CHAPTER 3

# A Unified Model of Cognition, Emotion, and Action and Its Relation to Vocally Encoded Cognitive-Affective States

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**Abstract**

The unified model of cognition, emotion, and action suggests that cognitive processes that steer and organize adaptive behaviors evolve in what is commonly known as affective space. By combining insights from constructivist epistemology (Piaget, 1950) and cybernetics, the unified model explains how and why affect is inherent to cognitive processes involved in adaptive interaction with the environment. The functioning of adaptive behavior is explained within the framework of dynamic systems with self-organizing properties. Valence, arousal, and potency are considered as the system's control parameters—critical organizing factors underlying adaptive change, while the amplitude and speed of change in control parameter values are seen as generators of more or less stable states that can be subjectively felt as emotional. Each state can then be defined as a point in a three-dimensional space. Depending on their structure and stability over time, such states can be conceptualized as *motivations*, *emotions, moods,* or *personality traits.* The choice of valence, arousal, and potency as control parameters is explained from the cybernetic point of view enriched with *genetic* epistemology. After defining the semiological status of vocal indicators of affect, the results of a pilot study on vocally encoded interpersonal stance are presented.

## Multiplicity of Emotion Theories—A Call for Integration

Over the past hundred years, emotion psychology has mainly concentrated on various constituents of the organism's emotional response such as: cognitive appraisals, physiological, neurological, and hormonal activations, motor, expressive, and behavioral reactions, linguistic "labeling," consciousness, and the subjective feelings, however without offering an integrative theoretical framework. One of the disturbing results of this gap is a remarkable diversity of emotion theories and consequently a lack of consensus on the definition of *emotion*—the main object of study.

In this chapter we shall suggest a theoretical framework that will allow the integration of several theories and suggest a definition of *emotion.* The epistemological orientation is that of *genetic* epistemology applied to open systems (Bertalanffy, 1968) with self-organizing properties (Carver & Scheier, 2002).

## Theoretical Framework of the Unified Model

Be it in the works of art, in sports, in intellectual pursuits, or at peace or war times, emotional states are considered to be initiators, modulators, or terminators of actions. They appear to mediate adjustment to environmental conditions and improve the individual's chances of biological and social survival. In the construction of autonomous agents, emotions are viewed as determinants of action selection and behavior arbitration (Scheutz, 2002; Snaith & Holland, 1991; Tyrrell, 1993). Does this mean that affective processes—emotions in particular—are dedicated systems that serve an adaptive purpose and that one needs to be in an emotional state in order to engage in adaptive behavior?

We would say "No." We believe that affective aspects of cognitions are inherent to the functioning of dynamic systems. In such systems adaptive behavior results from organization through a limited number of interacting lower-order elements acting as control parameters. The output is then a coordinated response of the system's components. Shifts in values and the interactions between control parameters produce different behavioral outputs.

As the behavioral adjustments are made with regard to each parameter's value, we are then concerned with the identification of the control parameters that guide adaptive action and influence the emergence of processes and states that may be subjectively felt or externally recognized as emotional. We believe that the system's control space can be defined by three dimensions: valence, arousal, and potency. These dimensions have so far been considered as intrinsically *affective* (Bachorowski & Owren, 1995; Laukka, Juslin, & Bresin, 2005; Mehrabian & Russel, 1974; Osgood, May, & Miron, 1975; Russell, 2003; Russell & Barrett, 1999).

In Faith and Thayer's model of emotion, valence and arousal are conceptualized as the dynamic systems' control parameters (Faith & Thayer, 2001). We agree with these authors' convincing demonstration of valence and arousal acting as control parameters, but we do not share their opinion that they are specific to *emotion systems.* Hence, we defend the view that these control parameters per se are inherent to the organism's interaction with the environment and that it is only under certain conditions (explained below) that valence, arousal, and potency come to be conceptualized as dimensions of emotions.

This is close to Peter Lang's view that " . . . there is no clear demarcation between affective and non-affective behavior. However, popular consensus defines the terrain of emotion as including responses that vary in valence, arousal and control or dominance . . . " (Lang, 1990, p. 221).

Stating this allegiance to Lang, we can thus take a stand against theories based on specific *emotional mechanisms* (Plutchik, 1962; 1980) and agree with George Mandler (Mandler, 1975; 1982) who argues "against any theories of emotion that are independent of or different from a more general analysis of human processing systems" (Mandler, 1975, p. 84). In their recent theoretical work, Matthews and colleagues pointed out the nonexistence of an overarching model allowing discrimination of higher order complexes of affect, motivation, and cognition that may reflect different modes of self-regulation (Matthews et al., 2002). Much earlier, Howard Leventhal (Leventhal, 1970) suggested that emotion theories should be included into a more general systems approach to describe the mechanisms that control behavior (Carver & Scheier, 1981; 1982; Leventhal & Nerenz, 1985). According to his model, two parallel systems structure and control behavior: one controls problem-oriented behavior and the other affect-oriented behavior. Each of the systems follows three stages: representing the environment, responding to it, and evaluating the response outcomes. A similar model of the structure and the stages of basic behavioral units was provided by Miller and colleagues (Miller, Galanter, & Pribram, 1986). While we agree on the nature of the three "stages," we do not share Levethal's view of there being two distinct control systems.

