggression. On the other hand, backing down (stimulus-gratification) makes the communicator stop his aggressive communication (fig. 4). Conciliatory communication intensifies on stimulus-gratification whereas agonistic communication intensifies on stimulus-frustration (table 2). The juxtaposition of conciliation with gratification recapitulates the suggestion that social cooperation is inherently rewarding irrespective of material gains (Rilling et al., 2002). The relationship between frustration and aggression, as in Dollard's frustration-aggression hypothesis is well known (Berkowitz, 1989).

3.5 Cephalo-caudal progression of channels

The communication is started by the cephalic channels and the caudal channels get recruited progressively with increase in intensity of the communication. Communication continues through the cephalic channels even when the caudal channels are recruited. That is, if a particular channel is active then it implies that all the channels above it are active and carry the same content. The progression of communication occurs in the following manner: Channel 1 → Channel 1+2 → Channel 1+2+3 → Channel 1+2+3+4 → Channel 1+2+3+4+5 → Channel 1+2+3+4+5+6 (Fig. 5). The channel latest to be recruited, is only the moving wavefront of the activity of channels accompanying social interaction. Thus, the latest channel is also the most prominent in that behavioral cross section and for lay purposes, summarizes the behavior. The flowcharts in figures 3 & 4 are prototypes of the behaviors at the extremes of the spectrum of interpersonal interaction. Most behaviors encountered in daily life lie somewhere in between the two extreme prototypes detailed. These behaviors can be accommodated easily within this model

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by considering the progression of the communication only till the appropriate channel used in the observed behavior. There is a large amount of evidence for formulating the model in the terms described above. von Cranach's suggestion of cephalo-caudal progress of communication has been mentioned above. The idea that communication starts with cephalic channels is consistent with the observation that gazing behavior acts as a signal for readiness to communicate (Eibl-Eibesfeldt, 1989). In autism, one of the first targets in the the training of the child is eye contact, and is considered a necessary antecedent to compliant behavior (Hamlet, Axelrod & Kuerschner, 1984). Perper (1985) has reported a fairly ritualized sequence of interactions in courtship behavior: eye contact followed by smiling, talking, touching and finally sexual intercourse. The celebrated anthropologist, Desmond Morris (2002), has described the 'ascending scale of intimacies in the sexual sequence'. Thus, the stages described by him, eye to eye, voice to voice, hand to hand, mouth to mouth and finally, genital to genital, exactly follow the stages of communication described here – non-contact communication, extremity-contact communication, followed by axial contact communication, with both extremity contact and axial contact communication showing a cephalo-caudal progression. Perper's and Desmond Morris's models are illustrated in fig. 7. It is also clear that the other stages described in his 'sexual sequence' (arm to shoulder, arm to waist, hand to head, hand to body etc) are merely preparatory to the next stage of communication and do not violate our rule of 'progressive proxemic approach with cephalo-caudal progression'. Again, staring and gaze aversion have been found to have aggressive and submissive meanings respectively (Ellsworth & Carlsmith, 1973). Physical aggression such as hitting and kicking are generally considered more 'serious' and hence more 'intense' forms of aggression than verbal aggression (Tremblay, 2000). Biting behavior has been

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described as part of aggressive behavior (Nijman, Evers, Merckelbach & Palmstierna, 2002). Simpson and colleagues, while studying attachment security, observed partners interacting while the female member of the dyad was under stress (Simpson, Rholes & Nelligan, 1992). In response to their partners' touch, secure women responded by engaging in touching and kissing, whereas avoidant women tended to resist physical contact. In other words, in response to extremity contact from their partners, secure women proceeded to axial contact communication whereas avoidant women resisted physical contact and preferred non-contact communication or even total withdrawal (fig. 6). This is exactly what the current model would predict, given that secure women proceed further with their communication and avoidant women do not. Finally, the most direct evidence for the model has come from recent research that has indicated that subtle emotions are better made out from the facial expressions and more intense emotions can be effectively discriminated only from the body cues and not the facial expression (Aviezer et al, 2012). Thus, studies of emotional expression need to consider the whole of the body and not merely the face, which has traditionally received the maximum attention. To summarize, the model describes behavior as a function of proxemic progression in the horizontal dimension and cephalo-caudal progression in the vertical dimension.

3.6 Caveats for an imperfect model

In the current model, speech is treated as just another channel of communication and there is no focus on the content of the speech. Whatever may be the speech message, the communication is likely to either proceed further to the next channels or may revert back to the earlier ones. Thus, the message is likely to be either conciliatory or agonistic in nature, and hence no attention need be paid to the content of the speech for our purposes. The model does not claim complete continuity of 'sexual assault' with other instances of aggressive behavior. Thus, aggression may escalate from abusive behavior, to hitting with the hands, to kicking. But further escalation may not necessarily result in sexual assault; nevertheless, it has been included as a manifestation of agonistic communication as many consider sexual assault to be actually a form of aggression (Donat & D'Emilio, 1992). There is evidence that sexual aggression is a distinct entity with distinct developmental antecedents (Prentky et al., 1989). A subset of sexual offenders engage in sexual assault, in part, as a means to achieve dominance over the victim to deal with their chronic feelings of low self esteem (Groth, Burgess & Holmstrom, 1977). The distribution of the channels in the flowchart is consistent with this interpretation as sexual assault involves the caudal-most channel, which indicates the maximum dominance compared to the other aggressive communications. The various acts of interpersonal behavior mentioned above are incorporated into the model as being expressions of conciliatory or agonistic communications with different intensities (figures 3 & 4). According to the model, caudal channels of communication are recruited when the intensity of the communication is not adequately expressed using the more cephalic ones. Thus, Ekman & Friesen (1972) have reported that the use of illustrators (mostly hand gestures) increases when speakers have difficulty conveying their message to the listener verbally. The increase in gesturing that occurs during word retrieval failure (Krauss & Hadar, 1999) also exemplifies the recruitment of caudal channels to communicate with greater intensity in case of inability to communicate adequately with cephalic channels. Apart from the empirical evidence cited, it is also intuitively understandable that the various behaviors described in different channels have differing communicative intensities. The intensity of emotions accompanying the communications in the caudal channels is higher than

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those accompanying communications in the cephalic channels. Every communication need not progress to the full extent involving all the channels. The behavioral sequences described here may be achieved in an interpersonal context over a period of time, thus behavior is considered longitudinally. It is possible to imagine behavioral sequences that skip some channels; nevertheless, the author argues that this characterization of the channels is justified as the cephalo-caudal gradient of emotional intensity accompanying the communications in each channel is still preserved. The author argues that these patterns are non-trivial, but once explicitated, become intuitively understandable. The difficulties in bringing scientific rigour in the behavioral descriptions of nonverbal communication have long been been noted by workers. For example, Ekman & Friesen (1969) have noted that nonverbal communication lacked an explicit code. Gould and Lewontin (1979) have pointed out that even the morphogenetic unit of behaviour is not known. Newston (1992) has pointed out that the difficulty with behavioral description is due to the fact that behavior is not a discrete categorical entity. Beer (1980) has noted that social communication is embodied in its own terms defying reduction to physiological terms. These are, in fact, remarkably astute observations and the irony of eloquently explaining theoretical ineloquence is striking. McHugo et al (1991) have also noted that studies of emotion often fail to measure behavior in real time. Moreover, despite an apparent abundance of behavioral studies, they have generally not looked at the long term naturalistic behavior between the same two interactants. One exception is Perper (1985) mentioned above. Also, though there is a growing body of research focusing on nonverbal behaviour and gestures, studies have, in general, not looked into the temporal characteristics of the different gesture modalities in relation to each other or their relationship with emotional intensity.

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4.0 Cephalo-caudal patterns in animal behavior and other examples

It is, perhaps, no accident that communicatory behavior in humans should have a cephalo-caudal directionality. A strong cephalo-caudal bias exists in the aggressive and mating behaviors of different animals. For example, in the mating behavior of the rat (fig. 8), initially there is genital sniffing, followed by rearing or passing over the female (involving placing the forelimbs on the female's back), clasping and finally pelvic thrusts (Whishaw & Kolb, 1985). Aggressive behavior in zebras is typically seen in the context of territorial challenge by an intruder and consists of various rounds of increasing aggression. To begin with, the behavior consists of staring fixedly and wrinkling upper lip; if the intruder persists, it proceeds to biting of the legs; if both persist, it proceeds to wrestling with the neck; if neither gives up, it proceeds to a full fledged attack including rearing up and striking with the forelegs (Attenborough,1992). Leyhausen (1979) notes that, in the attack behavior of tomcats, the tip of the tail twitches to and fro only with the highest intensity of aggression. This is a very interesting piece of observation that constitutes direct evidence for our theory of cephalo caudal progression. Apart from the cephalo-caudal sequencing in animal communicatory behavior, a similar organization is seen in grooming as well as in locomotion in many animals. For example, a robust finding has been that the grooming pattern in many mammals including rodents (Berridge, Fentress & Parr, 1987) and cats (Eckstein & Hart, 2000) is cephalo-caudal in nature. A cephalo-caudal recruitment of body segments has also been described in locomotion of fishes, amphibians and in reptiles (Eilam, 1992). Even in humans similar patterns are seen in various activities. It has been found that the washing and drying behaviors, which may correspond to 'grooming', follow a distinctly cephalo-caudal directionality (Young & Thiessen, 1991). In goal directed movements involving reaching for a target in humans, eye movements, head movements and arm movements were shown to appear sequentially in that order (Biguer, Jeannerod & Prablanc, 1982). de Seze et al. (2007) have shown that there is sequential activation axial muscles of the back in humans while walking and in a variety of other rhythmic movements. Thus, grooming, locomotion and communicatory behavior in many animals and humans show a cephalo-caudal organization. Also, cataplexy, the sudden loss of muscle tone triggered by strong emotions that is seen in neurological conditions like narcolepsy and Coffin-Lowry syndrome, shows a cephalo-caudal progression (Stephensen et al, 2005). Thus, it strongly suggests that the regulation of motor behavior has a cephalo-caudal directional bias and may perhaps, even be evolutionarily conserved across the order mammalia. The development of motor control in childhood in humans, and hence of purposeful movements, occurs in a cephalo-caudal direction (Lee, 1990). The ontogeny of locomotor behavior in various mammals shows the same pattern (Golani, 1981). Thus, the ontogeny of the voluntary control of movements gets reflected in the moment to moment behavior (actogenesis) of voluntary behavior. Golani and colleagues (1981) found that the 'warm up' movements seen in an animal as it came out of prolonged immobility induced by drugs or due to lateral hypothalamic section also occurred in a cephalo-caudal sequence.

5.0 Human behavior and mobility gradient

Golani and colleagues (1981) have described the 'mobility gradient' as consisting of a range of movements that is available to the animal from the hypomobile to the hypermobile end. The movements in the hypomobile portion, the so called 'warm up' movements and those in the hypermobile portion, the so called 'exuberant locomotion' have been examined in detail by Golani and colleagues (summarized in Golani, 1992). Psychomotor retardation seen in severe depression and increased psychomotor activity seen in manic states (Sadock & Sadock, 2003) could represent the hypomobile and hypermobile portions of the mobility gradient, respectively. Similarly, catatonic stupor and catatonic excitement seen in psychotic states (Sadock & Sadock, 2003) could represent the manifestations of the opposite ends of the mobility gradient. However, detailed examination and description of the motoric patterns in these states, possibly using the Eshkol-Wachmann system, is required. More detailed examination of the movement patterns in humans in various psychological and psychopathological states could clarify the links between the motor aspects of affective and psychotic disorders and the mobility gradient in humans.

