

# Vocal Indicators of Coping Style in Patients with Breast Cancer: A Pilot Study

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## Abstract

Coping styles are thought to be largely determined by the patient's emotional reactions to illness. Assessing such reactions is usually done via self-report questionnaires or by semistructured interviews evaluating the patients' mental adjustment to the disease (adaptive vs. maladaptive). As an alternative, more direct approach, a pilot study was conducted to assess the patients' coping styles as reflected in their oral communication. Voices of 10 breast cancer patients speaking spontaneously were analyzed acoustically. Their coping reactions were previously rated as adaptive versus maladaptive. Four samples of each patient's speech were acoustically analyzed and an index of vocally expressed emotional arousal was calculated for each voice sample. For three samples, the vocal arousal index (VAI) was consistently higher in cases with active/adaptive as opposed to passive/maladaptive coping style. In addition, a vocal differential index (VDI) representing the difference between the VAI of the highest and that of the lowest vocal arousal condition was calculated. With one exception, cases with adaptive coping style (median VDI = 53.8) had



higher VDI scores than those with passive/maladaptive coping (median VDI = 21.3). In conclusion, the results show a strong tendency for the vocal arousal to be associated with the patients' coping style.

### Theoretical Framework for Measuring Vocal Indicators of Coping Styles

The patient's way of coping with illness is of major importance for both psychosocial (e.g., well-being) and biomedical (e.g., compliance with treatment) aspects of the disease. Obrist (1981) described *passive coping* as a state of enduring a stressor without expending effort to act upon it, while *active coping* was defined as tonic readiness to act upon an event. This corresponds to the action readiness dimension of Cannon's emergency response (Cannon, 1929). Generally speaking, active coping styles are thought to be more appropriate for dealing with stressful events, while avoidant coping appears to be a psychological risk factor from a long-term perspective (Holahan & Moos, 1987).

An important determinant of coping reactions is the *feeling* of potency or control over the illness. The feeling of control, or lack of control, can induce cognitive-affective states of hopefulness or hopelessness (Ortony, Clore, & Collins, 1988, p. 132) and thus significantly influence the patients' coping reactions, which include both somatic and autonomic reactions. The latter can be induced by anticipated activity (Obrist, Webb, Sutterer, & Howard, 1970).  $\beta$ -adrenergic sympathetic effects on the heart have

been found to predominate during active rather than passive coping, particularly when environmental uncertainty and behavioral uncertainty are high (Bongard, 1995; Brener, 1987; Kelsey, 1991; Kelsey et al., 1999; Light & Obrist, 1980; Sherwood, Allen, Obrist, & Langer, 1986). Obrist (1981) also provided evidence regarding the role of parasympathetic physiological reactions in subjects with passive coping style.

As voice and speech production mechanisms (respiration, phonation, and articulation) are strongly influenced by the subjects' autonomic reactions, studying the patients' vocal expression appeared to be a more direct method of assessing the emotional factors associated with coping styles.

### What Is Measured: The Voice of Full-Blown Emotions or the Voice of Affective Dimensions?

Research on vocal indicators of affective states has been dominated by designs based on the relations between acoustic features and semantic tasks of emotion labeling. Psychologists and speech scientists rely on the subjects' intuitive labeling of the states called "emotions," often in forced choice recognition tasks (Cowie & Douglas-Cowie, 1996; Kienast & Sendlmeier, 2000; Mozziconacci & Hermes, 1999; Pereira, 2000; Schröder, 2001; Yuan,



Shen, & Chen, 2002). This kind of research can be “contaminated” inherently as the word *emotion* is semantically treacherous, because its meaning shifts according to context. This point has often been made by scholars such as Mandler (1981; 1990; 1992), Ortony and Turner (1990), and Russell & Barrett (1999). As recently pointed out by Roddy Cowie, the word *emotion* has only too often been taken “to refer to entities—natural units that have distinct boundaries, and that can be counted” (Cowie & Cornelius, 2003).

In addition to the ambiguities inherent to intuitive categorizations of emotions, states of arousal often overlap with emotions proper. Research has studied various states involving arousal such as excitement, agitation, lethargy, or stress. The latter has become a subtopic in its own right (Murray, Baber, & South, 1996). Yet, it is not clear whether the arousal associated with what is commonly known as “stress” can be distinguished from the arousal associated with an emotional state such as fear or happiness.

Other conceptions of emotions are based on broad elementary affective dimensions. The latter approach dates back to Wilhelm Wundt (1874/1905). Subsequently, Osgood, Suci, and Tannenbaum’s theory (1957) as well as other authors (Davitz, 1964; Mehrabian & Russell, 1974) suggested that affective reactions could be described in terms of two or three major bipolar dimensions (Bachorowski, 1999; Bachorowski & Owren, 1995; Davidson, 2000; Laukka, Juslin, & Bresin, 2005; Russell & Barrett, 1999), such as:

1. valence (displeasure—pleasure), i.e., how positively or negatively the situation is appraised,

2. arousal (sleepy—hyperactivated), i.e., the degree of physiological activation, and
3. potency/control (powerful—powerless), i.e., the degree of power or sense of control over the situation (Argyle & Crossland, 1987; Fecteau, Armony, Joannette, & Belin, 2005; Mehrabian & Russell, 1974; Osgood, May, & Miron, 1975).

In such an approach, emotion categories emerge as specific configurations in a two- or three-dimensional space. Intercultural research in emotion recognition from voice has shown that confusions are often made between emotions sharing the same degree of arousal (van Bezooijen, Otto, & Heenan, 1983). This led critics to suggest that judges’ ability to infer emotion from the voice might be limited to basing inference systematically on perceived arousal (Pittam & Scherer, 1993; Scherer, 1979; 1986). It thus appears that vocal indicators of affective states are more closely tied with basic emotional dimensions than with an emotion *per se*. In Schröder’s study of vocal outbursts (2000), an analysis of confusions among inferred emotions suggests two main dimensions: valence and arousal/activation. A vocal signature for a specific emotion thus remains elusive and the activation dimension often seems to dominate (Pittam, Gallois, & Callan, 1990). Activation dimension is of particular interest as it is related to the preparation for instrumental action (Frijda & Tcherkassof, 1997). In Frijda’s model of emotion, action readiness (or action tendency) plays a central role. As we considered the “feeling” of potency as one of cognitive prerequisites for action readiness, our approach to studying emotional factors associated with coping



styles was based on dimensional theories of affect (e.g., Lang, Greenwald, Bradley, & Hamm, 1993; Russell, 1980).