Rooted in Jean Piaget's *genetic* epistemology, we are proposing a unified model where the very functioning of the subject's interaction with environment implies the construction and usage of schemata (of varying complexity) that necessarily include affective aspects (Piaget, 1954). For reasons explained later we shall use the term *reaction* to mean the organism's hardwired responses (like reflexes or innate releasing mechanisms producing preprogrammed stereotyped behaviors or fixed action patterns) and the term *behavior* to mean the organism's adaptive response guided by cognitive evaluations of both the environment and the ongoing interaction with it. Our model will be mainly concerned with the architecture and the functioning of the interaction processes which apply to organisms described as open systems with dynamic teleology (Bertalanffy, 1968).

Piaget's general model of interaction comprises two types of interactions (Piaget, 1975). The Type I interaction produces the knowledge of the relation between the properties of the object and the properties of the subject's action. The most elementary form of such a relation is covariation. For example, in a situation where a subject lifts an object, the object's perceived weight is relative to the muscular effort employed to lift it. It then follows that the knowledge of the object's characteristics is inseparable from the knowledge of the characteristics of the subject's action schemes used in the interaction. The knowledge thus constructed becomes a cognitive instrument for the subject's further cognitions and actions. The discovery of the role of mirror neurons in cognition (Gallese, Keysers, & Rizzolatti, 2004) can be seen as empirical evidence for Piaget's concept of assimilation as a *computational* principle underlying human cognition—a mechanism for the coordination of perceptual and motor actions. The coupling of perception with actions via mirror neurons can then explain the simultaneous construction of the internal representations of the world and the self (Gallese & Lakoff, 2005).

Type II interaction includes the properties of perceptual and sensorimotor schemata as elaborated in Type I interaction, to which are added inferential coordinations, consciousness, and retroactive regulation. It then follows that adaptive action implies the construction and coordination of three types of knowledge (Cellérier, 1979):

1. A set of empirical features of a situation associated with the anticipated set of features to be resulting from action. The latter set of features is the value the set will acquire as a result of action.
2. A set of pragmatic features of the transformations due to action associated with the set of empirical features.
3. A cognitive composite reflecting a tripartite structure of an instrumental act with the transformation having the status of a means, the result having the status of the end, and the situational features playing the role of the operand.

For Cellérier the first two types of knowledge are functionally subordinate to the third. Both early cybernetic models of self-organizing adaptive systems (Cellérier, 1968) and modern architectures of autonomous agents (Canamero, 2001; Orlando, Canamero, & te Boekhorst, 2003; Tyrell, 1993) agree that for a system to be adaptive, it should perform at least five tasks:

1. Sense the internal and external environment (including its own actions), interpret, and store the sensory input (perception, information processing, and memory).
2. Use the perceptual inputs and memory to decide which of its repertoire of actions is most appropriate (action selection and arbitration, decision making).
3. Regulate the internal resources for execution of action (in humans: neuroendocrine, somatic, and autonomic adjustments).
4. Transform the chosen action into patterns of overt behavior including (if necessary) communicative actions.
5. Evaluate the outcome (perception, information processing, and memory).

The unified model proposed here suggests that the control parameters that steer the execution of the five tasks are: valence, activation, and potency. Figure 3-1 is a schematic representation of the affective space defined by these three dimensions. Why valence, arousal, and potency are proposed as the control parameters is explained below.

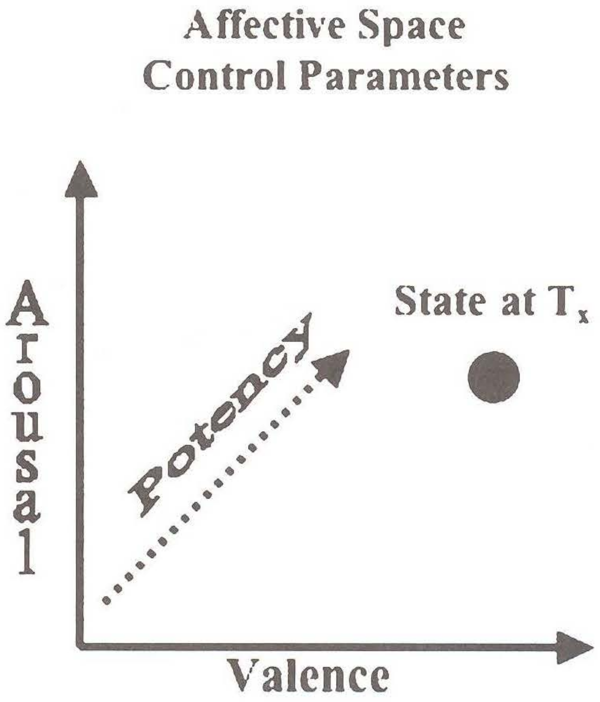


**Figure 3–1.** Schematic illustration of the dimensions of affective space with a the state of the organism marked as a point at t1 reflecting a possible configuration of valence, arousal, and potency values.

### Valence as Control Parameter

We consider the attribution of valence as inherent to tasks 1, 2, and 5, in which the subject assimilates internal and/or external stimuli into the already existing knowledge structures (perceptual, sensorimotor, and conceptual schemata). In the framework of these tasks, each knowledge structure is attributed a value related to the actual or potential hedonic valence of the stimulus and its beneficial or detrimental character. The value thus assigned can be conceived of as a *tag*[1] representing the subjective hedonic meaning attributed to the activated schemata (Piaget, 1954). Valence tagging is considered to be inherent to the subject's adaptive behavior, which aims at maintaining or achieving positively valenced states and/or avoiding negatively valenced states. The target states can concern any or all of the three dimensions of self, namely *intrapersonal self* (personal interests, including own body), *interpersonal self* (relational and social interests) (Hobson, 1993; Trevarthen, 1993), and *transpersonal self* (meta-cognitions, religious pursuits, or more global trans-societal interests).