6.1 Application of the model: Psychopathology

Certain psychopathological states can also be understood in terms of the proposed model. The severely depressed person is withdrawn, making minimal limb movements, reduced spontaneity in speech with poor facial reactivity and downcast eyes (Task force on DSM-IV, 1994). On the other hand, in mania, the person has no impairment of eye contact, has a lively facial emotional expression, increased talkativeness, increased hand gesturing and increased sexual energy (Task force on DSM-IV, 1994). Thus, in depression, communication through the channels is reduced or even suspended, whereas, in mania, communication through all the channels is increased. In moderately severe depression, eye contact and speech are preserved, but in the more severe forms, mutism occurs; and in the most severe forms, eye contact also is lost. In hypomania, which is a less severe form of mania, there is often only increased talkativeness; in more severe forms, the increase in psychomotor activity (consisting, in part, of increased moving about) is more marked. Thus, with increase in severity of depression, there is progressive shut down of communication caudo-cephalically (fig. 10); on the other hand, with increase in intensity of mania, there is progressive increase of communication cephalo-caudally (fig. 11). In other words, the cephalo-caudal progress of communication is inhibited in depression and disinhibited in mania. This formulation is consistent with the finding of decreased object focused movements indicative of reduced communicatory intent in depression (Freedman, 1972) and with increased sociability and over-familiarity seen in manic states.

6.2 Asymmetric communications

Some sort of social hierarchy is formed in every society (Hofstede, 2001). This hierarchy determines interpersonal behavior to a large extent by determining the dominant and submissive behaviors. Here, asymmetric communications are defined as those that occur between persons who are at hierarchically different levels. Example A: When a soldier salutes an officer, it may involve movements of the lower limbs, upper limbs and speech. The officer might respond by simply nodding the head to acknowledge the soldier (fig. 12). Now, suppose an order is given by the officer (speech, channel 3), the order is followed by the soldier and might involve moving from one place to another (channel 5). This is shown in fig. 13A. Example B: Now, suppose two people at hierarchically different levels have a disagreement and are making arguments (Channel 3) to persuade each other. If the subordinate does not immediately agree with the dominant, the dominant raises his hand (Channel 4) and the subordinate has to stop arguing and agree with the dominant (assuming the hierarchy is preserved). Thus, under usual circumstances, the caudal channels of the submissive are recruited in response to a communication by the cephalic channels of the dominant. But when the hierarchy is challenged, the dominant uses caudal-ward channels to those used by the subordinate to put an end to agonistic communications by the subordinate.

Hence, in an asymmetric conciliatory communication as in (A), the dominant uses cephal-wards channels relative to the ones used by the submissive. On the other hand, in an asymmetric agonistic communication as in (B), the dominant uses caudal channels, relatively. Thus, in asymmetric communications, the pattern of use of channels is such that the dominant always has stimulus-gratification. It is also worth noting that the cephalic channels have a smaller muscle mass compared to the caudal channels and as such it requires less energy expenditure for muscle contraction in cephalic channels than muscle contraction in the caudal channels. Thus, in conciliatory contexts, the dominant expends less energy compared to the subordinate. The adaptive significance of this is obvious.

6.3 Surrender signals in animals and humans

Social behaviors and cultural codes in eastern cultures are known to be more clearly hierarchic than elsewhere (Hofstede, 2001). Example C: Young people touching their parents' feet with the hands as a mark of obeisance is a common practice in India (Dube & Opler, 1955). In response, the parent blesses by touching the scalp of the supplicant with the palms. Here, the subordinate is 'equating' (by bringing into contact) his cephalic channels with the dominant's caudal-most channels to acknowledge the difference in hierarchical standing. This is shown in fig. 13B. A more universal example of this phenomenon is when a soldier or a subordinate while greeting his king kisses the king's hand (see below). Again, while allowing mutual contact, the dominant uses a channel caudal to the one used by the subordinate. Thus, the caudal channel of the dominant is 'equated' with the cephalic channel of the submissive. The dominant's use of caudal channels in this innocuous context is unexpected as it was argued above that the dominant is apt to use the cephalic channels in conciliatory contexts. However, the difference becomes understandable when it is noted that the situations in (A) and (B) are asymmetric 'non-contact communications' whereas those in the (C) are asymmetric 'contact communications'. All contact communications, in asymmetric contexts, are implicitly agonistic in nature, as the dominant's (proxemic) territory is violated by the submissive when achieving contact. This holds even if the communication is not overtly threatening in nature to either participant, as in (C). This assumption is in accordance with the principle of 'honest signalling' or 'handicap principle' (Zahavi & Zahavi, 1997); thus if the surrender signal does not constitute a true submissive posture, it leaves the dominant open and vulnerable to any sudden change of tack by the submissive and consequent aggression. For example, the surrender signal in dogs and wolves consists of falling to the ground and exposing the soft underbelly which puts the dominant in a position to deliver a fatal bite (Eibl-eibesfeldt, 1996) and thus is a honest signal of the submissive's intent to surrender. This results in the dominant stopping the aggression and letting the submissive away. Similarly, in case of (C), the touching of feet with the hands or the kissing of the king's hand by the subordinate is actually a surrender signal and may be understood as a form of ritual display seen in hierarchic, and hence implicitly agonistic, contexts. Thus, superficially innocuous behaviors may actually

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be occurring in an aggressive context from an ethological point of view. Hence, in contact communication, the dominant always uses caudal-wards channels relative to the submissive. But in non-contact communications, the dominant uses caudal-wards channels in agonistic contexts and cephal-wards channels in non-agonistic contexts. In these behavioural instances is seen the interplay of various components of behavior – the hierarchical standing of the interactants, the differential use of the communication channels, the territorial integrity and the affective-motivational consequence for the interactants. The actors achieve 'hierarchical compensation' by using different channels relative to each other to compensate for the difference in hierarchical standing. A similar observation was made by Leyhausen (1979) in cats when he pointed out that herd members pay about as much attention to a pariah cat adopting a defensive posture, hissing and feigning blows, as to a dominant cursorily laying its ears back (fig. 14A). Thus, he says that the social position of the animal needs to be taken into account along with the intensity of expression when understanding the mood state of the animal. A few more social rituals are analysed below and it can be seen how they actually constitute surrender signals in hierarchical contexts. A 'hat tip' is an act of tipping one's hat as an expression of recognition, respect, and acknowledgement between two persons (Morris, 2002).Where the ritual was used to emphasize social distance, the subordinate was obliged to make the more elaborate gesture, for example fully removing his hat while the superior merely touched his (fig. 14C). A more interesting example is that of the Thai greeting called 'wai'(Nguyen, 2012), also used in Malaysia and Brunei, and similar to the Indian 'namaste' which consists of a slight bow, with the palms pressed together in a prayerlike fashion. The higher the hands are held in relation to the face and the lower the bow, the more respect or reverence the giver of the 'wai' is showing (Nguyen, 2012).

. The phenomenon of 'hierarchical compensation' mentioned above, is clearly demonstrable from two examples of contact- communications mentioned below, one using the hands and the other with the lips. In these examples, contact with the same channel in the other person indicates equality, contact with a higher channel or a higher part of the body indicates dominance and contact with a lower channel indicates subordination. In the context of the use of channels in asymmetric communications, it is interesting to note that the universal social convention of 'shaking hands' denotes equality, among other things (Greenbaum & Rosenfeld, 1980; Morris, 2002). A dominant will place his hands on the scalp to bless the supplicant and an inferior will touch the dominants feet with his hands (Dube & Opler, 1955), otherwise head-pats are seen to be condescending and are to be avoided (Morris, 2002). This is summarized in fig. 15. According to Herodotus in his 'Histories', a person of equal rank received a kiss on the lips (Davis, 1912). A subordinate would kiss the hands of the superior. This is seen in multiple cultures across different time scales, including Indic cultures (mentioned above), British royalty (Brazier, 1997), ancient Judaism (Hecker, 2005) etc. A subordinate would even kiss the feet of the superior in a context of great hierarchical difference. However, a kiss on the forehead would mean that the 'kisser' is in a more dominant position to the recipient (Hecker, 2005). Desmond Morris (2002) also highlights this phenomenon when he says that 'equals kissed equally' and 'the lower the rank of the kisser, the lower his kiss had to be'. Hierarchy via kissing is summarized in fig. 16.

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6.4 Asymmetric communications: summary and rules of 'hierarchical compensation'

The rules of interaction followed in asymmetric communications analysed above are summarized below for the sake of clarity. These are followed to achieve 'hierarchical compensation' between actors at different hierarchic levels. (1) In an asymmetric conciliatory communication, the dominant uses cephal-wards channels relative to the ones used by the submissive. (2) In an asymmetric agonistic communication, the dominant uses caudal channels relative to the ones used by the submissive. (3) All asymmetric contact communications are implicitly agonistic in nature. Hence, the dominant uses its cephalic channels relative to the ones used by the submissive. Thus, in asymmetric communications, the pattern of use of channels is such that the dominant always has stimulus-gratification (see table 2). The dominant-submissive interactions are formed on the basis of 'honest signalling' and tempered by energy economy. This is achieved by following the 'hierarchical compensation' phenomenon. Thus, under stable conditions of the hierarchy being intact, hierarchical compensation is actually achieved by a dominant expending lower energy and a subordinate expending higher energy for mutual interaction. A corollary is that any violation of hierarchical compensation actually constitutes disruption of the hierarchy and is perceived by the dominant as a threat or challenge. Incidentally, some researchers suggest that social hierarchies and nonverbal social behaviors show culture-specific conventions and hence do not reflect adaptive evolved processes (Ellyson & Dovidio, 1985). However, analysis using the current model shows that the underlying pattern in dominant-submissive behaviors from different cultures has a

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basic unity. Hierarchical behaviour may take different forms but there are invariants underlying these forms and thus hierarchical behavior actually represents adaptive processes that are common to all cultures.

7.0 Approach to model building

An accurate description of behavior of, A and B, say, needs to incorporate components of (1) behavior of A to B, (2) B's response to A, and finally (3) A's response to B's response. These three components are necessary and sufficient for a complete description; necessary, because these take into account the corrective action that A might undertake to the behavior subsequent to feedback from B; and sufficient, because all subsequent behaviors of A and B can be accounted for by recursively considering steps (2) and (3) till the interaction goes on. The above three steps can be rewritten as (1) behavior of A to B, (2) A's perception of B's response to A and (3) A's response to B's response. In the current model, the communicant responds in one of only two ways, either encouraging the communication or discouraging it. Thus, the three steps can again be rewritten as (1) behavior of A to B, (2) affective feedback from B in the form of either stimulus-frustration or stimulus-gratification in A and (3) continuation or termination of A's behavior. This description of behavior is reminiscent of the perception-action cycle (Fuster, 2003), though that is a neuronal phenomenon rather than behavioral. One advantage of using this description is the ease with which social variables can be incorporated into the model. Thus the social context of the interpersonal behavior is accounted for. 'Situationism' is an important consideration in interpersonal behavior but has proved uniformly difficult to be incorporated in extant models of social behavior (Todorov, Harris & Fiske, 2006). The current model overcomes this obstacle by incorporating the social context in the

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actors' responses and finding standard rules of interaction for different social contexts. This is facilitated by assuming a hierarchical background to all social context and a further assumption that all interactions are either conciliatory of agonistic. The author believes that these are not empty or merely convenient assumptions, but grounded in the biological basis of all social interaction. Thus, instances of interactions that are neither conciliatory nor agonistic are actually those that form the testing ground for the actors and on further communication are bound to turn either conciliatory or agonistic. As a corollary, all contexts become hierarchical as interactions do not occur in vacuum but in a social milieu determined by the history of previous interactions between the actors. Thus, interactions form hierarchies and hierarchies in turn determine the form of interactions.