### Vocal Indicators of Coping Style

While coping styles are usually assessed via self-report scales (Carver, 1997; Carver, Scheier, & Weintraub, 1989), we tried to use a more direct way of measuring, that is, via the acoustic indicators of emotional dimensions associated with the patients' coping style. Our focus was on vocal indicators of the potency and arousal dimensions of emotions. Based on evidence about the link between the coping style and autonomic reactions (Waldstein, Bachen, & Manuck, 1997), we then investigated their relation to voice production mechanisms. The impact of the autonomic component of emotional arousal on voice was first modeled by Williams and Stevens (1972) in terms of direct causal relationships between high (dominantly sympathetic) or low (dominantly parasympathetic) arousal states on the one hand, and voice intensity, vocal cord vibration, and timing of speech on the other.

We hypothesized that the degree of vocal expressiveness would be higher in subjects using active/adaptive coping style than in those with passive/maladaptive style. This hypothesis was rooted in the chain of links:

1. the cognitive state of confidence in one's own control (the potency dimension of emotion) of the situation induces
2. a certain degree of cortical and physiological arousal (both autonomic and somatic), which influence
3. the three systems involved in speech production: respiration, phonation,

and articulation (Scherer & Zei, 1988), which in turn influence the

4. vocal characteristics of the person's verbal expression.

### Design of the Pilot Study

#### Study Sample

This study included a sample of 10 patients with operable breast cancer who were randomized within 6 weeks after primary surgery into different adjuvant therapy trials conducted by the International Breast Cancer Study Group (IBCSG). The data reported here were collected within two psychosocial substudies. The patients came from three main language areas of Switzerland (Swiss German, Italian, and French) and were interviewed in their primary language. Their ages ranged between 34 and 68 years. All patients were informed about the studies and agreed to participate.

#### Interview Rating

The patients were interviewed in the hospital about 2 to 3 months after randomization. At that time, patients had to cope with their disease, surgery sequelae, and side effects of adjuvant therapy (Hürny et al., 1996). The interview was semistructured and it was adapted from an interview evaluating mental adjustment in patients with early breast cancer (Morris, Blake, & Buckley, 1985). It covered disease- and treatment-related topics ranging from the discovery of the node in the breast to the thoughts regarding the patient's future. The interviews lasted 40 to 60 minutes, and were conducted by trained interviewers.



The audio-taped interviews were "blindly" rated by two female psychologists with experience in caring for breast cancer patients. The rating consisted of predefined categories in a binary response format (e.g., hopefulness versus hopelessness) as listed in Table 14-1.

These categories were applied to all topics. At the end, the raters estimated the overall mental adjustment as "adaptive" or "maladaptive" based on the ratings of each of the five criteria (Table 14-1). The raters were trained on other cases and reached a moderate agreement on the overall mental adjustment with kappa = 0.47 (N = 32). The test-retest agreement within each rater over several months was kappa = 0.55 and 1, respectively. For this pilot study, we selected five cases with adaptive and five cases with maladaptive adjustment on which the two raters had complete agreement.

### Voice Analyses

In experimental settings, voice analyses are typically done by computing the deviation of emotional speech patterns

from a neutral or a baseline reference level (Schröder, Cowie, Douglas-Cowie, Westerdijk, & Gielen, (2001); Amir & Ron, 1998; Simonov, Frolov, & Ivanov, 1980). As we measured vocal expression in a natural setting, the baseline level was not available. We therefore established for each subject her own range of vocal reactions by screening the interview for a passage of perceptually high vocal and one of perceptually low vocal arousal. The semantic content of the verbal passages was not predefined, although it was more likely to find low vocal arousal in "footnote-type" of statements or descriptions of sad events. Vocal characteristics of these passages were used to outline the range of vocal reactions for each subject.

The final parts of the interview, where patients talked about coping with illness and about their future prospects, were excluded from the screening for perceptually high vs. low vocal arousal. We assumed that these parts would be closely related to the potency dimension of the patient's emotional reactions and to her mental adjustment. These passages were analyzed separately for their degree of vocal arousal. The duration of

**Table 14-1.** Rating criteria for adaptive versus maladaptive mental adjustment\*

Tendencies toward	
Adaptive adjustment	Maladaptive adjustment
1. Hopefulness	Hopelessness
2. Active attitude toward disease and treatment	Passive attitude toward disease and treatment
3. Flexible coping style toward different problems of disease and treatment	Rigid coping style toward different problems of disease and treatment
4. Perceived good social support	No perceived social support
5. Conscious dealing with the malignancy and its implications	No conscious dealing with the malignancy and its implications

\*Global summary rating based on ratings of each of the five criteria.



each voice sample varied between 30 and 60 seconds.

The screening and the analysis of vocal parameters were performed by two voice analysts independently. Neither had information on the results of the clinical ratings or on the patient characteristics.

Three categories of vocal parameters were measured:

1. fundamental frequency (mean  $F_0$ ,  $F_0$  range,  $F_0$  sd);
2. acoustic energy expressed in pseudodecibel units computed from the raw signal (mean and voiced energy range);
3. speed of delivery expressed as the number of syllables uttered per second.

The acoustic variables were normalized by external reference values obtained from emotionally neutral speech samples Zei (1999). Each vocal parameter was thus expressed as a percentage of the respective reference value. All the acoustical analyses were done by means of Signalyze (Keller, 1994), a Macintosh platform software.