Affective neuroscience research suggests that primitive motivational subsystems based in subcortical neural structures subserve the attribution of valence by providing an evaluative outcome necessary to initiate an approach or withdrawal response (Davidson, 1992a; 1992b) (Lane et al., 1997; Lang, 1995). The function of valence tags would thus be to regulate approach-avoidance behaviors (Cacioppo, Klein, Bentson, & Hatfield, 1993). The attribution of valence is considered to occur unconsciously and automatically. The degree of valence can also be influenced by the contextual factors such as outcome expectancy and uncertainty (Mandler, 1997). It then follows

[1]Ohman (1999) uses the term *tagging* to denote the mainly unconscious process of assigning emotional meaning.

that the pleasure in relief would be different from that in satisfying an unhindered concern, because the former takes into account the past from which one has escaped, whereas the latter does not (Lambie & Marcel, 2002).

## Potency as Control Parameter

Attribution of the *potency tag* is inherent to task 2 of an adaptive system, which involves: action selection and arbitration, decision making, and an appraisal of the subject's coping potential. The latter aspect refers to the estimated relative coping power, that is, the relation between available resources and the resources needed to cope with the situation. The subject's coping potential can be strongly influenced by stimulus ambiguity or restricted response action availability. The decision making and action selection can also be influenced by errors in the judgment of the likelihood of future outcomes and simplified heuristics that people use to cope with the complexity of decision making (Tversky & Kahneman, 1981).

While the potency dimension is seen as a scalar, one can conceptualize it in terms of three broad categories, each related to a type of behavioral response:

1. Very low potency with no decisional power and no choice prior to execution such as instinctive reactions, vital emergency responses, or phobias (Lang, 1990).
2. Medium level of potency with partial decisional power and a limited choice of alternatives (e.g., imitation, "forced choice," or pseudo-choice situations).
3. High level of potency with full decisional power.

Decision taking implies choice. From the cybernetic point of view, it is only if the machine has the possibility of reacting in different ways (Bertalanffy's equifinality principle, (1968) that its behavior can be regulatory (Ashby, 1961). Many scholars have emphasized the importance of choice and decisional power. For example, Dewey pointed out that deliberation takes place in ideas, not in overt behavior, and that it requires a rehearsal of alternative possible courses of action (Dewey, 1922 ), while Damasio suggested that eating and avoiding falling objects belong to the "animal spirit" while deciding is typically "human spirit" (Damasio, 1994). Prieto offers an original and powerful theoretical explanation of how decision taking and choice are related to the construction of the self as an *acting subject* (Prieto, 1975). He argues that in an instrumental act, the subject's body is the initiator of the action that the tool will exert upon a material object in order to transform it. The object's transformation is then seen as a "natural" result of the tool's action. Now the tool's action is also a natural result of the subject's action applied on it. At the end of such backward chaining of cause-effect relationships, one comes to the subject's action itself that does not have a natural cause. It is the feeling that one can be a cause without being an effect that generates the sense of agency and allows one to acquire self-identity. To quote Gallagher, "This is the feeling of identity, of being the perspectival origin of one's own experience, which is a basic component of the experienced differentiation of self from non-self" (Gallagher, 2005, p. 201).

It then follows that if the subject's action is imposed by an outside agency, he or she can only *react* and not *behave*.

Consistent with this view, Prieto defines *behavior* as the act of engaging in praxis by one's own decision in a situation of choice. He also adds that the transformations of material reality due to man's praxis constitute the historic aspect of the reality, which is not a natural and possibly predictable consequence of the preceding state (Prieto, 1991).

## Activation as Control Parameter

Activation tag is inherent to tasks 3 and 4 of the cybernetic model. It denotes the afferent-feedback-based *on-line* percept of internal body tone as well as an estimate of the required task-relevant activation of resources. The *on-line* percept can be defined as a cognitive composite of feedback information from cardiovascular targets, gut, lungs, muscles, and electrocortical arousal and is conceptually close to Damasio's "somatic marker hypothesis" (Damasio, 1994). The *activation tag* thus carries the information about the amount of energy mobilization involved in autonomic, motor, physiological, and computational ongoing changes as well as those estimated as required to handle the stimulus and/or its consequences. In the latter case, it can be seen as schema activation before becoming overt energy engagement. Piaget considers bodily energy management to be an affective dimension of behavior involving the attribution of a *yield value* (*"valeur de rendement"*) which takes into account the actual or required investment of energy (Piaget, 1954). To the extent that activation mechanisms are *goal driven*, the behavior will tend to be oriented towards correcting disturbances in homeostatic variables of the internal milieu, rectifying undesirable external situations, and guiding the subject's actions towards his or her goals.

In summary, adaptive action involves the construction and usage of implicit and explicit knowledge of the environment, of the internal milieu, of one's own actions, and of the self as acting subject. We consider valence, arousal, and potency as the elementary parameters that control adaptive interaction with the environment. There is reason to believe that valence is primary in that it recruits and drives responses including the appraisal of potency and activation (Watt, 2001). From the neurological viewpoint, hemispheric specialization for valence is considered to represent the phylogenetic development of primitive networks that provide an evaluative outcome necessary to initiate an approach or withdrawal response (Davisdon, 1992a; 1992b; Lane et al., 1997). The interaction between control parameters produces complex schemata (perceptual-sensorimotor-conceptual) that tend to be assimilated into each other and serve as instruments for both adaptive action and further construction of knowledge.

## Emotions as Specific Configurations of the Control Space

Inspired by the insightful works of Elisabeth Duffy (1941) in the physiology of behavior and more recent work on neurological aspects of emotions (Chapman & Nakamura, 2001), we suggest the following conceptual framework for distinguishing between emotional and nonemotional responses.