8.0 Issues in behavioral description

Jacobs et al. (1988) argue that generally accepted rules for behavior have not been found despite many years of behavioral research because of faulty methods of behavioral description. They argue that the popularity of the functional classification of behavior which describes behavior by its consequence rather than the action or movement that achieved that goal, has contributed to the lack of clarity in behavioral descriptions. This is despite the exhortations by Tinbergen more than half a century ago that behavior needs to be described and analyzed as patterns of coordinated muscle activity (Jacobs et al., 1988). However, recent trends give cause for optimism. The Facial Action Coding System by Ekman and Friesen (1976) is one such example. Another is the Eshkol-Wachman movement notation, originally used for choreographic purposes but championed in recent years for rodent behavioral research purposes by Golani and colleagues (Golani et al, 1979; Eilam & Golani,

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1988). However, possibly because of the complexity and time consuming nature of the system, the Eshkol-Wachman system has not caught up with the human behavioral research community (Fagen, 1992). The system of behavioral description based on channels that is presented here ignores the differences between many specific movements. For example, it collapses all movements at the shoulder joint, elbow joint or hand movements into channel 4. However, the author believes that the system of channels offers a simple intermediate between the more accurate but complicated Eshkol-Wachman (EW) system and abandoning movement notation altogether in favor of the functional classification of behavior. Moreover, it has been shown here that this system of channels, though arguably crude, is capable of capturing previously undescribed patterns of behavior. It is possible that refinements in the model may allow it to capture behavior at a finer resolution.

Under the influence of apomorphine, rats show a gradual transition from forward movements to horizontal movements. This pattern was made clear only with the use of EW movement notation. Golani comments that once the pattern is pointed out, it was difficult to see how it was failed to be perceived earlier (Golani, 1992). If such relatively simple patterns were not observed till the application of the EW techniques in animal behavior, partly, due to premature judgement of function, it is not surprising that the same has limited behavioral descriptions of human behavior. If anything, human behavioral patterns are even more difficult to discern than animal behavior, because of their immediacy and the automatic empathy they evoke in their conspecific human observers. Thus, a temporary suspension of judgement, that is necessary to appreciate the structural aspects rather than the functional consequences of any behavior (Golani, 1992), becomes all the more difficult.

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9.0 Integration with extant models of behavior

The model is consistent with the dominant models of social behavior already existing. The major models such as the expectancy violation theory (Burgoon, 1978) and the discrepancy arousal theory (Capella & Greene, 1982) essentially say that individuals engaging in social interactions have certain expectations from their interacting partners and their subsequent behavior will depend on how these expectations were met. But they do not elaborate on what will be the precise form of the behavior in response in a mechanistic manner. The model suggested here is consistent with these formulations in the sense that it focuses on the expectations of the communicator and bases subsequent behavioral responses on how these expectations were fulfilled. However, the current model goes beyond a mere statement of the behavior being linked to expectations of the interactants. It makes specific predictions about what will be the form of the communicatory response based on either gratification or frustration of those expectations. Moreover, the model defines gratification and frustration in terms of the components of the model rather than leaving it to intuition or subjectivity of the observer, as the previously mentioned models do. Finally, the current model does not limit itself to expectations being violated; it makes specific predictions about what happens when these expectations are fulfilled too. The extant models do not give this scenario adequate attention, which seems unjustified. The model is also useful in laying down concrete parameters for the empirical testing of affiliative conflict theory (Argyle & Dean, 1965). For example, according to the current model, the caudal-wards channels carry stronger affiliative communications than the cephal-wards channels (Fig. 1). Thus, the communication channels used can easily be used as a measure for the degree of affiliation. Then it becomes easy to empirically define, in a given interpersonal context, what is appropriate intimacy and likely to encourage further affiliation and what is too intimate and likely to create conflict. Grey (1981, 1982) has proposed that two systems, the behavioral activation system (BAS) and the behavioral inhibition system (BIS) underlie human motivational behaviour. He suggested that the BAS is associated with reward seeking and positive affect, and the BIS is associated with punishment and non-reward. The BIS-BAS system has also been implicated in the pathophysiology of affective disorders like depression and mania (Depue & Iacono, 1989). It is immediately apparent that the cephalo-caudal hierarchical axis is consistent with the BIS-BAS model. Further, it is suggested here that the cephalo-caudal hierarchical system may be the final common pathway that is regulated by the BIS-BAS system to give behaviour its final 'motor' shape. The BAS is likely to be deployed when there is stimulus gratification to a positive affect or stimulus frustration to negative affect. The BIS may be deployed when there is stimulus frustration to a positive affector stimulus gratification to a negative affect. Dysregulation of the BAS could manifest as mania and dysregulation of the BIS as depression.

In summary, the current model is not only consistent with extant models but is a more elaborate formulation of behavior and its determinants. It makes specific predictions that are easily testable empirically, unlike the existing models whose empirical testing is dependent on the observer's subjectivity. Cephalo caudal hypothesis is consistent with the reinforcement sensitivety theory propounded by Gray in the 70s. Instead of using a generic terms like 'approach' and 'withdrawal', it goes further and specifies – 'how much approach towards each other?' and 'how much withdrawal from each other?'. Thus, the cephalo caudal hypothesis describes the nuts and bolts of the approach and withdrawal in terms of channels and the forces of stimulus gratification

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and frustration.

It is also consistent with the motor segregation theory in autism (Nebel et al, 2014) The precentral gyrus has five subcomponents - each representing different parts of the motor system cephalo caudally, from the facial muscles to the lower limbs. The study found that correlation between two distant components had higher odds of having autism. Correlation between consecutive components lowers the odds of autism. The Nebel et al study emphasises that the sequence of activation of muscle groups is important. Till now, there is no explicitly verbalised theory that recognises the importance of the sequence of activation of muscle groups. Thus, the cephalo-caudal hypothesis is implicitly assumed in this theory. Hence, the motor segregation theory of autism is an indirect proof for the cephalo-caudal hypothesis described here.

The cephalo caudal hypothesis is consistent with the theory of embodied cognition. In fact, it gives structure to the embodiment of the cognition. Thus, it lays down threadbare the different actions that are associated with different social cognitions. Further, it demonstrates how all the different actions and their cognitive counterparts are connected to each other in an almost continuous fashion along the emotional gradient. The cephalo caudal hypothesis connects the theory of embodied cognition to the real world of observable motor phenomena and thus sets the stage for experimental studies on embodied cognition.

The cephalo caudal theory is consistent with the theory of mirror neurons. It offers a ready mechanism for how the mirror neurons impact the response of the actors in the communicative act. As seen in fig. 17, the template for an actors response to the communication is available from the activation of the mirror neurons which is then possibly modified cephalwards or caudalwards according to the affective response of stimulus gratification or stimulus frustration.

10.0 Strengths, limitations and testability of the model

This model bridges the structural approach of Birdwhitsell and Scheflen, and the external variable approach of Ekman (Duncan, 1969). The structural approach describes the movements of the various different parts of the body with respect to each other during a communicatory behavior. The external variable approach describes the impact of an external (environmental) variable on a specific communicatory behavior. The current model describes the recruitment of various different 'channels' of the body both with respect to each other as well as with respect to an external variable (conciliatory or agonistic communication from the communicating partner). Thus it integrates the thus far divergent approaches in non verbal behavior research. The current model is sensitive to the social context in which the behavior occurs. The model incorporates the various bodily expressions of the emotions as being on a gradient and describes the relationship of these expressions with the intensity of the emotions and thus is amore faithful descriptor of behavior than extant models. The model can describe dominant-submissive interactions and also affective psychopathology such as depression and mania. The model is capable of faithfully describing interpersonal behavior not only cross-sectionally but also longitudinally by recursion. Moreover, even though some of the patterns may seem self-evident, formulation of the model in those terms is not superflous, as analysis of behavior using these patterns can provide new ways of understanding even complicated behavior (such as, asymmetric interactions). By breaking behavior

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down to its individual components, the paper tries to present an objective description of behavior and to minimize the use of subjective descriptors. A partially intuitive approach to defining the basic features of the model may be less than desirable but the author believes that does not take away the validity of the model. Moreover, by initially using an intuitive approach, the model ends by suggesting concrete parameters for the intensity of communication and if the observed facts fit this model, then the model is validated to that extent. Finally, social psychologists have, thus far, typically focused on the information processing of social stimuli but not enough on what the constituents of the social stimuli are (McArthur & Baron, 1983). Here, the model sheds light on the characteristics of the stimulus in greater detail and how those characteristics have potential for detailed socio-emotional meanings. The model suffers from certain limitations. The positions of channel 5 (lower limb movements) and channel 6 (pelvic movements) have been affixed on the basis of intuitively determined emotional intensity accompanying communications using these movements. A clear cephalo-caudal position for these channels does not emerge merely from a consideration of the lower motor neuron root values for these channels which overlap (Sinnatamby, 1999). The model breaks behavior down to its components and tries to present an objective account. But ‘stimulus gratification’ and ‘stimulus frustration’ are subjective entities and thus the model is not a completely mechanistic account. In retrospect, it may be unreasonable to expect a completely mechanistic description of human social behavior. This is because the epistemological assumptions that underlie the accepted methods of scientific investigation in the ‘hard’ sciences may not apply in their entirety to psychological enquiry. The amount of objectivity demanded by positivism or even post-positivism (Ponterotto, 2005), when studying ‘hard’ sciences may not be available in psychological studies, especially when the object of observation is the process of observation itself! Finally, it is obvious that human behavior is far more complicated than can be captured by a few recurring patterns. For example, there are other sensori-motor biases similar to the cephalo-caudal bias, dictated by our mammalian sexuality. But it is not entirely clear about what the place of these other minor biases in the overall behavior should be and so the author has left them out of the description completely. Another obvious lacuna is the role of volitional influences, especially when they act to resist these above mentioned biases and how these modify the structure of behavior. Thus it is clear that the paper is only scratching at the surface of our enormously complicated mass of seemingly fluid and seamless behavior. The model suggested here is easily testable and may be verified using qualitative studies, possibly using split-second camera and also longitudinal studies of pair interactions.

11.0 Conclusion

A novel model for human social behavior is presented which focuses on the specific body movements made in the context of interpersonal communication and emotional expression. The basic thesis of the model is that the spatial distribution of the body movements (in the cephalo-caudal hierarchy) has functional consequences. It points out that the cephalo-caudal progress of movements is so basic an entity that it has a threefold history – in phylogenesis, ontogenesis and actogenesis (Leyhausen, 1985). The model is a convergence of concepts from non verbal behavior, behavioral neuroscience, psychiatry, social psychology and comparative psychology and hence is truly interdisciplinary. These various disciplines converge and this inter disciplinary narrative overcomes the limitations that present themselves in these fields when used in isolation. Further, it opens up new lines of thought for theoretical

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formulations as well as new testable hypotheses for empirical studies. It has been mentioned above that social communication defies reduction to physiological terms and is embodied in its own terms (Beer, 1980). But by the current channel based model, social communication is seen to be composed of orderly activation of certain movements and thus reduction to physiological terms is actually achieved. The author believes that this is a significant breakthrough in the understanding of social communication. The advantage of this model is that it is heuristic and therefore open to further improvements. The author believes that there is a need to return to natural historical approaches to human behavior. Kendon (1990) has also suggested that human behavior could be understood through naturalistic observations and fine-grained structural studies of interactions in their everyday contexts. That there are patterns buried in the mass of complicated human behavior is not surprising. That these patterns can be used to further describe behavior in complex contexts provides a high degree of internal consistency to the model and enhances the construct validity of the model. It is imperative for students of human social behavior to understand the advances in comparative psychology and explore how animal behavior and comparative anthropology could lead to new insights in human social behavior. The paper presents new observations in human behavior which parallel known animal behavior patterns and thus presents one more piece of evidence for a basic unity between animal and human behavior, thus dispelling a widely held, if unstated, notion that ‘ humans are different from animals because of the complexity of our behavior’. This paper suggests that while it is a no-brainer to say that human behavior is more complex, we are not really all that different from animals even in our ‘complex’ inter personal behavior.

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***Table 1:* Primary and secondary layers of 'behaviour-movements'**

The primary layer contains the hubs that orient to the appropriate stimulus and the secondary layer contains channels of communication that carry messages of differing intensities, the caudal channels carrying greater intensity communications than the cephalic ones (Ch = channel).