## Data Transformations

### Vocal Arousal Index (VAI)

Because of the trading relationships between vocal intensity, fundamental frequency, and timing (Lieberman, 1960), a *vocal arousal*<sup>1</sup> index (VAI) was created. It was computed as the averaged sum of normalized values of the parameters significantly related to vocal differentiation

between low-arousal and high-arousal emotions (mean  $F_0$ ,  $F_0$ max/min ratio,  $F_0$  coefficient of variation, voiced energy range, rate of delivery) (Zei & Archinard, 2002). The *vocal arousal* index thus reflected an overall degree of vocally expressed emotional arousal. The VAI was calculated for each condition.

### Vocal Differential Index

VAI was expected to be higher in samples of high emotional arousal compared with those of low emotional arousal. To measure such differentiation, we computed a vocal differential index (VDI), which represented the difference between the VAI of the perceptually highest and that of the perceptually lowest arousal condition. Our assumption was that vocal differential index would reflect the width of what we termed the subject's *emotional space*.

### The Concept of Emotional Space

Based on evidence from research in normal vocal expression (Kaiser & Scherer, 1998) and that of affective disturbances (Porges, Doussard-Roosevelt, & Maiti, 1994), we hypothesized that high vs. low level of vocal variation could be related to high vs. low level of affective involvement. Andreasen and colleagues (Andreasen, Alpert, & Martz, 1981) demonstrated that affective flattening was reflected in speech in a diminished variance in both amplitude and fundamental frequency. Similar findings (Zei & Archinard, 2001) support the link between affective flat-

<sup>1</sup>By analogy to the concept of emotional arousal, the term *vocal arousal* is used to signify the amount of vocal activation resulting from emotional arousal.



tening and poor vocal expressiveness. We thus expected a narrow emotional space (low VDI) to be related to passive coping, that is, maladaptive mental adjustment, and a wide emotional space (high VDI) to be related to active coping, or adaptive mental adjustment.

### Statistical Analysis

The exact Wilcoxon test was used to compare the VDI in the cases rated as adaptive with the VDI in the cases rated as maladaptive (two-sided test; StatXact, version 4). To check for consistency, the association between mental adjustment, vocal parameters, and the VAI was explored separately for each condition and illustrated by confidence intervals of the medians (Hodges & Lehmann, 1963).

### Results

As shown in Figure 14-1, the (VAI) was consistently higher in cases with adaptive than in those with maladaptive adjustment. This was found for the following conditions: high arousal (90% CI of median = 108.3-129.6 vs. 91.6-119.4), topics of coping (90% CI of median = 85.6-129.6 vs. 84.5-104.9), and the topic of future (90% CI of median = 93.8-110.1 vs. 80.0-111.6). In four cases (Table 14-2: A, C, E, F), the perceptually high arousal condition was identical to that in the topics of *coping* or *future*.

The associations between the pitch parameters and mental adjustment were mostly consistent. Of particular interest is a bigger difference in pitch range between high and low arousal conditions

Vocal Arousal by Condition and Type of Adjustment

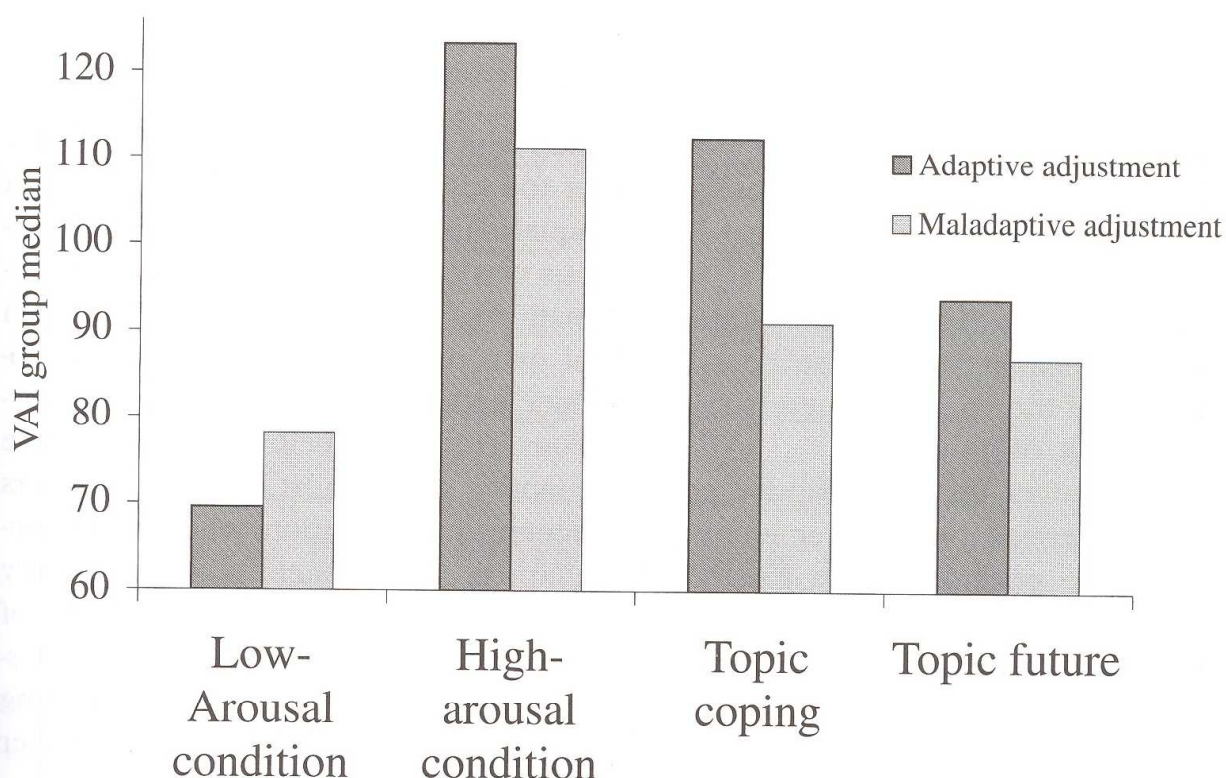


Figure 14-1. Median values of vocal arousal index per type of topic.