A relentless change in the configuration of the control parameter values assures a dynamic equilibrium of the system. As long as these variations are within a limited range, the equilibration processes are largely unconscious and the state of the organism is perceived as *normal*. If however, the amplitude and/or the speed of change of control-parameter values falls outside their normal range of variation, such a state becomes cognitively dominant. It is then likely to penetrate consciousness, be felt as *unusual,* and conceptualized as emotional. From the neurological point of view LeDoux explains that (at least in the domain of fear) this transformation of cognition into emotion—this hostile takeover of consciousness—occurs when the amygdala comes to dominate working memory (LeDoux, 2002). Sander and colleagues convincingly demonstrated the amygdala's pivotal role as a general relevance detector (Sander, Grafman, & Zalla, 2003), which in our view determines the focus and the content of the working memory that influences and modulates executive functions.

In summary, we suggest that when any or all of the control-parameter values falls outside a *normal* range of variation, such a configuration becomes cognitively dominant and lends itself to be subjectively known as a motivational or emotional state (see Figure 3-2).

The detection of deviations in control parameters is rooted in the fundamental physiological principle of *set-point* detection. As Douglas Watt writes:

> When internal physiological states are outside a desirable range, both visceral sensations and action dispositions (thirst and pursuit of fluids) are activated. But phenomenal states of rage, separation distress, fear must have similar mechanisms, that these are "not OK" departures from ideal organismic baselines, activating defensive responses, while play and affection, sexual stimuli etc., must encode or activate the opposite, setting in motion basic appetitive mechanisms. These are central and not peripheral aspects of affect. Events that

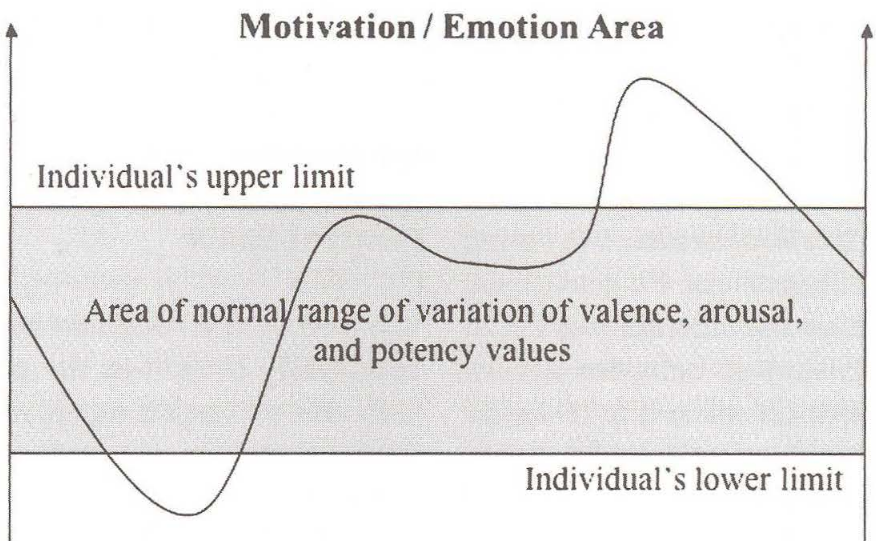


**Figure 3–2.** Schematic illustration of the position of motivation/emotion areas as zones situated ouside a *normal* range of control-parameter variations.

> modify this crucial valence aspect alter the whole experiential picture, and not just pieces or fragments of affect. (Watt, 2001, p. 306).

The deviation from a set-point is implicit in Russel's two-dimensional model of emotion, where the center of the circumplex represents a neutral point on both bipolar dimensions, and "each emotion label can be thought of as a vector originating from the center of the circle with its length representing intensity (extremity or saturation)" (Russel, 1989, p. 87). The deviation principle is also conceptually close to Mandler's discrepancy detection mechanism (Mandler, 1997). Once triggered, an emotional response can then involve a resetting of procedural priorities and the regulation of the speed of task execution (which can be set to zero, as in the a case of a freeze-reaction). As evidenced by Watson and Tellegen (1999), avoidance gradients have steeper slopes than approach gradients.

It goes without saying that the sensitivity thresholds and ceiling values will vary from one person to the other depending on genetic, physiological, contextual, and social factors. Drawing on Van Geert's dynamic systems model of developmental mechanisms (Van Geert, 1998), we assume a weight update function to be applied each time the system has gone through an action/experience sequence. Such a mechanism would allow valence, potency, and activation tags to be updated. Stable reaction schemata, which include prototypical situational features with prototypical values for valence, activation, and potency, acquire a weight that can then give access precedence over less automatic schemata. In dynamic systems terminology, this behavioral mode is in *attractor state.*

Attractors may have varying degrees of stability and instability. Some attractor states are so stable that they appear inevitable. The concept of attractor states may correspond to what are usually referred to as *discrete emotions*; that is, when systems self-organize, they settle into a few modes of behavior that the system prefers over all the possible modes. Interestingly, Plutchik's theory of emotion assumes that a small number of types of adaptive behaviors are the prototypes that form the basis for emotions. The latter are then defined as behavioral adaptations that have been successful in increasing the chances of survival (Plutchik, 1962; 1980; Plutchik & Kellerman, 1986).

The effects of increase or decrease in control parameter *readouts* could be conveniently studied within the framework of nonlinear dynamic systems theory. Molenaar and Oppenheimer (Molenaar & Oppenheimer, 1985) have shown that models based on nonlinear dynamic systems theory transcend the dichotomy between the organismic and mechanistic paradigms.

