The Journal of Teaching Language Skills (JTLS)
3(2), Summer 2011, Ser. 63/4
(Previously *Journal of Social Sciences & Humanities)*

An Acoustic Study of Emotivity-Prosody Interface in Persian Speech Using the Tilt Model

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Abstract

This paper aims to explore some acoustic properties (i.e. duration and pitch amplitude of speech) associated with three different emotions: anger, sadness and joy against neutrality as a reference point, all being intentionally expressed by six Persian speakers. The primary purpose of this study is to find out if there is any correspondence between the given emotions and prosody patterning in Persian. Such a study considers articulation and perception in the context of spoken communication. For this purpose, the Tilt Model (Taylor 1998, 2000 and 2009) is used to describe the detailed acoustic knowledge of how an utterance is modulated when a Persian speaker's emotion deviates from neutral to certain emotional and attitudinal states. The results of our statistical analysis indicate that there exists a rather strict acoustic correlation between sadness and neutrality on the one hand, and between anger and joy, on the other. The noticeable acoustic feature which changes as a function of emotion is pitch amplitude, while duration is involved to a lesser degree.

Keywords: emotion, acoustic properties, prosodic patterning, attitudinal states, tilt model, spectral parameters

Received: 01/04/2011 Accepted: 05/15/2011
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1. Introduction

At the outset, it would be well to point out what communication is about. To quote Lyons (1995:97): "Communication is not merely an exchange of words. Linguistic, paralinguistic and non-verbal communication elements such as co-speech gestures and non-speech sounds are part of the communication and all convey meaning." Moreover, in a natural communication situation, emotional arousal is a quite complex phenomenon. In this respect, acoustic parameters of speech and prosodic cues such as variation in pitch, intensity, speech rate, duration of vowel and rhythm may be manipulated —exaggerated, diminished, sped up, slowed down— to convey emotions and attitudes. As Laver (1995) said:

> prosodic features are available to speaker and listener in order to encode and decode the full emotional speech. Prosodic cues can also provide paralinguistic information such as the speaker's view, emotion and attitude toward the dialogue partner and the situation. Indeed, all the information contained in speech contributes to the interpretation of the message.

The issue as to which acoustic parameters contribute much more in conveying emotion is a hotly debated topic in several disciplines. However, a more specific study of emotional speech, especially speech technology, seems to enhance the interdisciplinary aspect of this kind of study. This can be considered as a meeting point of diverse disciplines such as linguistics, psychology, phonetics, neuro- psychology and acoustics.

What this paper sets out to explore are prosodic variations which convey emotions and attitudes in a number of real Persian speech samples. Commonly analyzed acoustic parameters for such a description of emotional speech include pitch range and duration of each prosodic event measured to compute the tilt of each prosodic contour. In this connection, acoustic information about four basic emotions (anger, sadness, joy and neutrality, the last type being treated as emotion free and hence a reference point) expressed by six speakers (3 males and 3 females) is obtained. For this purpose, statistic estimations are used in order to investigate the meaningful differences in the acoustic features associated with the four emotions. Such a discriminant analysis is performed in order to investigate the effectiveness of these parameters in emotion categorization in Persian based on the intonation model of the research, i.e. the tilt model. This study can also be viewed as an attempt to shed light on the type of contribution proposed by the tradition of intonation study to the investigation of emotion in speech technology in general, and in speech synthesis, in particular. The advantage of the present research is that language teaching can be benefited from the contrastive study of the phonetic systems of the two languages involved.

In this research, the production aspect is supplemented by the perception one, in view of the fact that the complementarity of the production and the perception processes is the basis of the spoken communication process, and thus firmly establishes the communicative importance of the parameters being studied.

In what follows, we present the main research efforts made by Persian and non-Persian scholars in the field of the newly established discipline designated phonopragmatics.