**Table 14-2.** Differential index according to adaptive versus maladaptive mental adjustment

Cases	Vocal differential index	Mean (SD)	Wilcoxon rank-sum test <i>P</i>
Adaptive mental adjustment			
A	64.5	49.7 (11.7)	0.095 (0.05)*
B	54.3		
C	53.8		
D	40.0		
E	35.7		
Maladaptive mental adjustment			
F	58.5 (42.6)*	28.5 (17.7)	
G	28.6		
H	24.3		
I	16.1		
K	15.2		

\*Value obtained after correcting subsequent to unblinding the data.

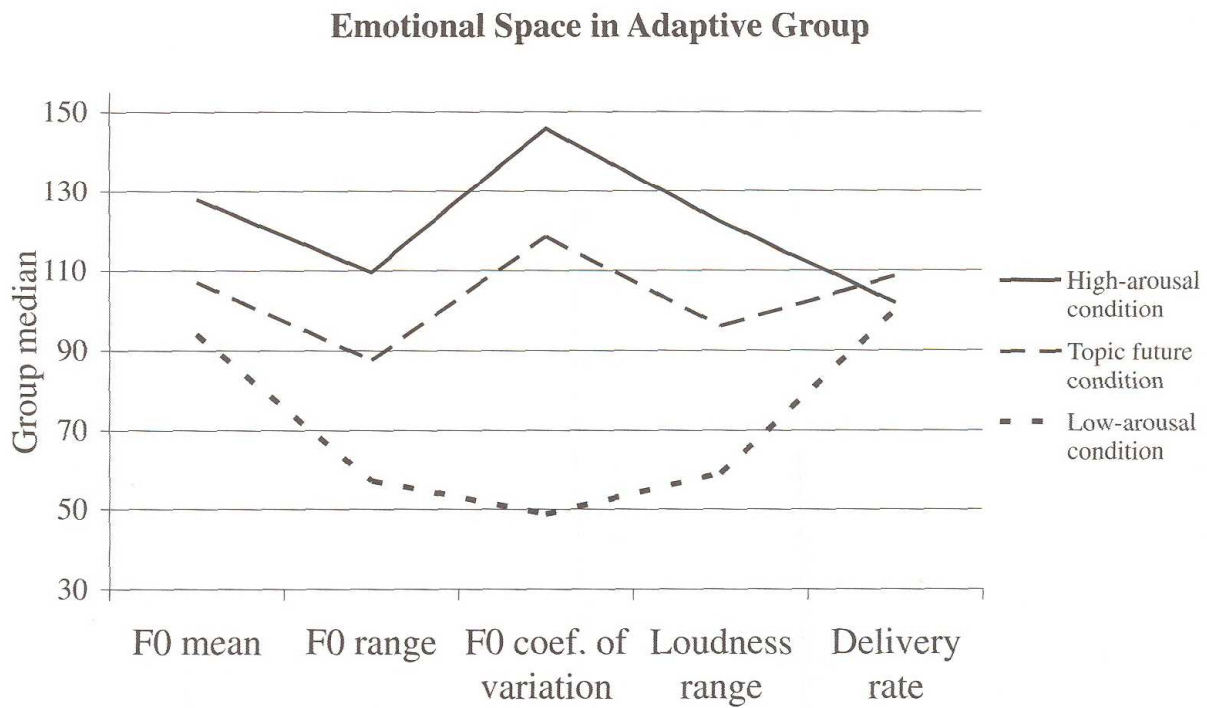
in cases with adaptive (median = 55.2, 90% CI = 46.0-60.4) versus those with maladaptive adjustment (median = 35.2, 90% CI = 8.0-42.4).

Figures 14-2(a) and 14-2(b) illustrate the differences in emotional space and the position of the vocal parameters related to the topic of future.

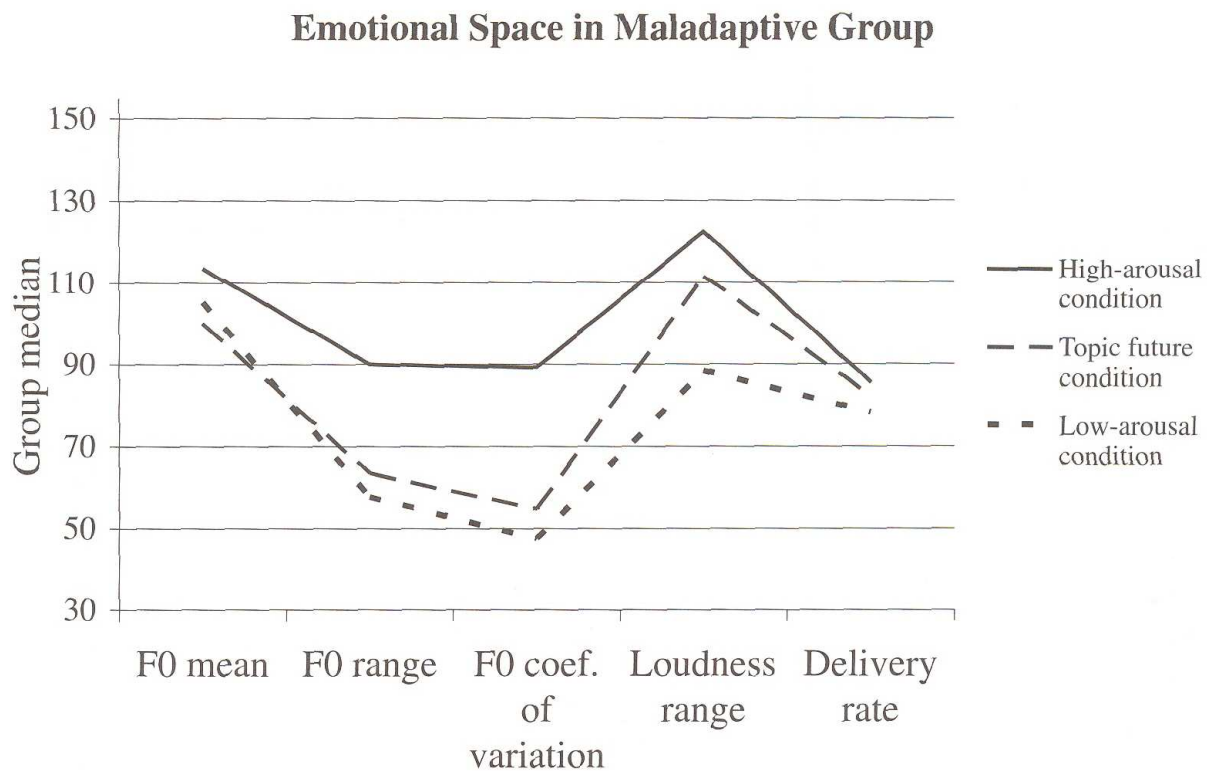
One notices that the adaptive group is characterized by a wider emotional space. The position of the parameters related to the topic of future was considered as indicative of mental adjustment. It was hypothesized that a mid-position (reflecting a medium level of vocal arousal for this topic) would be associ-