The *catastrophe theory* models (Thom, 1974) are of particular interest as they consider discontinuities in behavioral variables as a function of continuous variation in the control variables. The original goal of catastrophe theory was the classification of all possible discontinuities in a series of elementary catastrophes. The *cusp* model is one of the elementary catastrophes that has been used in many fields. Applications have been made in social sciences (Zeeman, 1976), in perception research (Stewart & Peregoy, 1983), in phonetics (Noblitt, 1978), and more recently in appraisal processes of emotions (Scherer, 2000).

To conclude, the proposed *unified model of cognition, emotion,* and *action* suggests that in the context of adaptive interaction with environment, cognition steers the organism's response by assigning values to the activated perceptual-sensorimotor-conceptual schemata in terms of valence, potency, and activation. It then follows that such complex schemata necessarily include affective aspects. In addition, the activated schemata tend to be assimilated into each other and form new complex cognitive structures subserving both perception and action. An interesting example of a unitary action of complex schemata can be seen in the fact that the processing of information is facilitated if actions and thoughts are congruent—positively valenced thoughts with approach behavior and negatively valenced thoughts with avoidance behavior (Bargh, 1997; Förster & Strack 1997).

## Representation of Affect and Language

Piaget's theory of knowledge posits that knowledge is constructed by means of assimilation of the object of cognition into the subject's own schemata (perceptual, sensorimotor, and conceptual), which are also continuously enriched and accommodated to new situations. Assimilation itself involves *thematization*—a process whereby different components of the object are selected, categorized, often translated into semiotic entities (e.g., words), and placed into a relational network of concepts. As pointed out by Karmiloff-Smith, the development of knowledge proceeds through a process called "representational re-description" (Karmiloff-Smith, 1992). This is consistent with the view that the way language is used to describe emotions modifies what one knows about emotions and how they are experienced consciously. Drawing on Piaget's theory of knowledge, Richard Lane's model of emotional consciousness links the different levels of consciousness to the levels of the complexity of representational schemata (Lane, 2001). A key assumption in the author's work on emotional awareness is that "language promotes the development of schemata for the processing of emotional information, whether that information comes from the internal or external world" (Lane & Zei Pollermann, 2002, p. 280). The verbal expression of emotional experiences can be considered as a process which elevates the procedural dimension of emotion onto a representational level, allowing for more flexible and more powerful handling of emotional contents. The shifting of sensorimotor contents onto a representational level requires conceptualization, which is facilitated by the use of language as a semiotic system that translates concepts into communicable entities.

Linguistic signs seem to facilitate the representational redescription of activated schemata through the mechanisms of thematization and generalization. Hans Kurath's work on the semantic sources of the words for emotions in Sanskrit, Greek, Latin, and the Germanic languages exemplifies how various components of complex perceptual-sensorimotor schemata are thematized and linguistically encoded (Kurath, 1921). Interestingly, one could draw a parallel between Kurath's classification of names of feelings and emotions and the foci of various emotion theories. Kurath reports the following semantic fields related to the words expressing emotions: (a) parts of the body and organs not subject to conscious control (the heart, the organs of respiration, the viscera, liver, spleen, gall), (b) physiological displays of vigor or weakness, gestures related to approach and avoidance behaviors, excitement and inhibition movements, (c) sense perceptions with kinesthetic and tactile perceptions having stronger affective tone than those of hearing and especially those of sight, (d) vocal gestures—inarticulate sounds, wailing, and grumbling. By this work Kurath provided evidence for a firmly established principle of semantics, that all the more complex processes (including both body and mind) are named according to their simpler and more tangible components (Wundt & Schaub, 1921). This also illustrates the observer-dependent character of our knowledge about emotions. The history of physics provides examples of how the same material phenomenon can be conceptualized in different ways. For instance, electromagnetic phenomena can be conceptualized either as waves or as particles (photons). The physicist knows that such different "realities" result from the differences in the measuring methods applied to the same material reality.

By analogy, Piaget suggests that the subject's perceptual-sensorimotor-conceptual schemata be conceived of as the measuring instruments that determine the nature of the object of cognition—be it external-world-object or self.

## Vocal Indicators of the Speaker's Cognitive-Affective States and Processes

Speech communication, just as any other interactive behavior, necessarily reflects the configuration of the speaker's affective space at two levels: (a) the underlying configuration extending over a longer period of time (moods, stable attitudes, and personality traits) and (b) each moment's *on-line* configuration (emotions, interpersonal stances, and communication strategies).

In natural settings the on-line configuration is influenced by ever-changing discursive context including the speaker's and the receiver's own nonverbal reactions, the discourse content, and the conversational interaction pattern itself. Vocal variations are manifest on three levels: suprasegmental (e.g., intonations, accentuation, speaking rate), segmental (e.g., format precision), and intrasegmental (voice quality).

Now, what is the cognitive mechanism involved in the attribution of emotional meaning to vocal variations? Piaget's concept of assimilation offers a model whereby vocal information is directly mapped onto the observer's analogous complex perceptual-sensorimotor-conceptual schemata elaborated in his previous experiences (with their respective valence, activation, and potency tags). This is also in agreement with Gallese and colleagues' findings that the fundamental mechanism, at the basis of the experiential understanding of others' emotions, involves activation of the corresponding viscero-motor centers in the observer (Gallese et al., 2004). Indeed, a great deal of emotion research is successfully done by exposing the subjects to emotion-inducing stimuli (visual, auditory, and imagery) in the laboratory (as an example, see Faith & Thayer, 2001). Given the fact that the subjects are aware of the artificiality of the situation, it appears that the induction of emotions is made possible in such conditions precisely because the stimuli are assimilated into the subject's cognitive-affective schemata.