Primary Layer	Secondary layer	Lower motor neurons
Module 1: Eyes	Ch 1: Eye movements	Cranial Nn. III, IV, VI
Module 2: Head	Ch 2: Facial expression Ch 3: Speech	Cranial Nn. VII Cranial Nn. V, X, XII
Module 3: Trunk	Ch 4: Upper limb movements Ch 5: Lower limb movements	Brachial plexus C5-T1 Lumbo-sacral plexus L1-S3
Module 4: Pelvis	Ch 6: Pelvic movements	Lumbar plexus L1-L3

Table 2*: *Affective consequences and communication:

Stimulus-gratification and stimulus-frustration have opposite effects on conciliatory and agonistic communications; conciliatory communication intensifies (moves caudal-wards) with stimulus-gratification whereas agonistic communication intensifies with stimulus-frustration (also see figures 2 & 3).

	Stimulus gratification	Stimulus frustration
Conciliatory communication	Proceeds further	Terminated
Agonistic communication	Terminated	Proceeds further

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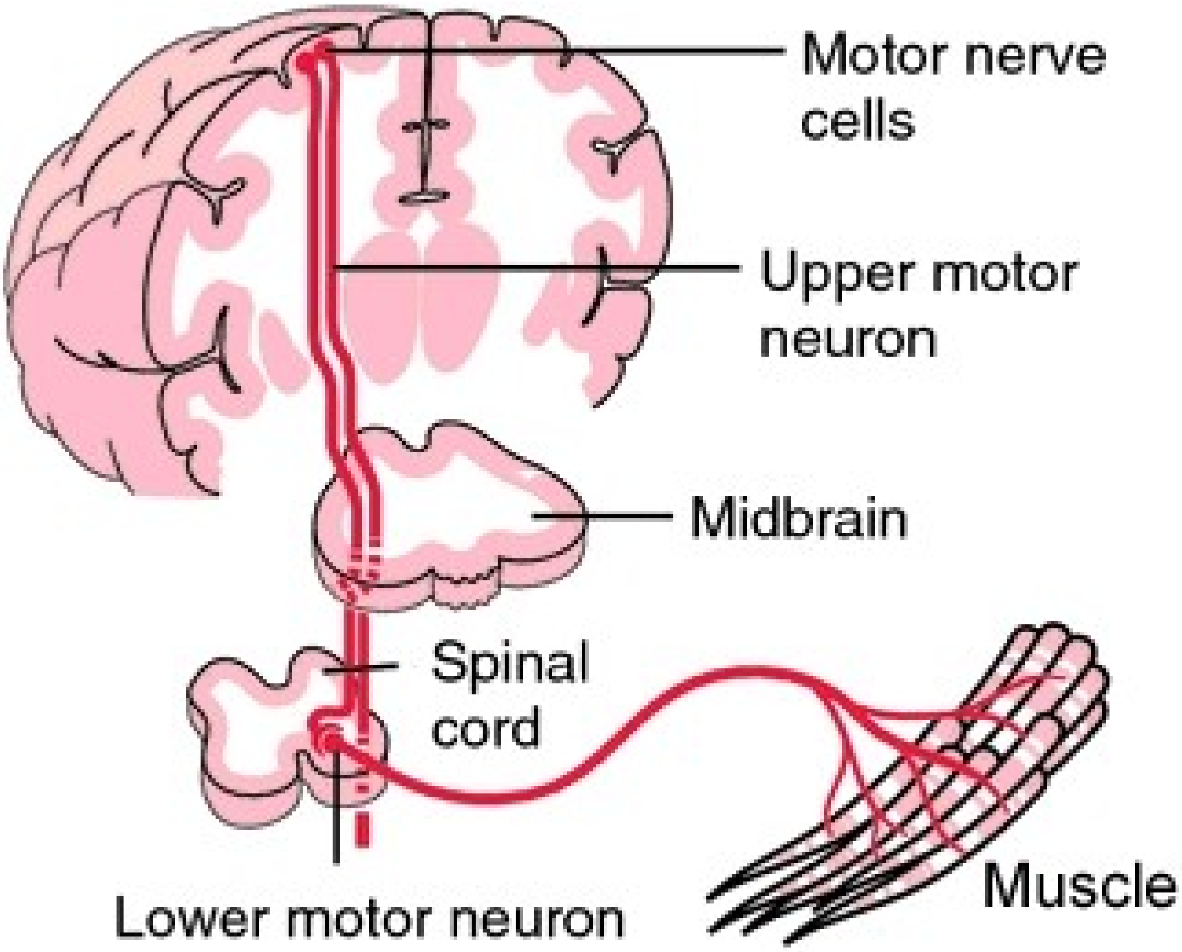
Motor nerve cells
Upper motor neuron
Midbrain
Spinal cord
Lower motor neuron
Muscle

Figure 1

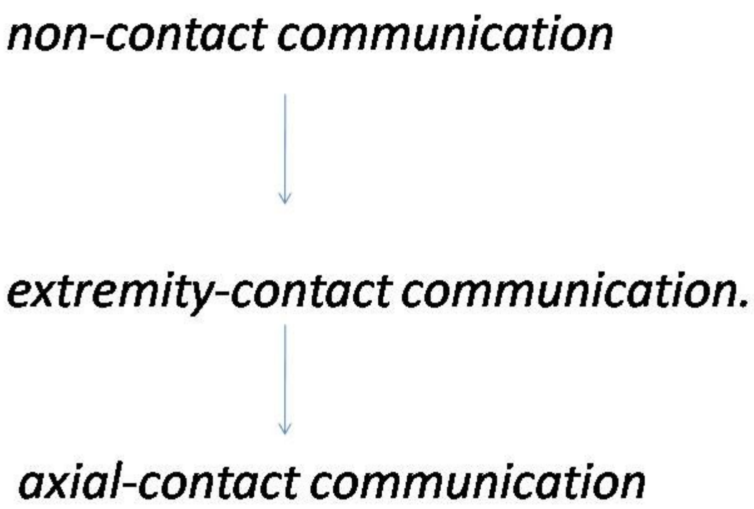

Figure 2

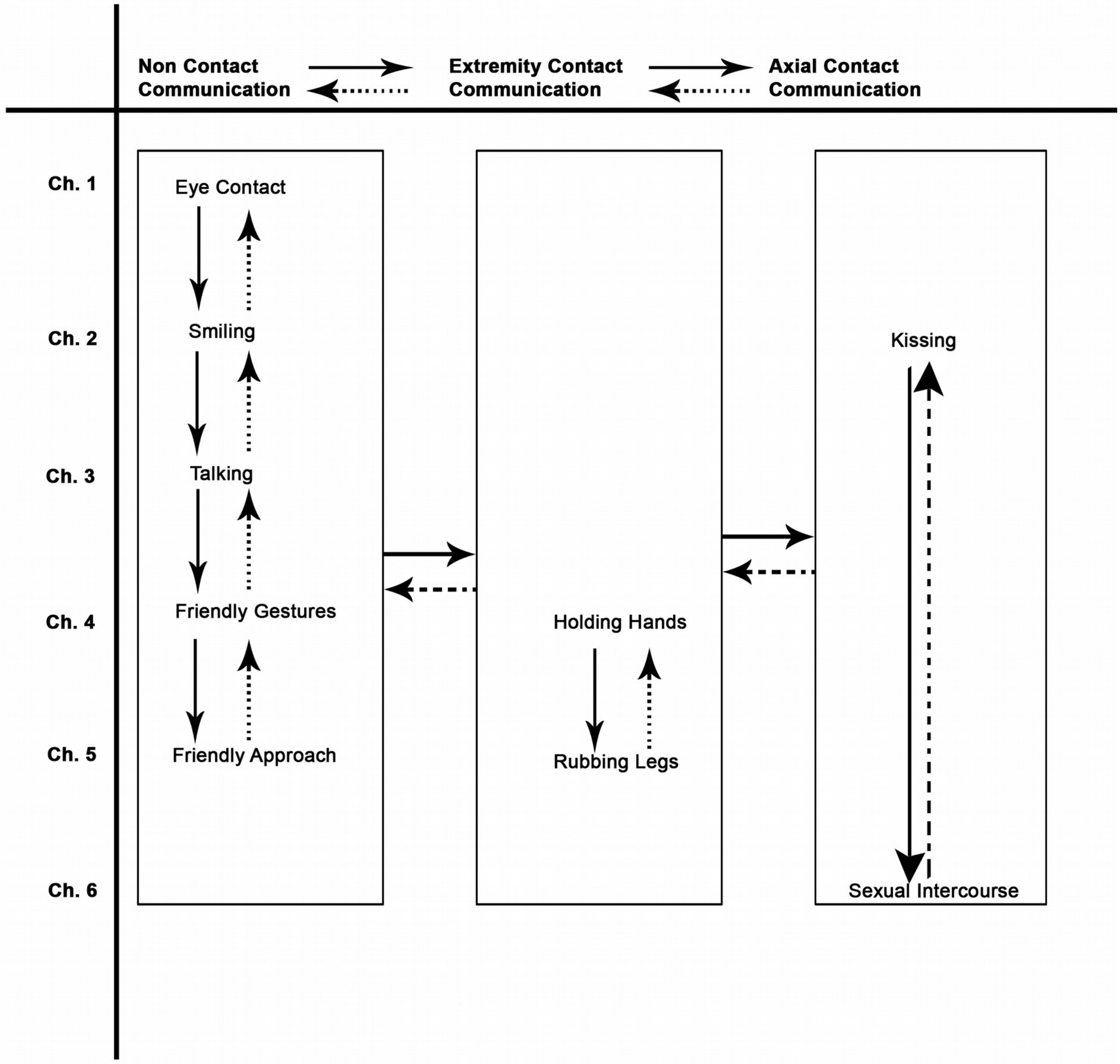

Figure 3

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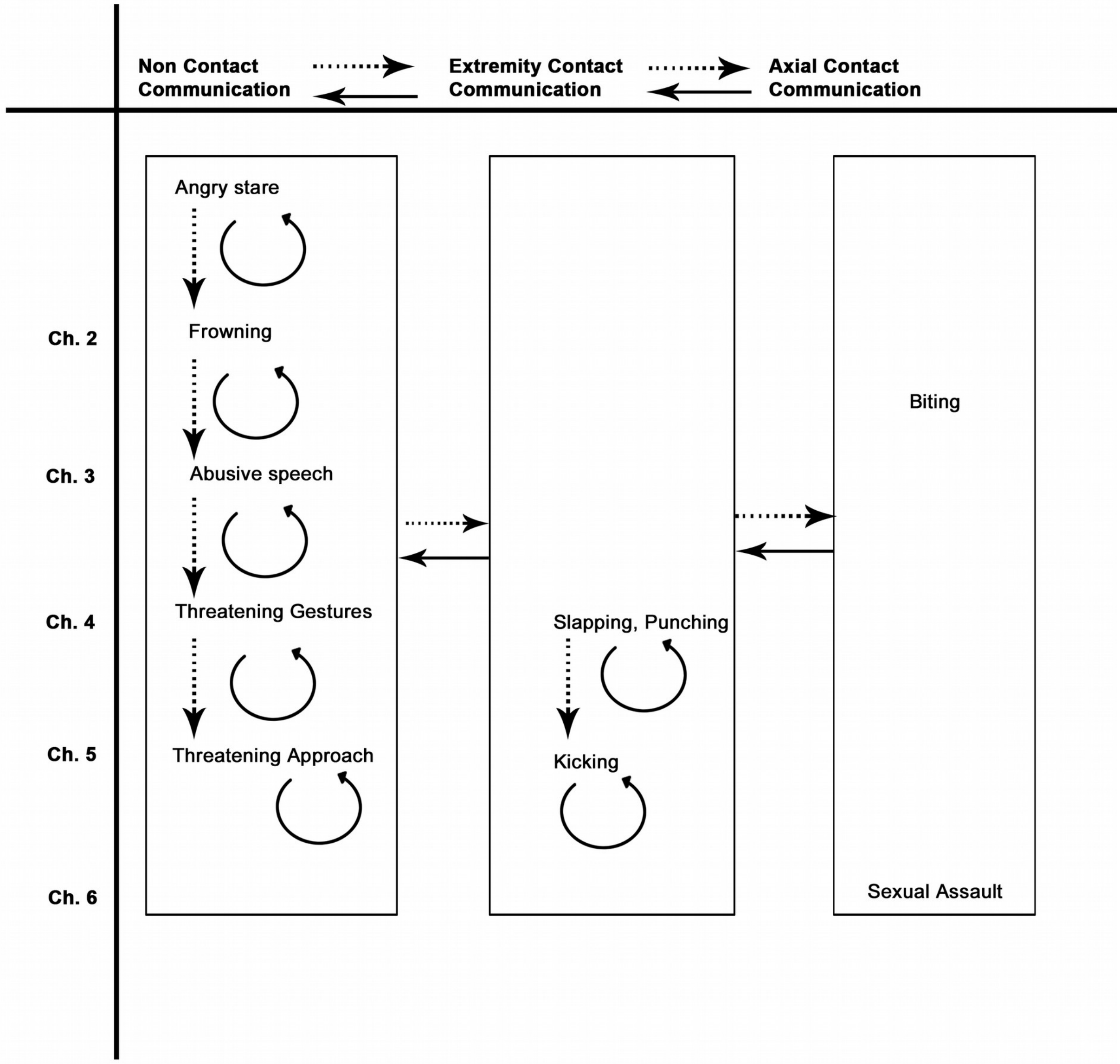
Non Contact Communication
Extremity Contact Communication
Axial Contact Communication
Ch. 2
Ch. 3
Ch. 4
Ch. 5
Ch. 6
Angry stare
Frowning
Abusive speech
Threatening Gestures
Threatening Approach
Slapping, Punching
Kicking
Biting
Sexual Assault