2. Previous Empirical Studies

The acoustic investigation of emotionally oriented paralinguistic information expressed in speech has received increasing attention over the past years. Williams and Stevens (1972) conducted research to demonstrate the importance of intonation as a medium of expressing emotion in speech. They emphasized the importance of supplementing production studies with perception studies.

Mozziconacci (1984, pp. 79-163) investigated intonation in production and perception of Dutch speech conveying six emotions or attitudes: joy, anger, sadness, boredom, fear and indignation against neutrality as a reference. In the first stage of the study, 315 utterances (3 speakers × 5 sentences × 7 emotions × 3 trials) successfully conveying emotion in speech were selected as speech samples. This selection was made on the basis of the perception test. An acoustic analysis was carried out on the subset of fourteen utterances (1 speaker × 2 sentences × 7 emotions × 1 trial) successfully conveying the emotion categories, involving the global measures, pitch range, pitch level and speech rate. The pitch curve in all individual utterances was described in terms of the IPA model known as Intonation Perceptual Analysis. The measurements obtained in the study were used as a source of inspiration for speech manipulations. In a series of experiments, Mozziconacci found that pitch level, pitch range and speech rate were systematically varied per emotion around the values found for these parameters in the original speech.

Ladd, Silverman, Bergman, and Scherer (1985) conducted different experiments on the relationship between prosodic cues and emotional states. It was shown that not only fundamental frequency (F0) variation (pitch range) and voice quality had strong effects on listener's influences of the arousal-related state of the speaker (relaxed, hurried), but also on the inference of cognitively related attitudes and emotions communicated by speech. The result they obtained was that voice quality is a primary means by which speakers project their identity, and their social characteristics (personality, occupation, education and regional origin). They also came to the conclusion that three prosodic cues: F0 range, voice quality and type of pitch contour function independently of each other in conveying emotions and attitudes in speech.

The most detailed and valuable study was conducted by Scherer (1990). He expressed the need for a combination of production and perception studies in order to enhance the understanding of emotional vocal communication. Scherer (1990) applied different techniques to simulate standard emotions like anger, sadness and joy to test how well subjects can identify those emotions from their acoustic signals. Conducting another study on Dutch and Hungarian, Scherer (1995) tested assumptions concerning intonation theories, and reached conclusions very similar to Mozziconacci's (1995).

Tickle (1990) addressed methodological issues surrounding cross-cultural studies of speech conveying emotion. She distinguished the influences of biological factors, leading to the expectation of universal expression of emotions across cultures, from those of culturally determined factors, leading to expectations of emotions between cultures.

Laver (1995) emphasized that the prosodic function of conveying the expression of emotion seems to involve both a linguistic and a paralinguistic component, and that it is frequently considered a paralinguistic function, despite the doubts expressed on the subject. He said that the choice of contour would be more related to the type of sentence, while the pitch level and excursion size of the pitch movements would be more related to the speaker's emotional state.

The pertinence of intonation contour to conveying emotional states and meaning was also demonstrated in Grabe , Gussenhoven , Hann and Post (1997). In their study, an orthogonal design was used, combining high and low preheads with three Dutch pitch accents: H*L, H*LH and L*H, which resulted in six experimental intonation contours. A perceptual experiment was conducted in order to test which of the contours would best convey friendliness, aloofness, irritation, uncertainty and politeness.

Higuchi, Hirari and Sagiska (1997) also carried out an experiment seeking correlation between emotivity and prosodic features such as pitch level, pitch range, and speech rate. The framework of Fujisaki's model of intonation was used for the analysis, as well as for the synthesis of speech. The results confirmed that utterances produced while conveying different emotions could vary considerably with regards to the prosodic features. The relative height of the pitch accents, and the extent of the final lowering measurements of relative duration of accented and unaccented speech segments were made in order to gain some insights into the internal temporal structure of emotional utterances.