Studying the manifestations of affect in speech communication poses the question of the semiological status of vocal signaling of affect, which in turn raises the issue of expression vs. communication of affect whereby *expression* has the status of an automatic external manifestation of an inner state (Darwin, 1872), while *communication* implies intentional signaling (Prieto, 1975).

To address these questions let us consider the three basic types of semiotic entities involved in the mechanism of indication:

1. *Spontaneous indicators* (Prieto, 1975) are semiotic entities where the link between the signifier and the signified is naturally given. It is said to be *motivated* because the link reflects relations such as spatial or temporal contiguity, causality, implication, or *pars pro toto* relationship, e.g., footprints in snow or temperature as a symptom of illness. In other words, spontaneous indicators have an informative value without having been produced to this purpose (Piaget, 1967).
2. *Falsely spontaneous indicators* (Buyssens, 1943; Prieto, 1975) are those that are purposely produced in order to appear as natural or spontaneous, e.g., a foreign accent produced by a speaker wanting to appear as a foreigner.
3. *Intentional indicators* are semiotic entities that are produced in order to provide information other than their own existence. These include:
   a. *Symbols*, where an originally natural link between the signifier and the signified has been conventionalized for purposes of communication, e.g., a picture of a snake symbolizing a pharmacy. In the course of history, a symbol may lose its previously motivated nature.
   b. *Icons*, where the link between the signifier and the signified is motivated by topological similarity between the two (Sebeok, 1985), e.g., maps, images, diagrams.
   c. *Signs*, where the relationship between the signifier and the signified is unmotivated and conventionalized for purposes of communication, e.g., words of a language (Saussure, 1972).

We believe that the semiological status of vocal affect signaling can be that of a spontaneous indicator (a symptom), a falsely spontaneous indicator, or a symbol, but never a sign as defined above. The nonarbitrary nature of vocal indicators of affect is supported by cross-cultural studies showing that the subjects can quite accurately infer emotional states from acoustic cues produced in other cultures and languages (Clynes & Nettheim, 1982; Juslin & Laukka, 2003). Parallelisms in animal affect signaling are of interest here as well. Scherer's model of vocal-affect signaling provides precise predictions for phonetic and macroprosodic changes related to the outcome of each of the stages of the cognitive appraisal steering emotional processes (Scherer, 1986). It then follows that emotionally induced phonetic and prosodic variations primarily have a status of spontaneous indicators or symptoms of physiological reactions. They reflect the so called *push* force in affect signaling (Scherer, Helfrish, & Scherer, 1980). In the case of intense *primary emotions* (anger, fear, joy, sadness, and disgust), the push effects may be dominant and the speaker may have little freedom in influencing his vocal expression. A special case could be made for highly distressful situations where vocal characteristics are intentionally modified for purposes of better transmission over a distance and as cues for the sender's localization. In addition to the *push* force, speech communication is influenced by the norms or expectations imposed by the physical or social environment, which require production of specific acoustic features allowing the sender to achieve a particular effect. Such a *pull* force may restrict or enhance some of the surface features of the *push* effects (Scherer, Helfrish, & Scherer, 1980).

It then follows that, when *push* and *pull* factors are blended, vocal signals have a twofold status of symptoms and symbols. When *pull* effects dominate, vocal signals may have a status of falsely spontaneous indicators or symbols. An example would be the use of highly pitched voices in signaling submission and appeasement in friendly or submissive encounters.

The semiological status of affect signaling can thus vary from a symptom to a conventionalized or ritualized symbol. This also raises the issue of speaking *styles*. Is any speaking pattern a style? We link the answer to this question to the potency dimension of cognitive-affective states and suggest that a speaking pattern will be a style as long as it is a result of the speaker's choice. Vocal choice may thus be a psychologically important factor related to the speaker's identity.

In Table 3–1, we present the control-parameter features for five types of cognitive-affective states with the corresponding semiotic status of their vocal correlates. The five states correspond closely to Scherer's descriptions of major types of affect (Scherer, 2005).

**Table 3–1.** Predictions for control-parameter configurations for five types of cognitive-affective states and the semiotic status of their vocal correlates. *Open* = unpredicted

| Type of cognitive-affective state | Position of control-parameter values | Rapidity of change of control-parameter values | Stability over time | Semiological status of vocal patterns |
|---|---|---|---|---|
| Emotions | Outside normal range | Very high | Low | Symptom |
| Moods | Within normal range or close to critical limits | Medium | Low to Medium | Mainly symptom |
| Attitudes | Within normal range | Low to medium | Medium to high | Symptom and/or symbol |
| Interpersonal stances | Within normal range | Medium to high | Short to medium | Mainly symbol |
| Personality | Within normal range | Open | Very high | Symptom |

As the interpretation of the speech signal is probabilistic, we believe that affectively marked speech patterns function as parallel codes that provide contextual information, thus helping the receiver to disambiguate the meaning of the utterance (see Chapter 15).