Figure 4

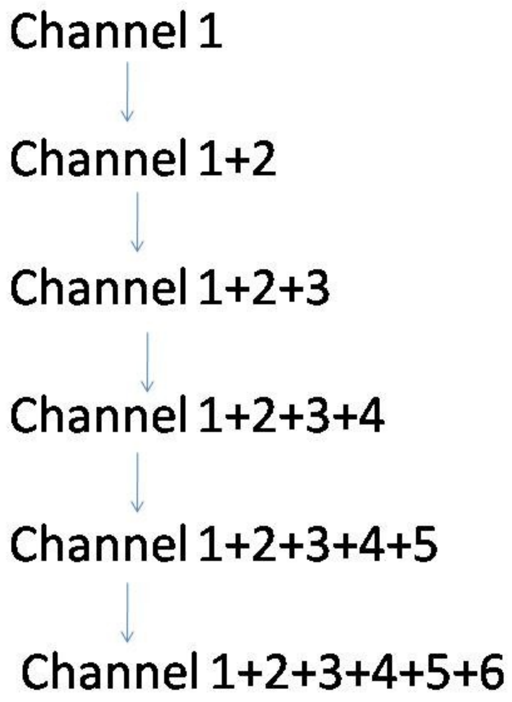
Channel 1
Channel 1+2
Channel 1+2+3
Channel 1+2+3+4
Channel 1+2+3+4+5
Channel 1+2+3+4+5+6

Figure 5

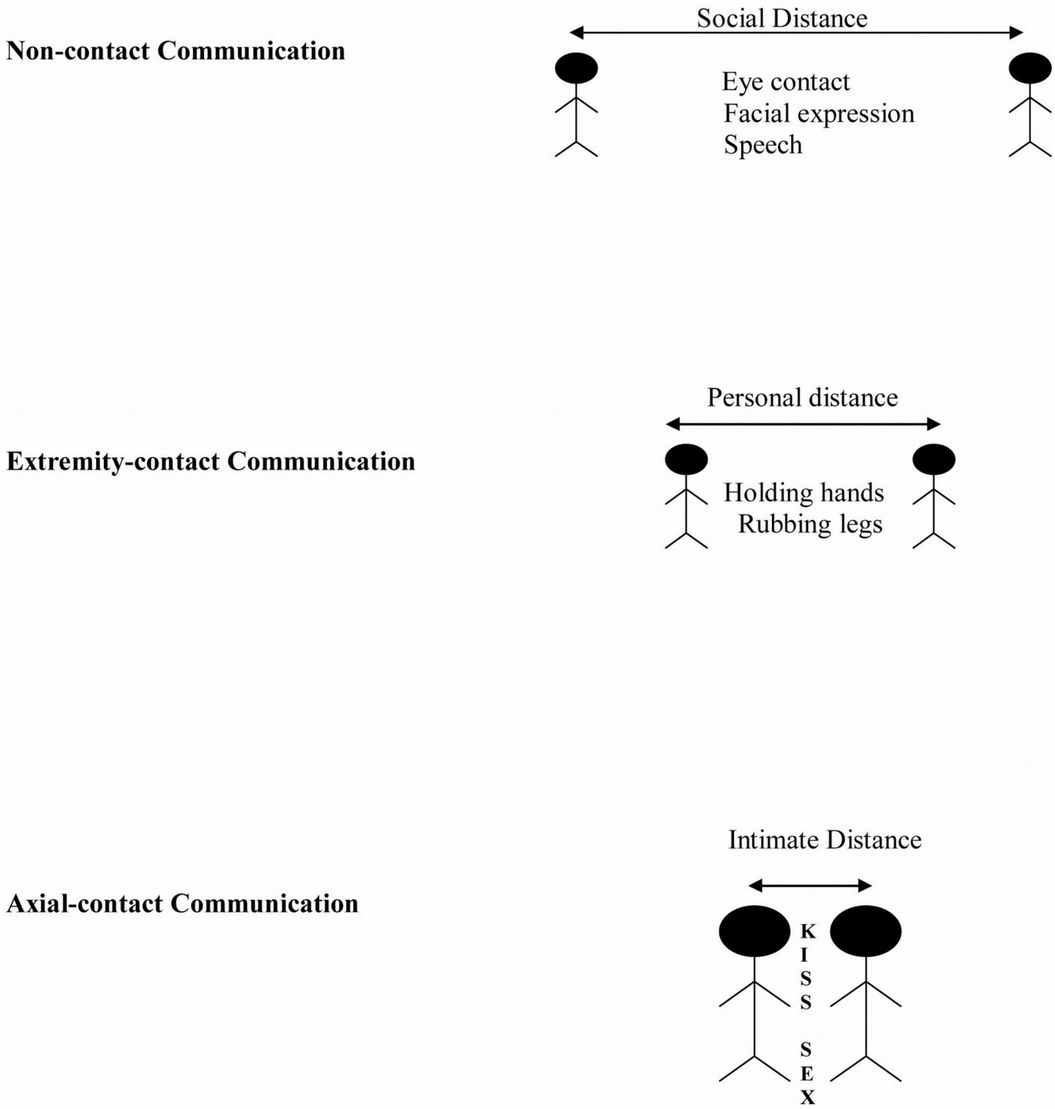
Non-contact Communication
Social Distance
Eye contact
Facial expression
Speech
Extremity-contact Communication
Personal distance
Holding hands
Rubbing legs
Axial-contact Communication
Intimate Distance
KISS
SEX

Figure 6

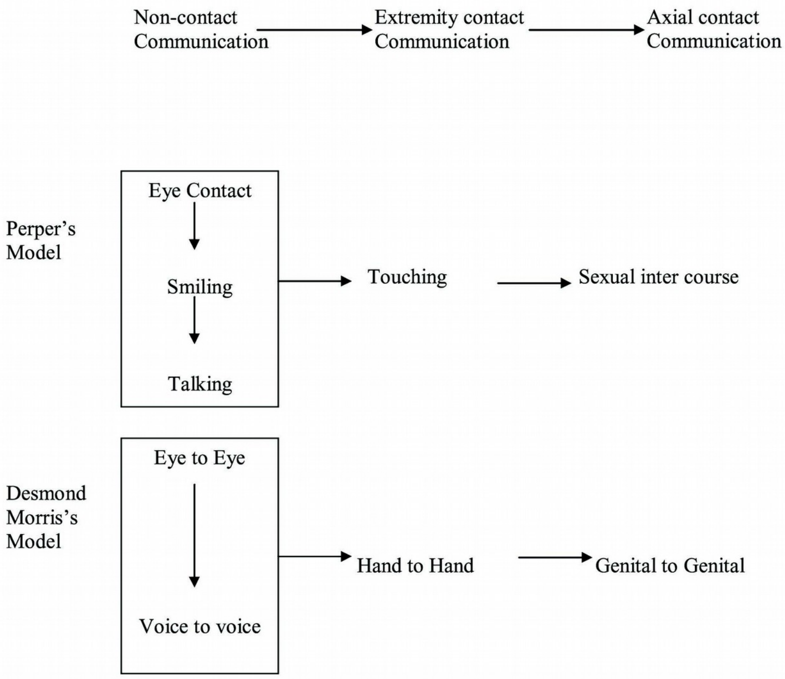
Non-contact Communication
Extremity contact Communication
Axial contact Communication
Perper's Model
Eye Contact
Smiling
Talking
Touching
Sexual inter course
Desmond Morris's Model
Eye to Eye
Voice to voice
Hand to Hand
Genital to Genital