As far as the concepts of prosody and emotivity are concerned, experimental research on the study of prosodic features and emotional speech has been scarcely conducted in Persian. Alinezhad (2010) found that the prosodic variations of a particular lexical item /bale/ in Persian provides information about their role in the interpretation of different emotions as paralinguistic information. Alinezhad and Vaysi (1386/2007) conducted experimental research seeking various degrees of correspondence between prosodic cues (duration, pitch level and intensity) and paralinguistic information in some samples of speech in Persian. Their analysis demonstrated a noticeable correlation between prosodic features and paralinguistic information in Persian.

Further investigation into the contribution of prosody to emotivity would most probably promise a rich source of information in the investigation of long-term concerns in related fields.

3. Methodology

3.1 Materials and recordings

To collect the speech samples of this research, two different stages, production and perception, were adopted. First, at the production stage, six participants (3 males and 3 females) among the students at the Shahid Chamran University in Ahvaz were asked to produce the utterances. They had no voice pathologies or abnormalities. Nor were they dialect-conscious. Participants' age ranged from 18 to 28. The major source of data for this research project came from dialogues in daily conversations and movies. Five selected utterances were spoken several times, first in a neutral voice and then in an emotive one involving with the feigned emotions of anger, joy and sadness. To achieve a realistic portrayal of emotion, the speakers were instructed to imagine a situational context in which the utterances could appear. They were also asked to act out the different emotions and then express them. The speakers produced the utterances with the four different emotional states until we were satisfied with the expression of the given emotions.

One advantage of this method is that it helps us to control and compare the acoustic variations in the same context for all given emotions in all participants. Another noticeable property of the method used is that the sample data could appear in all emotional contexts without semantical inconsistency. It must be pointed out that the samples analyzed in this study were uttered with each of the four emotions, i.e. anger, joy, sadness and neutrality. Naturally, using only one speaker puts a restriction on a general interpretation of the results because there can be variations in the expression of emotions depending, for example, on age, sex and idiosyncrasies of the speaker.

The disadvantage of this method, however, is that using it for constructing data may appear to have some unnatural consequences. Thus, the most natural samples are selected out of a big number of utterances which carry the given emotions.

To avoid the unnaturalness of the data, the utterances produced by each speaker were played to some listeners in separate sessions at the second stage. The listener group consisted of 40 undergraduate students who were native speakers of Persian. They were of varying ages and sexes. The listeners were instructed to mark any utterance that sounded as acted or emphasized as unnatural in the questionnaire. The emotional content was evaluated using 5 categories: neutrality, joy, sadness, anger and unnatural or not recognizable emotional content. Only the utterances that were recognized by at least 80% of all listeners were used for our acoustic analysis. These utterances were evaluated as natural and their emotional content was treated as being unambiguous.

3.2 Acoustic parameters and measurements

Considering the model of intonation in the present study, namely the Tilt model, such parameters as pitch range and duration were measured from the corresponding label files.

We calculated the pitch contours of each utterance using PRAAT (Boersma & Weenink, 2006) speech processing software. Global level statistics related to F0 (maximum-minimum) were calculated from F0 contours in each peak. All speakers' selected token were acoustically analyzed through pitch tracks and spectrogram. When the measurement of intonational events was over, all the scales were put in a matrix. A statistical analysis of all measurements related to each utterance was done and Linear Regression was used to test the correlation between emotions (i.e. neutral, sadness, joy and anger) as independent variables and acoustic features (i.e. duration and pitch amplitude of speech) as dependent variables to test the hypothesis that there exist some significant differences between the emotions expressed and the acoustic cues used by the speakers.

Since this research is conducted in the framework of a model of intonation, it is appropriate to provide a brief description of the Tilt model which we appealed to as the basis of this research.

4. Framework of the Tilt Model of Intonation

Intonation models constitute a tool for representing and interpreting relevant data. They serve to structure the data, facilitate controlling the parameters and the generalization of the results. Conducting research within such a model of intonation enhances the systematic aspect of procedures and also allows for testing whether the specific model can be considered adequate for processing emotional speech. If a piece of research is conducted in the framework of such a model, its results can lead to confirming the usefulness of the corresponding approach of intonation or to refuting assumptions underlying the model in question. Moreover, considering intonation data concerning emotional speech within the theoretical framework of approaches to intonation helps us to understand which parameters, as mentioned in section 3.2, have a prominent role in conveying emotions in speech.