ated with adaptive coping, while too low or too high arousal levels would reflect a maladaptive coping style. This hypothesis was conceptually linked to overestimation of threat and/or underestimation of own resources—states liable to produce underaroused or overaroused reactions. The graphs below show that in the adaptive group most of the parameters occupy a mid-position, while in the non-adaptive group their position is very close to either low or high limits of the *emotional space*. Figure 14-3 illustrates the group differences regarding the values for each vocal parameter across all topics.





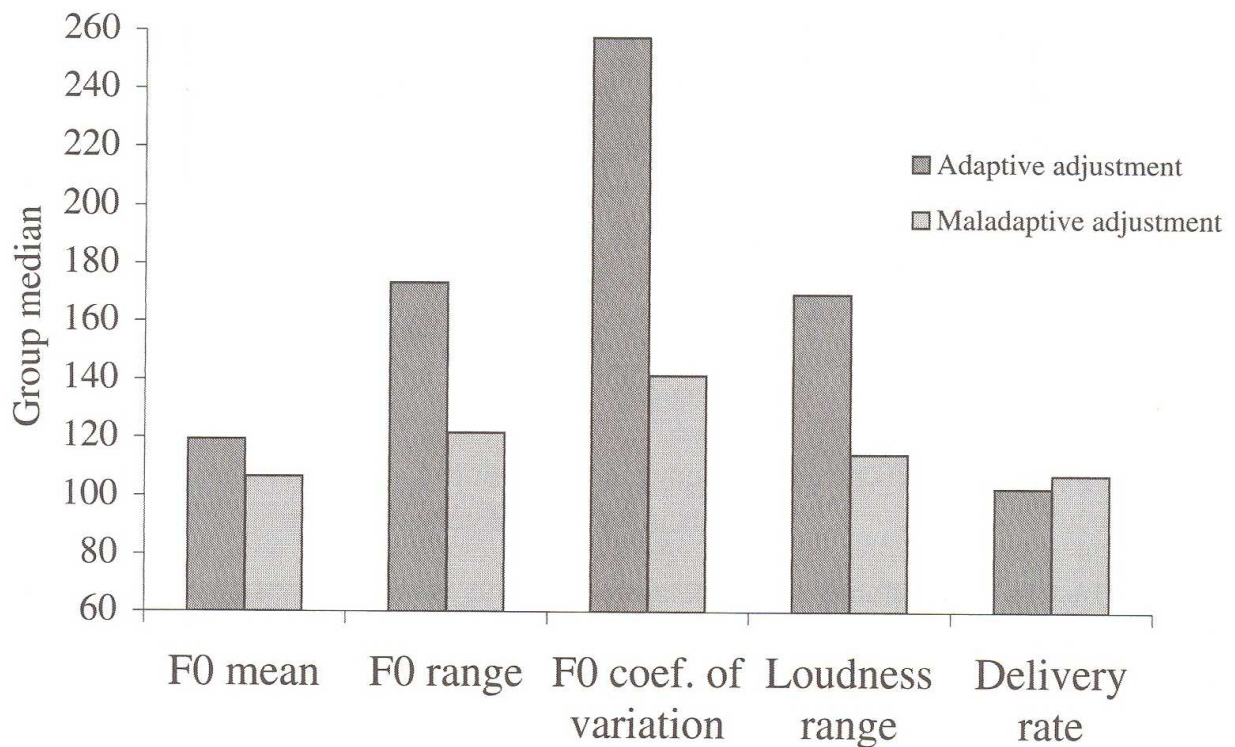
**Figure 14-2(a).** Emotional space delimited by the values related to low and high arousal conditions and the position of those related to the topic *future* for the group of adaptive cases.



**Figure 14-2(b).** Emotional space delimited by the values related to low and high arousal conditions and the position of those related to the topic *future* for the group of maladaptive cases.



### Vocal Parameters by Type of Adjustment



**Figure 14-3.** Vocal parameters pooled across all topics and displayed by condition (adaptive and maladaptive).

The ranking of the differential index scores is shown in Table 14-2. As expected, the cases whose mental adjustment was rated as adaptive had a higher score (median VDI = 53.8) than those with maladaptive adjustment (median VDI = 24.3;  $p = .09$ ). The only exception was case F whose VDI was high. After unblinding the ratings of adjustment, this case was reinvestigated. We found an incorrect notification of the low arousal passage. A revised analysis resulted in a considerably lower differential index score for this case (VDI = 42.6) and significant result on the Wilcoxon test ( $p < .05$ ).

### Discussion

In this pilot study we investigated mental adjustment via vocal indicators of

emotional reactions. We hypothesized that patients rated as having an adaptive mental adjustment would display active emotional involvement in their communicative behavior, which in turn would be reflected in a wider VDI. The vocal differential index represented a cumulative mean score of differences between the values of five vocal parameters (mean  $F_0$ ,  $F_0$  max/min,  $F_0$  coefficient of variation, voiced energy range, rate of delivery) measured in the low arousal condition and those found in the high arousal condition. Prior to the creation of the VDI, each value was normalized by its respective external (emotionally neutral) reference value and expressed on a percentage scale. In our model, the VDI represented the subject's individual *emotional space*. A high VDI score was expected to reflect a wide *emotional space* with adaptive mental adjustment.