Figure 7

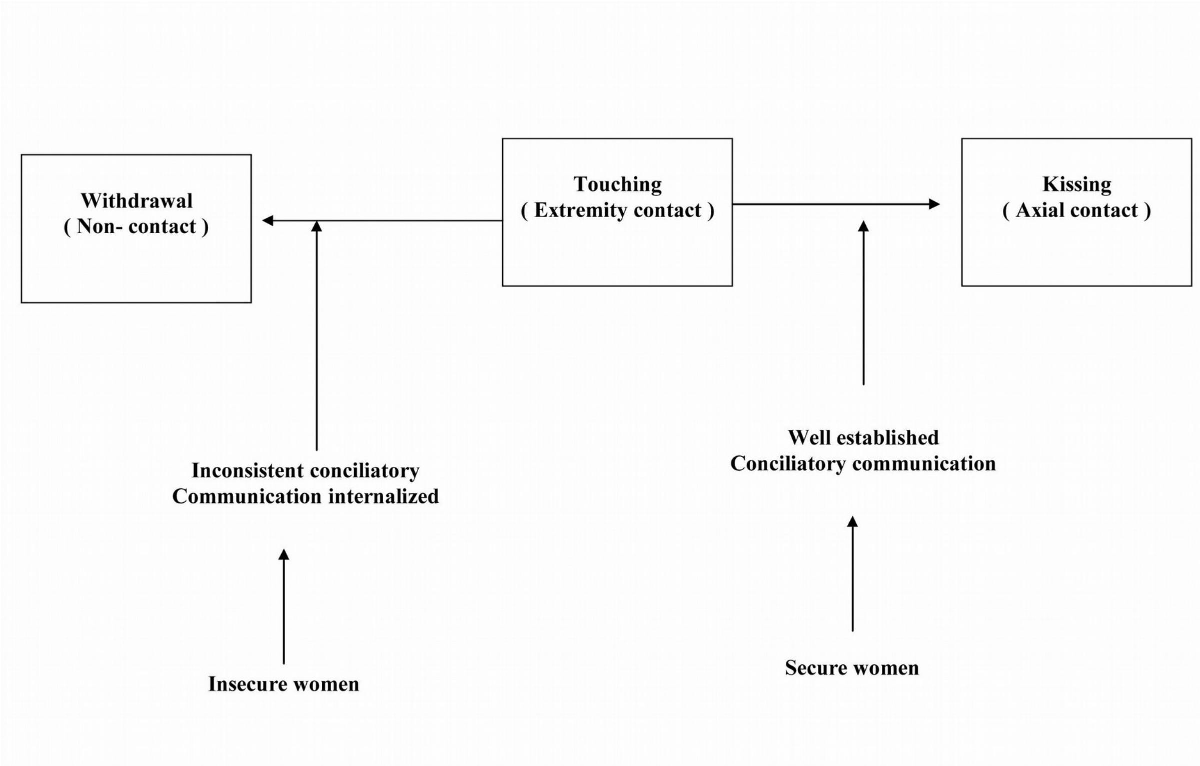

Figure 8

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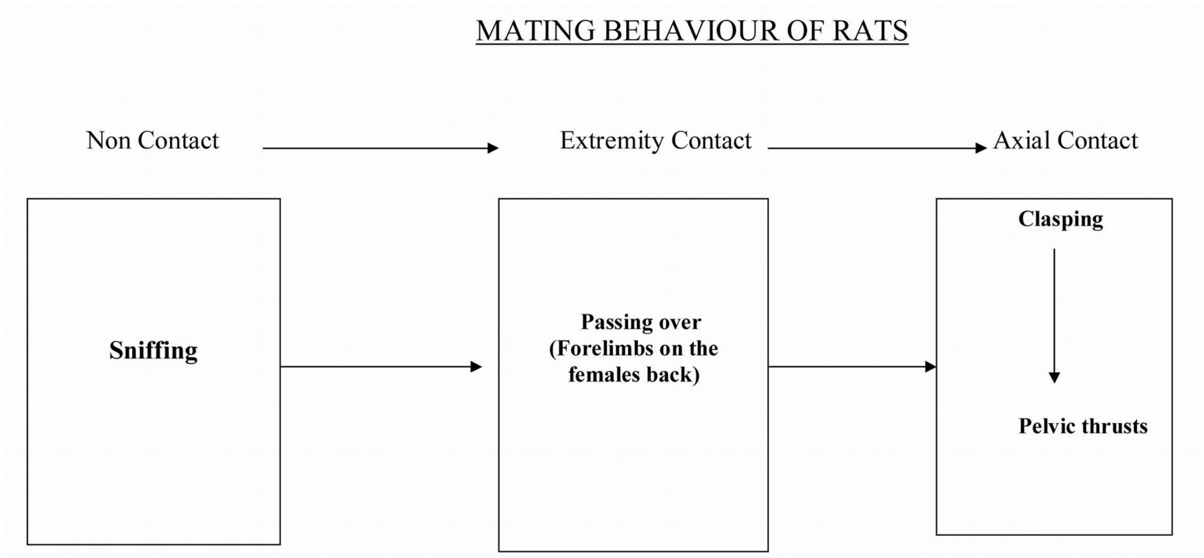
MATING BEHAVIOUR OF RATS
Non Contact
Extremity Contact
Axial Contact
Sniffing
Passing over
(Forelimbs on the
females back)
Clasping
Pelvic thrusts

Figure 9

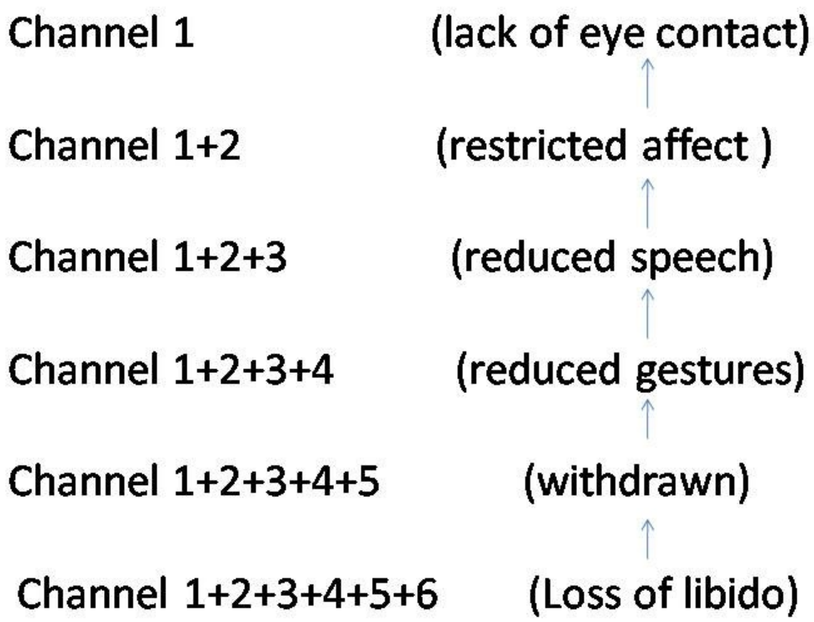

Figure 10

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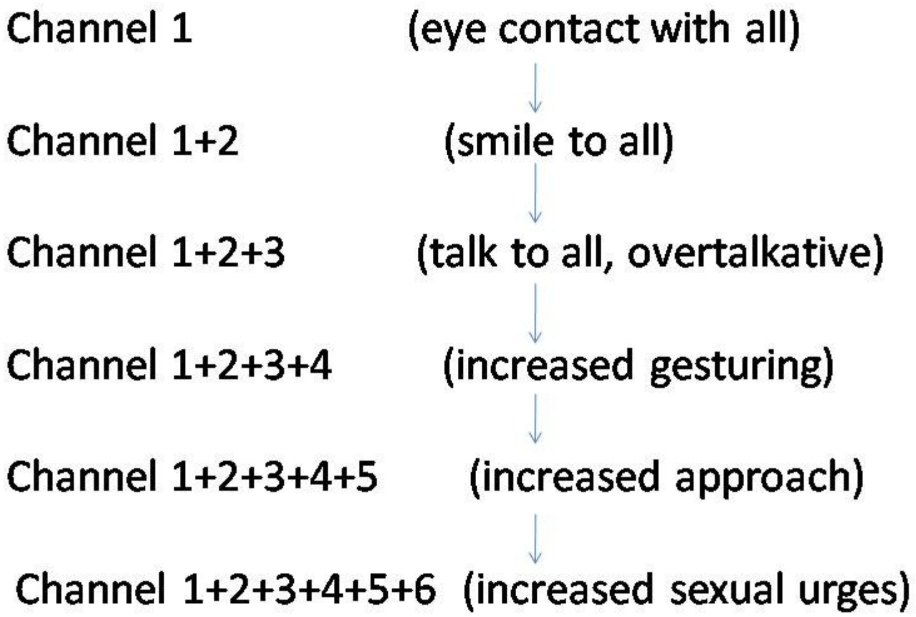
Channel 1
(eye contact with all)
Channel 1+2
(smile to all)
Channel 1+2+3
(talk to all, overtalkative)
Channel 1+2+3+4
(increased gesturing)
Channel 1+2+3+4+5
(increased approach)
Channel 1+2+3+4+5+6
(increased sexual urges)

Figure 11

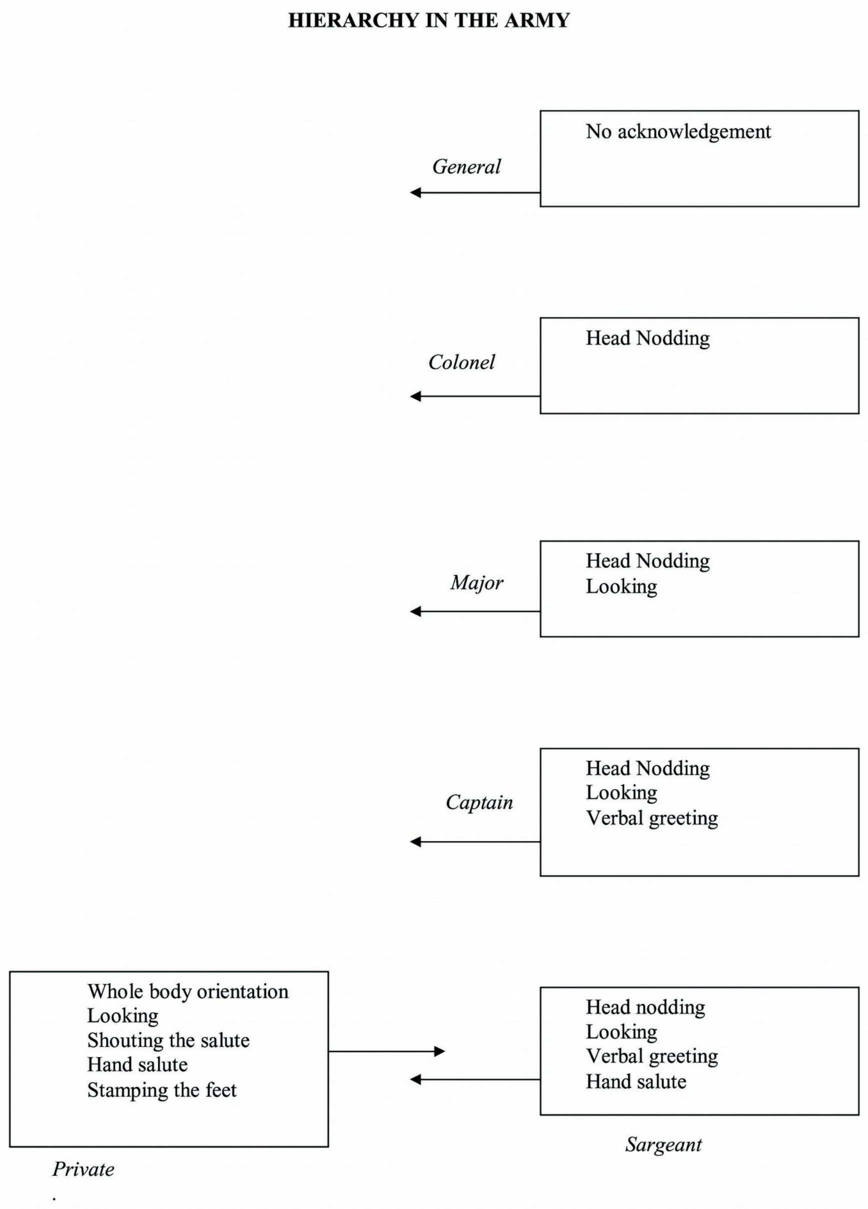
HIERARCHY IN THE ARMY
No acknowledgement
General
Head Nodding
Colonel
Head Nodding
Looking
Major
Head Nodding
Looking
Verbal greeting
Captain
Whole body orientation
Looking
Shouting the salute
Hand salute
Stamping the feet
Private
Head nodding
Looking
Verbal greeting
Hand salute
Sargeant

Figure 12

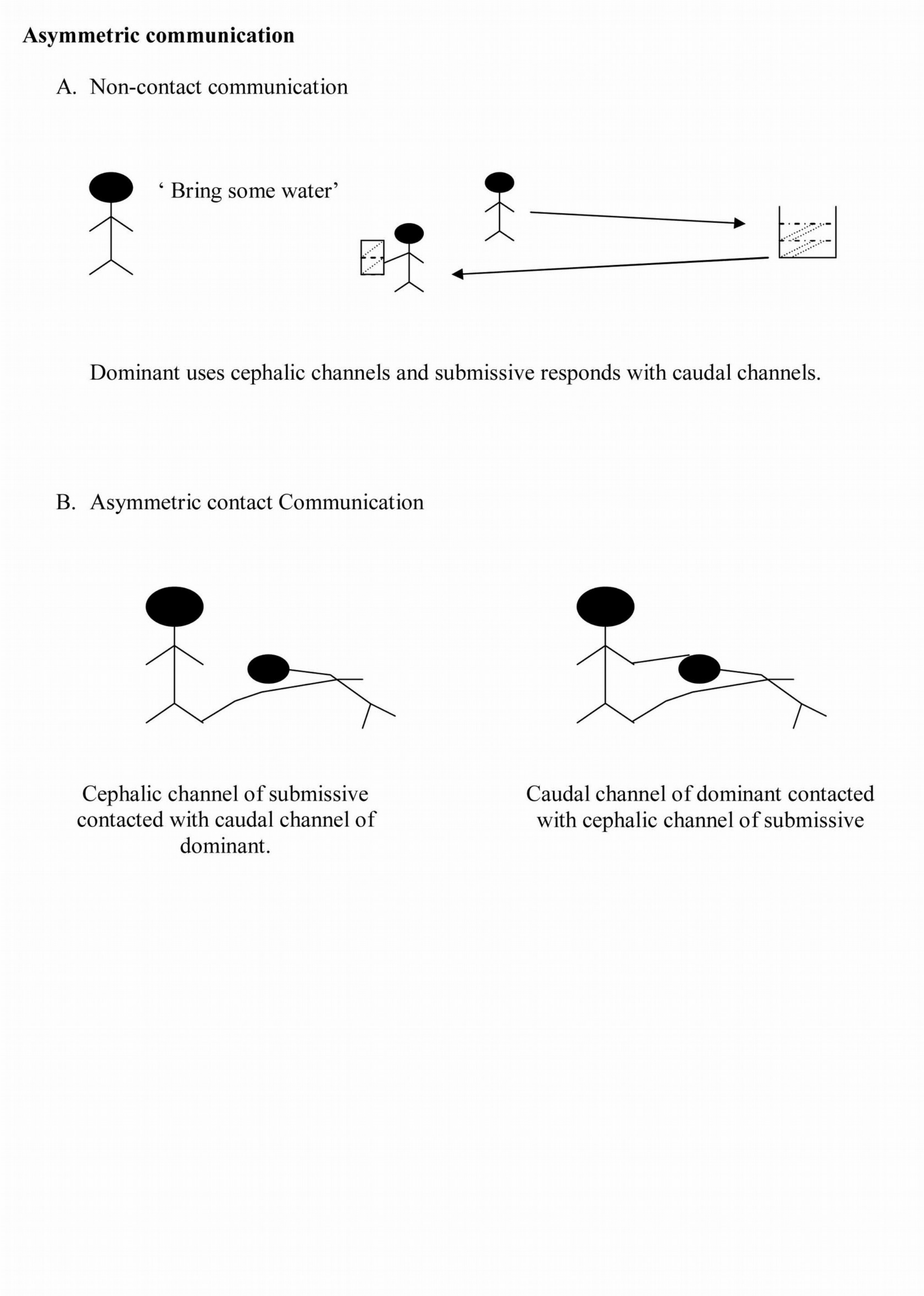

Figure 13

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Aggression by Subordinate Cat	Aggression by Dominant Cat
Hissing	Laying ears back
Feigning blows	
Defensive posture	