## Vocal Manifestations of Cognitive-Affective States and Processes

Within the framework of the unified model, vocal manifestations of cognitive affective states and processes can be studied in their continuity from the states traditionally regarded as purely cognitive (doubt, certainty) and unemotional, to emotionally *colored* interpersonal stances (friendly), up to full-fledged emotional reactions. While vocal correlates of discrete emotions have been amply studied in the past two decades, those of other affectively colored states have received less attention. Exceptions are relatively recent studies in assessing the emotional tone in spontaneous dialogues (Cowie, Douglas-Cowie, & Romano, 1999), those related to the acoustic indicators of attitudes (Wichmann, 2002), and various cognitive-affective dimensions (Kehrein, 2002). Both Wichmann's and Kehrein's work emphasize the importance of social and linguistic context for the interpretation of vocally encoded cognitive-affective states. In addition to the classical vocal parameters related to $F_0$, Nì Chasaide and Gobl (2002) found the association between voice quality and the perceived *affective coloring* of speech. Eric Keller's study (2003) provided evidence for vocal changes related to attitude and thematic coloration of speech. Research on vocal indicators of emotional dimensions has shown that listeners can consistently rate vocal expressions of emotions on the scales of activation, valence, and potency and that each dimension is correlated with a number of vocal parameters (Laukka et al., 2005).

## Vocal Correlates of Interpersonal Stance in Medical Interviews

Zei Pollermann conducted a pilot study of vocal correlates of interpersonal stance in pre-anesthesia medical interviews. Interpersonal stance is defined as an affective stance taken toward another person in a specific interaction, coloring the interpersonal exchange in that situation as for example: distant, cold, warm, supportive, reassuring, calming, or contemptuous. As the pre-anesthesia medical interview has a well-defined structure (Wolff & Scemama-Clergue 2002), it allowed setting clear hypotheses about the type of affective stance appropriate for each of the two main phases of the interview. The aim of the first phase is to obtain anamnestic information and examine the patient, while the aim of the second phase is to decide on the type of anesthesia, to inform the patient about the risks without creating anxiety, and to obtain the patient's consent. It was hypothesized that the interpersonal stance appropriate for the examination phase could be described as encouraging, while that appropriate for the announcement of risks would be reassuring and calming. Our predictions regarding vocal correlates of such affective stances took into account discursive operations of topicalization, focalization, and comment. These operations use prosodic marking to attribute various degrees of informative salience to different topics (Caelen-Haumont, 1991) and signal the speaker's emotive involvement in the conversation (Selting, 1994).

### *Hypotheses*

It was hypothesized that vocal signaling of an encouraging affective stance would follow the prosodic patterns congruent with higher informative salience, higher than neutral levels of positively valenced arousal, and a medium level of potency. By contrast a reassuring and calming affective stance would be characterized by prosodic patterns congruent with low informative salience, low level of arousal, neutral or slightly negatively valenced state, and a medium level of potency. We thus expected the acoustic configurations of the physicians' voices at the time of examining their patients (*exam-voices*) to be different from those at the time of informing them about anesthetic risks (*risk-voices*). Drawing on our previous work regarding acoustic patterns of affect (Scherer & Zei, 1988; Zei Pollermann & Archinard, 2002) and more recent studies (Juslin & Laukka 2003 ; ), we expected the *exam-voices* to display higher values on $F_0$ parameters, close to neutral or low levels of mean vocal intensity and its range (the doctor being physically close to the patient), and a slower speaking rate. By contrast, the *risk-voices* (reflecting a reassuring affective stance) were expected to be characterized by lower values on $F_0$ parameters, unchanged levels of energy parameters, and a faster pace.

### *Subjects and Design*

Twenty-six patients expected to undergo minor surgical operations were interviewed by six physicians (comprising 19 male-to-male dyads and 7 female-to-female dyads)[2]. The interviews were recorded in a noise-free room, on a professional CD recorder with head fitted microphones allowing mouth-to-microphone distance to be kept constant. Prior to the interview, the patients gave their written consent. The duration of the interview varied from 20 to 30 minutes. The physicians' voices were analyzed by using Praat (Boersma & Weenink, 1996). A classical set of vocal parameters was extracted: mean $F_0$, $F_0$ coefficient of variation, $F_0$ range, $F_0$ mean absolute slope, mean energy of voiced speech segments, voiced energy range, and the rate of delivery (expressed as the number of syllables uttered per second). The obtained values were normalized by dividing each value by that obtained from the acoustic analysis of the physicians' neutral speech samples recorded outside the hospital environment.

Three external judges assessed the interviews by using the Relational Communication Scale for Observational measurement (RCS-O) (Gallagher, Hartung, & Gregory, 2001), which measured six dimensions of doctor-patient interactions: affection, similarity/depth, receptivity/trust, composure, formality, and dominance.

### *Statistical Analyses*

Paired Samples t-Test was applied to measure the difference between the vocal

[2]The authors thank the physicians of Anesthesiology Department of Geneva University Hospitals and specifically Dr. Alain Forster for their active involvement in this study.

parameters obtained in *exam-voices* vs. *risk-voices*. Table 3-2 presents the t-Test results and basic statistics for the normalized values of vocal parameters.

As shown in Table 3-2, the results confirm most of our predictions regarding the configuration of vocal parameters related to the change of affective stance from *encouraging* (in the examination phase) to *calming reassuring* (in the risk-announcing phase) of the interview. The *exam-voices* displayed higher mean $F_0$, more pitch variability, and a slower pace compared with *risk-voices*. The vocal pattern of the *risk-voices* could be described as *vocal minimization* and is congruent with the aim of informing the patient about the risks without making him or her anxious. The faster rate of delivery in the risk-announcing phase of the interview could also be interpreted as a cue that augments the speaker's credibility (Miller et al 1976).