We hypothesized that a narrow space would be related to maladaptive mental adjustment.

We found that adaptive versus maladaptive adjustment to breast cancer as rated by clinicians was associated with both *vocal arousal* index and vocal differential index in the expected direction. We used dichotomous categories of adjustment to reduce variability and reach a sufficient agreement between the raters. Thus, the resulting judgment did not provide a grading as it is to be expected clinically. The vocal indices scores showed a plausible pattern, suggesting that this measure may reflect such grading.

The VDI as related to the *emotional space* is a concept with links to theories on emotions, mental adjustment, and mind-body interaction. Adaptive adjustment and the corresponding action are usually linked to higher and more dynamic emotional involvement and consequently to higher *vocal arousal* in speech communication. In patients with advanced breast cancer, self-reported emotional expression was associated with better adjustment (Classen, Koopman, Angell, & Spiegel, 1996). Indirect support for our hypothesis is given by two consistent findings in various chronic diseases. Patients with a generalized high appraisal of threat and those with a response of helplessness or hopelessness are particularly vulnerable, as shown for cancer patients in a longitudinal design (Parle, Jones, & Maguire, 1996). Both an overestimation of threat and an underestimation of own resources are characterized by generalizing the focus of concern and consequently by a poor differentiation between low and high arousal topics.

In our data, this differentiation was particularly reflected in pitch range. The substantially greater difference in this parameter between low and high arousal

condition in cases with adaptive adjustment may be taken as an indication of "normal" emotional functioning (Zei & Archinard, 1998; Scherer & Zei, (1988).

Individuals characterized by active coping and internal locus of control usually exhibit higher cardiovascular arousal as compared to those with passive coping (Chevrie-Muller, Dodart, Seguir-Dermier, & Salomon, 1978), thus creating the conditions for sympathetically driven *vocal arousal*. In subjects with passive coping, Obrist (1981) provided evidence of cardiovascular reactions resulting from parasympathetic vagal activity. Scherer (1985) proposed a model relating sympathetic and parasympathetic autonomic reactions to mental adjustment potential and in turn to well-defined vocal characteristics.

We developed the vocal differential index as an indicator of mental adjustment in general and not for specific disorders such as depression for which vocal parameters have been established (Hargreaves, Starkweather, & Blacker, 1965; Helfrich, Standke, & Scherer, 1984; Scherer, 1979; 1987; 1989; Siegman & Boyle, 1993). This concept of a broad "bandwidth" is similar to that of the distress thermometer as proposed for the care of cancer patients (Holland, 2000; Roth et al., 1998). Capturing this vocal information may be a method to identify patients with poor adjustment, for example in monitoring psychiatric morbidity induced by experimental drugs or burdensome situations (e.g., bone marrow transplantation).

We used interviews taped for clinical ratings and not for voice analysis. The quality and standardization of the recordings were suboptimal. Our method is distinct from self- and observer-reported measures. In clinical settings, vocal information may be less influenced by interfering factors such as social desirability.



In a standardized setup a high reliability and responsiveness could be assumed. Given these features, the differential index may be an alternative measure of emotional functioning for studying mind-body interactions, for example with the immune or endocrine systems. Finally, in teaching clinicians on how to recognize psychological distress, nonverbal cues usually do not receive the attention deserved. Our method may be used to sensitize clinicians for the immense richness of vocal information.

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## References

- Amir, N. & Ron, S. (1998): Towards an automatic classification of emotions in speech. Paper No 0199 presented at *ICSLP-98 (International Conference on Spoken Language Processing)*, November 30–December 4, Sidney, Australia
- Andreasen, N. C., Alpert, M., & Martz, M. J. (1981). Acoustic analysis. *Archives of General Psychiatry*, 38, 281–285.
- Argyle, M., & Crossland, J. (1987). The dimensions of positive emotions. *Journal of Social Psychology*, 26(Pt. 2), 127–137.
- Bachorowski, J. A. (1999). Vocal expression and perception of emotion. *Current Directions in Psychological Science*, 8(2), 53–57.
- Bachorowski, J. A., & Owren, M. J. (1995). Vocal expression of emotion: Acoustic properties of speech are associated with emotional intensity and context. *Psychological Science*, 6(4), 219–224.
- Bongard, S. (1995). Mental effort during active and passive coping: A dual-task analysis. *Psychophysiology*, 32, 242–248.
- Brener, J. (1987). Behavioural energetics: Some effects of uncertainty on the mobilization and distribution of energy. *Psychophysiology*, 24, 499–512.
- Cannon, W. B. (1929). *Bodily changes in pain, hunger, fear and rage*. New York: Appleton.
- Carver, C. S. (1997). You want to measure coping but your protocol's too long: Consider the Brief COPE. *International Journal of Behavioral Medicine*, 4(1), 92–100.
- Carver, C. S., Scheier, M. F., & Weintraub, J. K. (1989). Assessing coping strategies: A theoretically based approach. *Journal of Personality and Social Psychology*, 56(2), 267–283.
- Chevrie-Muller, C., Dodart, F., Seguir-Dermier, N., & Salomon, D. (1978). Étude des paramètres acoustiques de la parole au cours de la schizophrénie de l'adolescent. *Folia Phoniatrica*, 23, 401–428.
- Classen, C., Koopman, C., Angell, K., & Spiegel, D. (1996). Coping styles associated with psychological adjustment to advanced breast cancer. *Health Psychology*, 15, 434–437.
- Cowie, R., & Cornelius, R. R. (2003). Describing the emotional states that are expressed in speech. Special issue on speech and emotion [Special issue]. *Speech Communication*, 40(1–2), 5–32.
- Cowie, R., & Douglas-Cowie, E. (1996, October). *Automatic statistical analysis of the signal and prosodic signs of emotion in speech*. Paper presented at the International Conference on Spoken Language Processing, Philadelphia.
- Davidson, R. J. (2000). Affective style, psychopathology, and resilience: Brain mech-