Soldier	General
Looking	Head nodding
Shouting the salute	
Hand salute	
Stamping feet	

Hat tip by subordinate	Hat tip by dominant
Fully remove hat	Merely touch the hat
Bend	
Verbal greeting	

Figure 14

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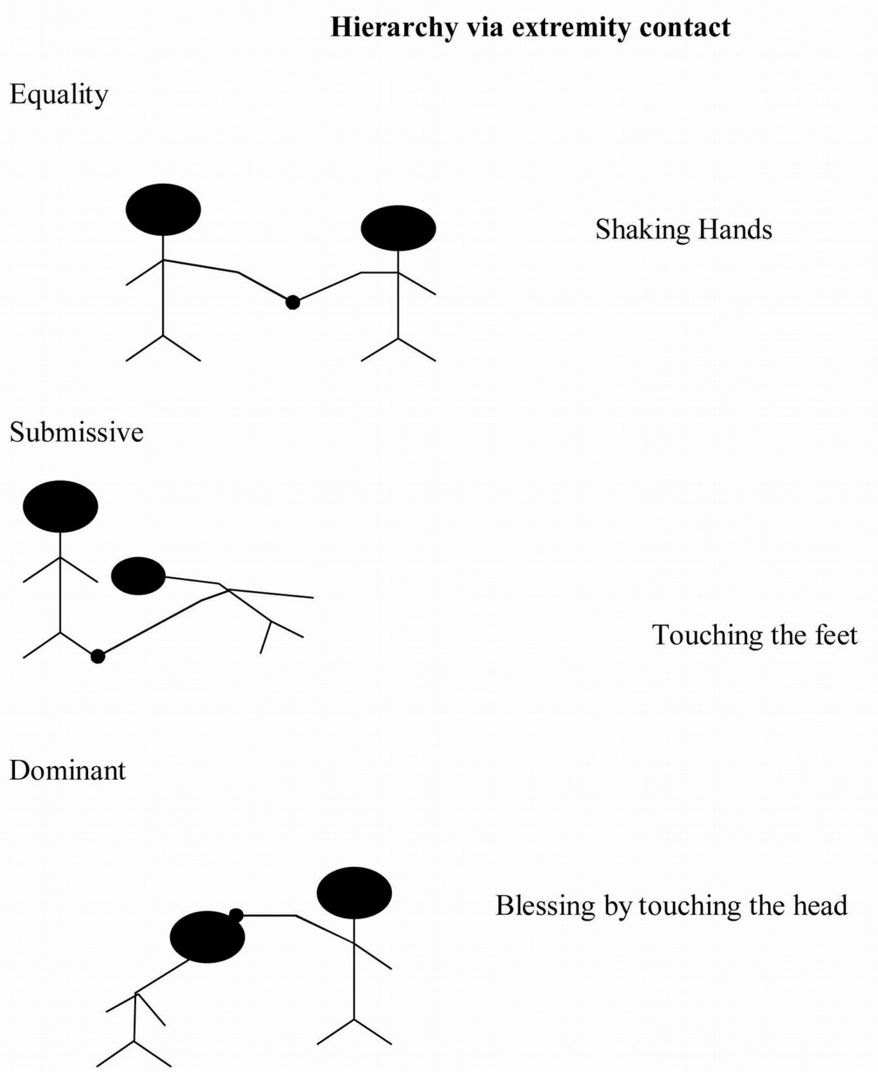

Hierarchy via extremity contact
Equality
Shaking Hands
Submissive
Touching the feet
Dominant
Blessing by touching the head

Figure 15

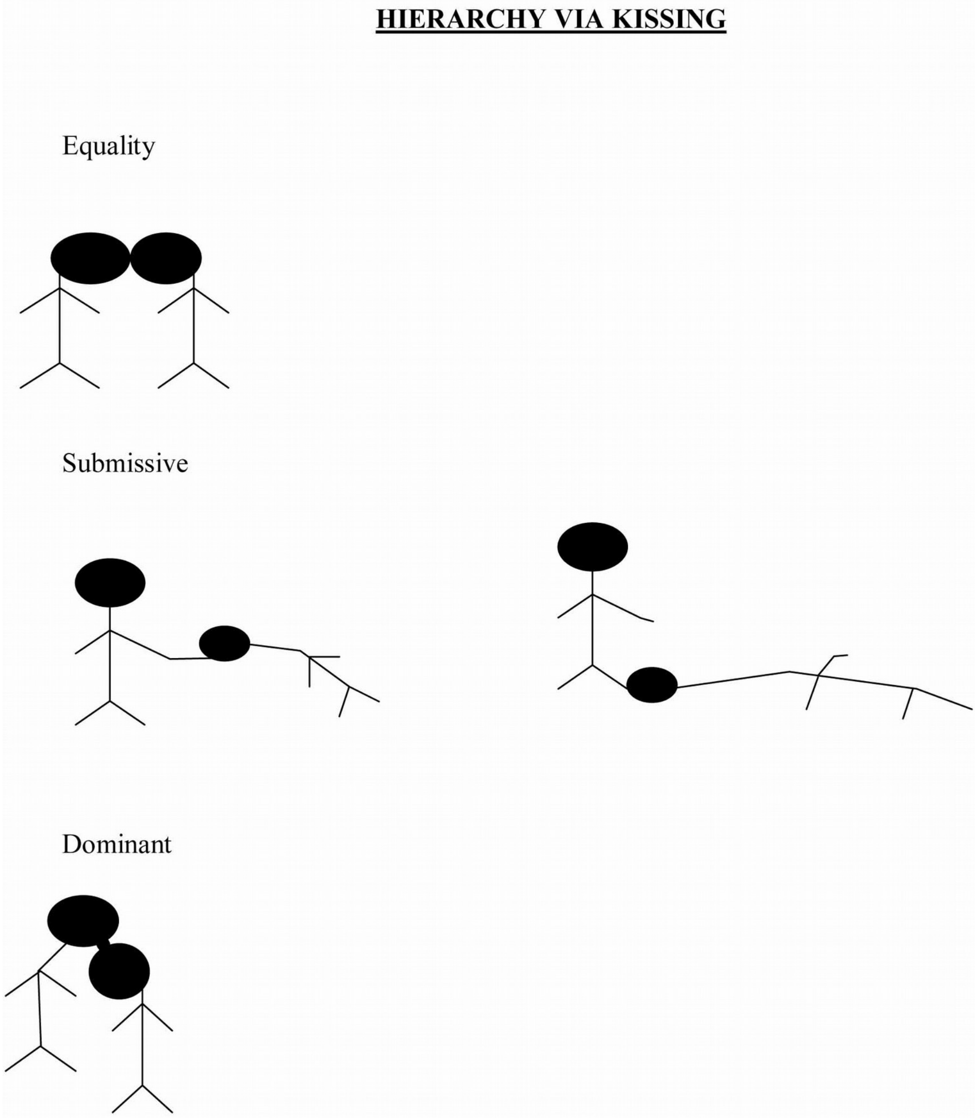


Figure 16

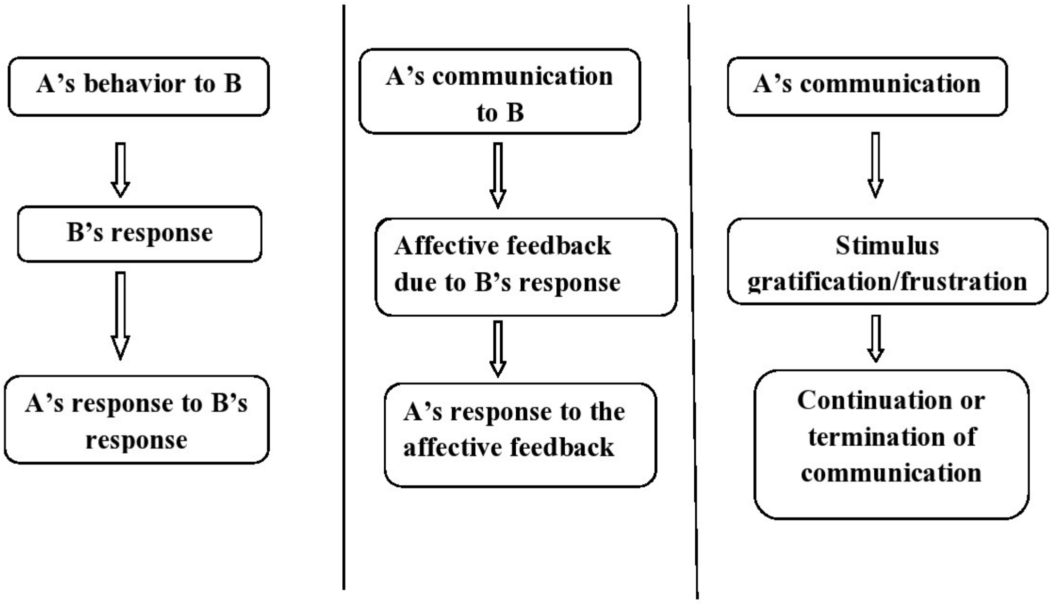
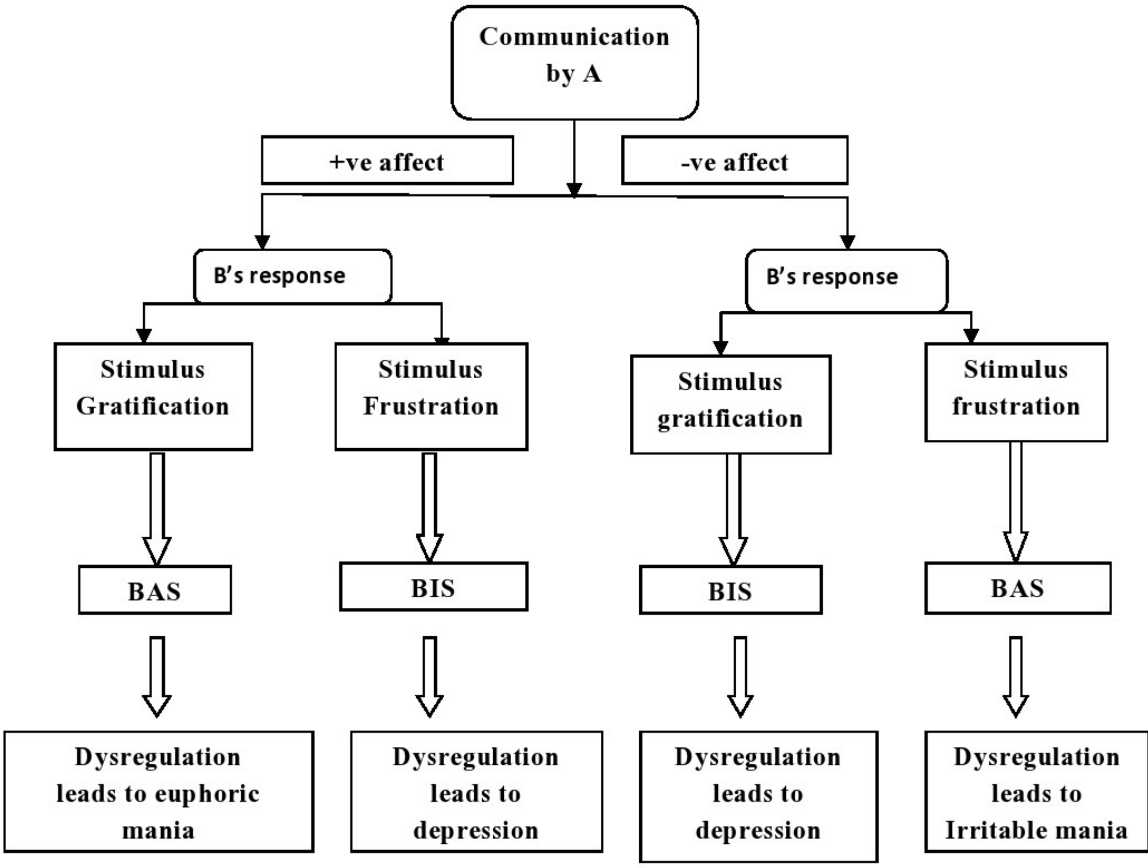