Pearson correlation coefficients were computed between various dimensions of the RCS-O scale and the vocal parameters. The conversation partners' gender, age and age difference were controlled for when necessary. The results presented in Table 3-3, show that in both conditions *Affection* was negatively correlated with mean $F_0$, while it was positively correlated with voiced energy range. The *Similarity/depth* dimension was also related to the same parameters. On the *Trust/receptivity* dimension, the exam voices differed from those of *risk-voices* in that the former were correlated with the rate of delivery ($r = .39; p = .05$) and $F_0$ coefficient of variation ($r = -.38; p = .05$). No such correlations were found in *risk-voices* for this dimension. In the *exam-voices* the *Composure* dimension was negatively correlated with mean $F_0$ ($r = -.74; p = .000$), and mean absolute slope ($r = -.40; p = .05$), while it was positively related to the speaker's pace ($r = .57; p = .000$). In the *risk-voices* the *Composure* dimension was negatively correlated with mean $F_0$ ($r = -.65; p = .000$) while it showed a positive correlation with the voiced energy range ($r = .43; p = .04$). The *Dominance* dimension was found to be significantly related to $F_0$ coefficient of variation in *risk-voices* only.

**Table 3–2.** Paired Samples t-Test results for risk-voices vs. exam-voices, with basic statistics for the normalised values of vocal parameters.

| | Exam-voices | | Risk-voices | | Paired Samples t-Test | | |
|---|---|---|---|---|---|---|---|
| **Vocal parameter** | **Mean** | **SD** | **Mean** | **SD** | **DF** | **T** | **Sig. (2-tailed)** |
| Mean $F_0$ | 1.24 | 0.17 | 1.12 | 0.16 | 25 | 6.47 | 0.000 |
| $F_0$ coef. of variation | 0.15 | 0.04 | 0.12 | 0.03 | 25 | 3.33 | 0.003 |
| $F_0$ range | 2.48 | 0.59 | 2.24 | 0.53 | 25 | 1.73 | 0.095 |
| $F_0$ mean absolute slope | 1.16 | 0.22 | 1.07 | 0.21 | 25 | 2.40 | 0.024 |
| Rate of delivery | 0.87 | 0.12 | 0.98 | 0.12 | 25 | -3.95 | 0.001 |
| Mean voiced energy | 1.06 | 0.93 | 1.08 | 0.11 | 25 | -1.62 | 0.118 |
| Voiced energy range | 1.38 | 0.10 | 1.40 | 0.10 | 25 | -1.10 | 0.283 |

**Table 3–3.** Pearson correlation coefficients with 2-tailed significance levels for the correlations between vocal parameters and five dimensions of the Relational Communication Scale for Observational measurement. Only the parameters significant for at least one dimension are noted for each condition.

| | Vocal parameter | Affection | | Similarity | | Trust | | Composure | | Dominance | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | r | Sig. | r | Sig. | r | Sig. | r | Sig. | r | Sig. |
| Whole Interview | Mean $F_0$ | –.68 | .00 | –.67 | .00 | –.74 | .00 | –.73 | .00 | | ns |
| Whole Interview | $F_0$ coef. of variation | | ns | –.45 | .02 | | ns | –.38 | .05 | | ns |
| Whole Interview | $F_0$ mean abs. slope | | ns | | ns | –.40 | .05 | | ns | | ns |
| Whole Interview | Rate of delivery | | ns | | ns | .57 | .00 | .39 | .05 | | ns |
| Whole Interview | Voiced energy range | .44 | .03 | .43 | .04 | | ns | | ns | | ns |
| Risk-voices | Mean $F_0$ | –.61 | .00 | –.55 | .00 | –.58 | .00 | –.65 | .00 | | ns |
| Risk-voices | $F_0$ coef. of variation | | ns | | ns | | ns | | ns | .43 | .04 |
| Risk-voices | Voiced energy range | .63 | .00 | .48 | .02 | | ns | .43 | .04 | | ns |
| Exam-voices | Mean $F_0$ | –.66 | .00 | –.63 | .01 | –.65 | .00 | –.72 | .00 | | ns |
| Exam-voices | $F_0$ coef. of variation | | ns | –.44 | .03 | –.44 | .03 | –.45 | .03 | .43 | .04 |
| Exam-voices | $F_0$ mean abs. slope | | ns | | ns | | ns | | ns | .41 | .04 |
| Exam-voices | Rate of delivery | | ns | | ns | | ns | .40 | .05 | | ns |
| Exam-voices | Voiced energy range | .61 | .00 | .52 | .01 | | ns | | ns | | ns |

In summary, most of statistically significant correlations with the RCS-O scale are related to $F_0$ parameters. The results seem to confirm most of our hypotheses regarding the difference between vocal correlates of an encouraging affective stance and a reassuring and calming one. The two types of stances appear to follow the prosodic patterns congruent with the presumed configurations of the speakers' affective-cognitive states (the *push* force), and the interaction context (the *pull* force).

## Final Remarks

The proposed unified model of cognition, emotion, and action suggests that cognitive processes that trigger and steer adaptive behavior necessarily evolve in a three-dimensional affective space—the dimensions being valence, arousal, and potency. As a result, the subject's perceptual-sensorimotor-conceptual schemata activated for purposes of goal driven action always include affective components. States and processes called *emotions, moods, attitudes, interpersonal stances,* or *personality traits* are then observer dependent conceptualizations of transitory and/or long-term configurations of the person's affective space. Seen from such a perspective, human voice necessarily reflects the ever-changing configurations of the speaker's affective space. The model needs further elaboration in terms of theoretical sophistication and empirical examination of (a) the interactions between the three control parameters, (b) retroactive influence of consciousness and learning on valence, activation, and potency tagging, and (c) the relations between intrapersonal, interpersonal, and transpersonal dimensions of self as major sources of competing interests at stake in adaptive behavior.

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