- anisms and plasticity. *American Psychologist*, 55, 1196-1214.
- Davitz, J. R. (1964). Auditory correlates of vocal expression of emotional feeling. In J. R. Davitz (Ed.), *The communication of emotional meaning* (pp. 101-112). New York: McGraw-Hill.
- Fecteau, S., Armony, J. L., Joanette, Y., & Belin, P. (2005). Judgment of emotional nonlinguistic vocalizations: Age-related difference. *Applied Neuropsychology*, 12(1), 40-48.
- Frijda, N., & Tcherkassof, A. (1997). Facial expressions as modes of action readiness. In J. Russell & J. M. Fernandez-Dols (Eds.), *The psychology of facial expression* (pp. 78-102). Cambridge, UK: Cambridge University Press.
- Hargreaves, W. A., Starkweather, J. A., & Blacker, K. H. (1965). Voice quality in depression. *Journal of Abnormal Psychology*, 70, 218-220.
- Helfrich, H. R., Standke, R., & Scherer, K. R. (1984). Vocal indicators of psychoactive drug effects. *Speech Communication*, 3, 245-252.
- Hodges, J. L., & Lehman, E. L. (1963). Estimates of location based on rank tests. *The Annals of Mathematical Statistics*, 34, 598-611.
- Holahan, C. J., & Moos, R. H. (1987). Risk, resistance, and psychological distress: A longitudinal analysis with adults and children. *Journal of Abnormal Psychology*, 96, 3-13.
- Holland, J. (2000). Psychosocial distress in the patient with cancer. Standards of care and treatment guidelines. *Oncology*, 15, 19-24.
- Hürny, C., Bernhard, J., Coates, A. S., Castiglione Gertsch, M., Peterson, H. F., Gelber, R. D., et al. (1996). Impact of adjuvant therapy on quality of life in women with node-positive operable breast cancer. International Breast Cancer Study Group. *Lancet*, 347, 1279-1284.
- Kaiser, S., & Scherer, K. (1998). Models of "normal" emotions applied to facial and vocal expressions in clinical disorders. In W. F. J. Flack & J. D. Laird (Eds.), *Emotions in psychopathology* (pp. 81-98). New York: Oxford University Press.
- Keller, E. (1994). *Signal analysis for speech and sound*. Lausanne, Switzerland: Info Signal.
- Kelsey, R. M. (1991). Electrodermal lability and myocardial reactivity to stress. *Psychophysiology*, 28(6), 619-631.
- Kelsey, R. M., Blascovich, J., Tomaka, J., Leitten, C. L., Schneider, T. R., & Wiens, S. (1999). Cardiovascular reactivity and adaptation to recurrent psychological stress: Effects of prior task exposure. *Psychophysiology*, 36(6), 818-831.
- Kienast, M., & Sendlmeier, W. F. (2000). Acoustical analysis of spectral and temporal changes in emotional speech. In R. Cowie, E. Douglas-Cowie, & M. Schröder (Eds.), *Proceedings of the ISCA workshop on speech and emotion* (pp. 92-98) [CD-ROM]. Belfast, Ireland: International Speech Communication Association.
- Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, 30, 261-273.
- Laukka, P., Juslin, P. N., & Bresin, R. (2005). A dimensional approach to vocal expression of emotion. *Cognition and Emotion*, 19(5), 633-653.
- Lieberman, P. (1960). Some acoustic correlates of word stress in American English. *Journal of the Acoustical Society of America*, 32, 451-454.
- Light, K. C., & Obrist, P. A. (1980). Cardiovascular response to stress: Effects of opportunity to avoid, shock experience, and performance feedback. *Psychophysiology*, 17(3), 243-252.
- Mandler, G. (1981, August). *Affect, emotion, and other cognitive curiosities*. Paper presented at the Third Annual Meeting of the Cognitive Science Society, Berkeley, CA.
- Mandler, G. (1990). A constructivist theory of emotion. In N. S. Stein, B. L. Leventhal, & T. Trabasso (Eds.), *Psychological and biological approaches to emotion* (pp. 21-43). Hillsdale, NJ: Lawrence Erlbaum Associates.