A's behavior to B
B's response
A's response to B's response
A's communication to B
Affective feedback due to B's response
A's response to the affective feedback
A's communication
Stimulus gratification/frustration
Continuation or termination of communication

Figure 17

Figure18



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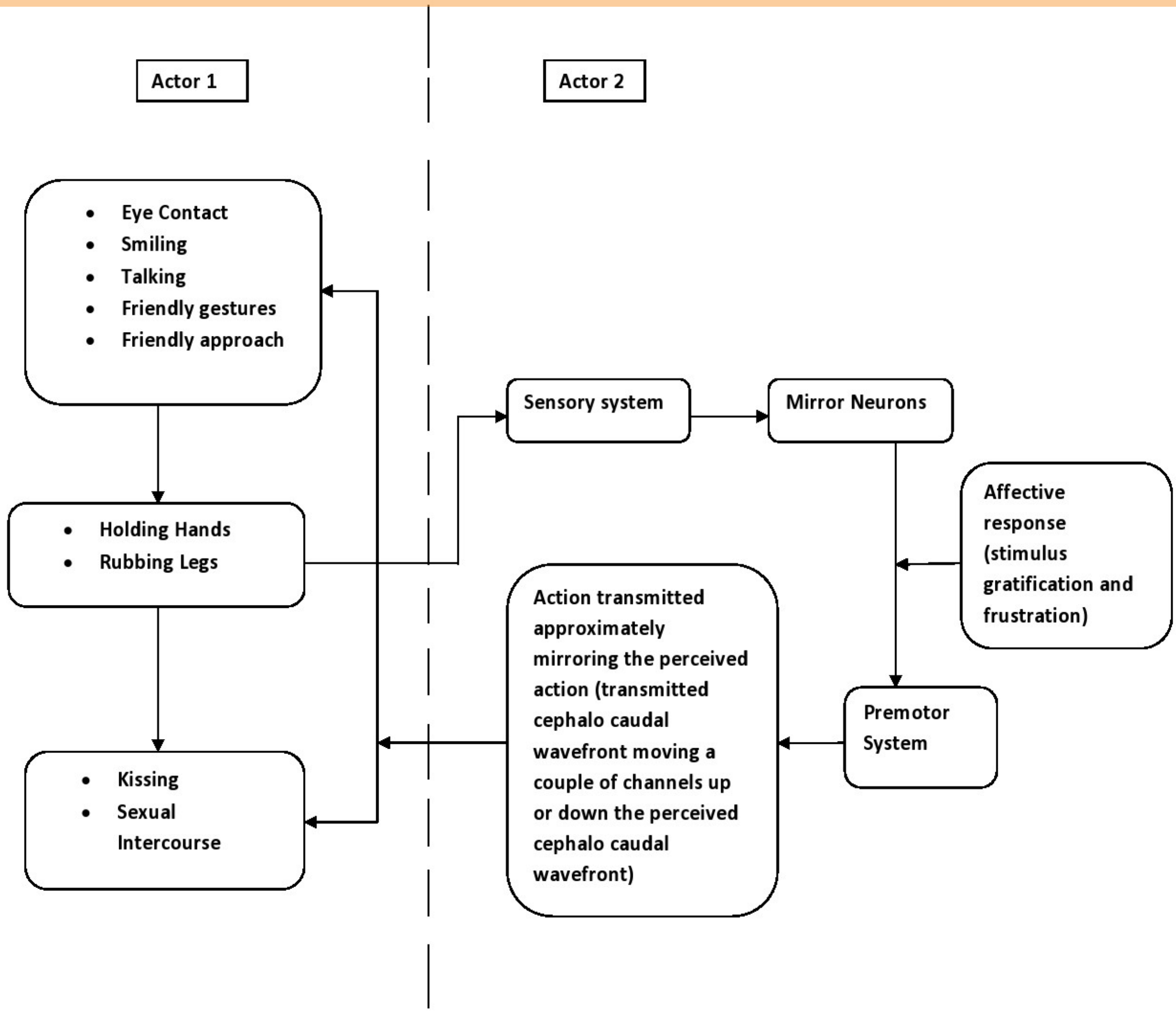
Actor 1
Actor 2
Eye Contact
Smiling
Talking
Friendly gestures
Friendly approach
Holding Hands
Rubbing Legs
Kissing
Sexual Intercourse
Sensory system
Mirror Neurons
Affective response (stimulus gratification and frustration)
Action transmitted approximately mirroring the perceived action (transmitted cephalo caudal wavefront moving a couple of channels up or down the perceived cephalo caudal wavefront)
Premotor System

Figure 19

FIGURE CAPTIONS

Figure 1: Upper and lower motor neurons

The neurons that originate from the brain stem and the spinal cord directly innervate the muscles and are called the lower motor neurons. The neurons that originate from the cerebral cortex project onto the lower motor neurons and are called the upper motor neurons. The model presented here arranges the channels according to the position of the lower motor neurons supplying the channels in the cephalo-caudal axis (see Table 1).

Figure 2: Progress of communication from non- contact to contact-communication and from extremity-contact to axial-contact communication

Figure 3: Conciliatory communication

Conciliatory communication proceeds from non-contact communication to appendicular-contact communication and finally, to axial-contact communication. Thus, eye contact, smiling, talking, friendly gestures and friendly approach precede holding hands and rubbing legs which precede kissing and sexual intercourse.

⟶ *Stimulus gratification*

- - -▸ *Stimulus frustration*

Figure 4: Agonistic communication

Agonistic communication also proceeds from non-contact communication to appendicular-contact and finally, to axial-contact communication. Thus, angry stare, angry facial expression, abusive speech, threatening hand gestures and threatening approach precede slapping and kicking, which in turn, precede biting and sexual assault. There is a possible discontinuity between sexual assault and the rest of the aggressive communications.

Stimulus gratification

Stimulus frustration

Figure 5 : Progressive recruitment of channels cephalo-caudally

Figure 6: Progressive proxemic approach of the cephalo-caudal channels

This figure illustrates the interface between Edward Hall's model of proxemics and the model of cephalo-caudal communication channels presented here. Thus, Hall's social distance corresponds to non-contact communications in our model, personal distance to extremity contact communications and intimate distance to axial contact communications.

Figure 7: Correspondence to existing models

The figure illustrates how the existing models are consistent with the model of cephalo-caudal communication channels presented here. Thus, the sequence of behaviors found in Perper's study of courtship behavior and Desmond Morris's model of 'ascending scale of intimacies' actually fall within the framework presented

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by the cephalo-caudal communication channels model.

***Figure 8**: Schematic showing that Simpson et al's experiment falls within the framework of the cephalo-caudal communication channels model*

In Simpson et al's experiment studying the response of women under stress to touch by their partner, secure women proceeded to hugging and insecure women tended to withdraw. Assuming that secure women have internalized a consistent conciliatory communication pattern and that insecure women have internalized an inconsistent conciliatory communication pattern, this translates to the extremity-contact communication proceeding to axial-contact communication in secure women, but extremity-contact communication degenerating to non contact communication in insecure women, as predicted by the model presented here.

Figure 9: Mating behavior of rats.

This figure illustrates that the mating behavior of rats also follows the cephalo-caudal channels model. Thus, the sequence of sniffing, passing over and clasping with pelvic thrusts corresponds to non-contact communication, extremity-contact communication and axial-contact communication.

Figure 10: Representation of depressive symptoms by cephalo-caudal channels

Figure 11: Representation of manic symptoms by cephalo-caudal channels

Figure 12: Hierarchy in the army.

This is a schematic showing the hypothetical responses of the officers at various hierarchical levels to a soldier's salute. Notice that the response of the dominant

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reduces as the dominant moves up the hierarchy. The general point intended is that in asymmetric non-contact communication, the dominant uses the channels cephalic to those used by the submissive.

Figure 13: Asymmetric communications – non-contact and contact communication.

This figure illustrates the use of channels by the dominant and submissive while communicating with each other.

Top: In response to the dominant's asking for water (channel 3), the submissive walks (channel 5) and carries the water (channel 4) to the dominant. Thus, in asymmetric non-contact communication, the dominant uses channels cephalic to those used by the submissive.

Bottom: The submissive pays obeisance to the dominant by touching the dominants feet (channel 5) with his hands (channel 4). The dominant blesses the submissive by touching the head with his hands. Thus, in asymmetric contact communication, the dominant uses the channels caudal to those used by the submissive. The difference in the dominants response in asymmetric contact and non contact communications is explainable by invoking Zahavi's honest signaling principle to surrender signals.

Figure 14: Similarity in dominant-submissive interactions in humans and cats

Dominant-submissive interactions follow a similar structure across humans and animals too.

Top: The members of a group of cats pay about as much attention to a subordinate *cat adopting a defensive posture, hissing and feigning blows as to a dominant tom cat cursorily laying its ears back.*

Bottom: To the elaborate ritual of hat tip by the subordinate consisting of bending, verbal greeting and removing the hat fully, the dominant might merely touch his hat in response.

Figure 15: Hierarchy expressed by extremity contact.

The hierarchical standing can be made out when two people come in physical contact with each other. Here, this is examined when contact is established with the upper limbs. Equals shake hands (both channel 4). A submissive touches the feet (channel 5) of the dominant with his hands (channel 4). A dominant blesses the submissive by touching the head with his hands.

Figure 16: Hierarchy expressed by kissing.

Equals kiss equally (both channel 2). A submissive kisses (channel 2) the hands (channel 4) or the feet (channel 5) of the dominant. A dominant kisses the head of the submissive.

Figure 17: Approach to model building

Behavioral interaction between two participants is described as the recursion of the response of the participants to each other's behavior. This is then written in the form of recursion of communication from one to the other, the affective consequences thereof and the response to the affective consequences.

Figure 18: BIS BAS dysregulation of the cephalo caudal framework leads to affective disturbances

It is suggested that the cephalo-caudal framework is the final common pathway for the BIS-BAS regulation. BIS-BAS dysregulation can result in manic and depressive symptoms.

Figure 19: Mirror neurons and the cephalo-caudal model

The cephalo-caudal framework offers a ready mechanism for the mirror neurons to form a template for the response to the communication. This template is modified cephalwards or caudalwards based on the affective feedback in the form of stimulus gratification or frustration.

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