- Mandler, G. (1992). Cognition and emotion: Extensions and clinical applications. In D. J. Stein & J. E. Young (Eds.), *Cognitive science and clinical disorders* (pp. 61-78). San Diego, CA: Academic Press.
- Mehrabian, A., & Russel, J. (1974). *An approach to environmental psychology*. Cambridge, MA: MIT Press.
- Morris, T., Blake, S., & Buckley, M. (1985). Development of a method for rating cognitive responses to a diagnosis of cancer. *Social Science & Medicine*, 20, 795-802.
- Mozziconacci, S. J. L., & Hermes, D. J. (1999, August). *Role of intonation patterns in conveying emotion in speech*. Paper presented at the ICPhS 99, San Francisco.
- Murray, I., Baber, C., & South, A. (1996). Towards a definition and working model of stress and its effects on speech. *Speech Communication*, 20, 1-12.
- Obrist, P. A. (1981). *Cardiovascular psychophysiology: A perspective*. New York: Plenum.
- Obrist, P. A., Webb, R. A., Sutterer, J. R., & Howard, J. L. (1970). The cardiac somatic relationship: Some reformulations. *Psychophysiology*, 6, 569-587.
- Ortony, A., Clore, G. L., & Collins, A. (1988). *The cognitive structure of emotions*. New York: Cambridge University Press.
- Ortony, A., & Turner, T. J. (1990). What's basic about basic emotions? *Psychological Review*, 97, 315-331.
- Osgood, C. H., May, W. H., & Miron, M. S. (1975). *Cross-cultural universals of affective meaning*. Urbana: University of Illinois Press.
- Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957). *The measurement of meaning*. Urbana: University of Illinois Press.
- Parle, M., Jones, B., & Maguire, P. (1996). Maladaptive coping and affective disorders among cancer patients. *Psychological Medicine* 26, 735-744.
- Pereira, C. (2000). Dimensions of emotional meaning in speech. In *Proceedings of the ISCA workshop on Speech and Emotion*, September 5-7 (pp. 25-28). Newcastle, Northern Ireland.
- Pittam, J., Gallois, C., & Callan, V. (1990). The long-term spectrum and perceived emotion. *Speech Communication*, 9, 177-187.
- Pittam, J., & Scherer, K. R. (1993). Vocal expression and communication of emotion. In M. Lewis & J. M. Haviland (Eds.), *Handbook of emotions* (pp. 185-197). New York: Guilford.
- Porges, S. W., Doussard-Roosevelt, J. A., & Maiti, A. K. (1994). Vagal tone and the physiological regulation of emotion. *Monographs of the Society for Research in Child Development*, 59, 167-186.
- Roth, A. J., Kornblith, A. B., Batel, Copel, L., Peabody, E., Scher, H. I., et al. (1998). Rapid screening for psychologic distress in men with prostate carcinoma: A pilot study. *Cancer*, 82, 1904-1908.
- Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, 39, 1161-1178.
- Russell, J. A., & Barrett, L. F. (1999). Core affect, prototypical emotional episodes, and other things called emotion: Dissecting the elephant. *Journal of Personality and Social Psychology*, 76, 805-819.
- Scherer, K. R. (1979). Nonlinguistic vocal indicators of emotion and psychopathology. In C. E. Izard (Ed.), *Emotions in personality and psychopathology* (pp. 495-529). New York: Plenum Press.
- Scherer, K. R. (1985). Vocal affect signaling: A comparative approach. In J. S. Rosenblatt, C. Beer, M. C. Busnel, & P. J. B. Slater (Eds.), *Advances in the study of behavior* (Vol. 15, pp. 189-244). New York: Academic Press.
- Scherer, K. R. (1986). Vocal affect expression: A review and a model for future research. *Psychological Bulletin*, 99(2), 143-165.
- Scherer, K. R. (1987). Vocal assessment of affective disorder. In J. D. Maser (Ed.), *Depression and expressive behaviour* (pp. 57-83). Hillsdale NJ: Erlbaum.
- Scherer, K. R. (1989). Vocal correlates of emotional arousal and affective disturbance. In H. Wagner & A. Manstead (Eds.), *Handbook of social psychophysiology* (pp. 165-197). New York: Wiley.



- Scherer, K. R., & Zei, B. (1988). Vocal indicators of affective disorders. *Psychotherapy and Psychosomatics*, 49, 179-186.
- Schröder, M. (2000). Experimental study of affect bursts. In R. Cowie, E. Douglas-Cowie, & M. Schröder (Eds.), *Proceedings of the ISCA workshop on speech and emotion* (pp. 132-135) [CD-ROM]. Belfast, Ireland: International Speech Communication Association.
- Schröder, M., Cowie, R., Douglas-Cowie, E., Westerdijk, M. & Gielen, S. (2001). Acoustic correlates of emotion dimensions in view of speech synthesis. *Proceedings of Eurospeech 2001*, September 3-7 (Vol. 1, pp. 87-90). Aalborg, Denmark: International Speech Communication Association.
- Sherwood, A., Allen, M. T., Obrist, P. A., & Langer, A. W. (1986). Evaluation of beta-adrenergic influences on cardiovascular and metabolic adjustments to physical and psychological stress. *Psychophysiology*, 23(1), 89-104.
- Siegmán, A. W., & Boyle, S. (1993). Voices of fear and anxiety and sadness and depression: The effects of speech rate and loudness on fear and anxiety and sadness and depression. *Journal of Abnormal Psychology*, 102, 430-437.
- Simonov, P. V., Frolov, M. V., & Ivanov, E. A. (1980). Psychophysiological monitoring of operator's emotional stress in aviation and astronautics. *Aviation, Space, and Environmental Medicine*, 51, 46-49.
- van Bezooijen, R., Otto, S. A., & Heenan, T. A. (1983). Recognition of vocal expressions of emotion: A three-nation study to identify universal characteristics. *Journal of Cross-Cultural Psychology*, 14, 387-406.
- Waldstein, S. R., Bachen, E. A., & Manuck, S. B. (1997). Active coping and cardiovascular reactivity: A multiplicity of influences. *Psychosomatic Medicine*, 59(6), 620-625.
- Williams, C. E., & Stevens, K. N. (1972). Emotions and speech: Some acoustical correlates. *Journal of the Acoustical Society of America*, 52, 1238-1250.
- Wundt, W. (1905). *Grundzüge der physiologischen psychologie* [Fundamentals of physiological psychology, originally published 1874] (5th ed.). Leipzig, Germany: Engelmann.
- Yuan, J., L. Shen, & F. Chen (2002). The acoustic realization of anger, fear, joy and sadness in Chinese. *Proceedings of ICSLP* (pp. 2025-2028). Denver, CO.
- Zei, B., & M. Archinard (1998). La variabilité du rythme cardiaque et la différenciation prosodique des émotions, Actes des XXIèmes Journées d'Etudes sur la Parole. Martigny-Switzerland, IDIAP, 167-170.
- Zei, B. (1999, April). *Acoustic patterns of emotions*. Paper presented at COST 258 (European Cooperation in the field of Scientific and Technical Research) Meeting on Improving the naturalness of synthetic speech, Morges, Switzerland.
- Zei, B., & M. Archinard (2001). The role of autonomic balance in experiencing emotions. In A. Kaszniak (Ed.), *Emotions, qualia, and consciousness* (pp. 278-284). Singapore: World Scientific.
- Zei, B., & Archinard, M. (2002). Acoustic patterns of emotions. In E. Keller, G. Bailly, A. Monaghan, J. Terken & M. Huckvale (Eds.), *Improvements in speech synthesis* (pp. 237-245). Chichester: Wiley.