In the present study, the Tilt model (Taylor, 1998, 2000, 2009) is used as a useful theoretical framework for processing intonation variation. The model seems to be adequate for the description of the variations relevant to the expression of emotion in Persian speech. It must be added that the Tilt model has not been previously employed in speech processing in Persian. Before going into the main details of data analysis, it seems to be appropriate to provide a brief overview of the model.

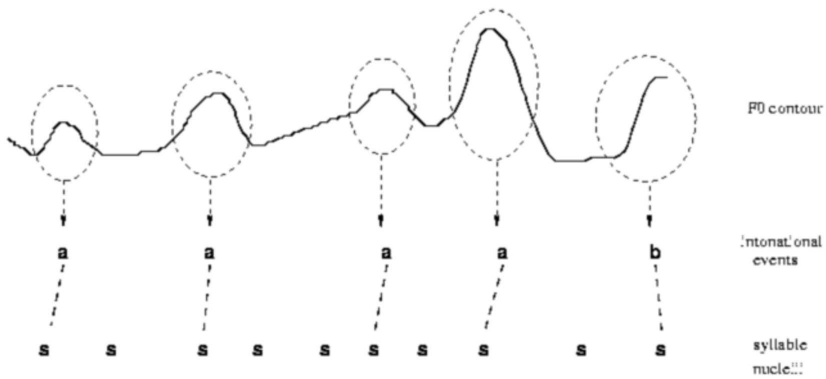
4.1 The Tilt model

The Tilt intonation model is designed to facilitate automatic intonational processing for speech technology applicants. The model represents intonation at a phonetic level as a sequence of parameterized intonational events. From such a representation, it is possible to encode the linguistically relevant information in F0 contours, and then recreate the original F0 from this coding.

In the Tilt model, intonation is characterized by a sequence of phonetic intonational events shown in Figure 1. There are two kinds of pitch accent: "a", and the boundary tones, "b" .Each event has a rise and fall component which can vary in size, while some events have a zero rise or zero fall component indicating that they only have a fall or a rise respectively. The middle of the event is defined as the end of the rise component or the start of the fall component. Each event is characterized by Tilt parameters which describe its F0 shape. In this model both pitch accent and boundary tones are characterized using the same set of parameters.

In the present investigation, the acoustic parameters of the first three peaks, or events, of the five utterances representing rise and fall components were measured. Intonational events are represented in Figure1.

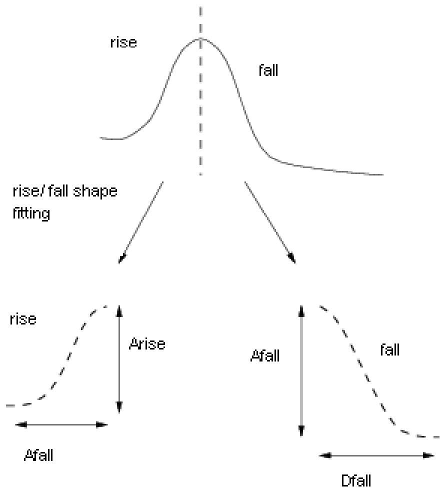
Figure 1: Representation of Intonational events in the Tilt model (Taylor, 2009, p. 122).



The Tilt model has been previously used and tested on English, Korean and Japanese databases. As mentioned, the Tilt model facilitates automatic intonational processing. It follows up different stages. The first stage in automatic analysis is to find the events from the waveform. Waveforms are parameterized into F0 and energy. The Tilt parameters for each of the events are then derived. This stage uses an algorithm which examines each event and fits rise or fall shapes by minimizing the error between the original contour and the fitted shape. The result of this process is that each event is now described as a rise shape, a fall shape or a rise followed by a fall shape. This parameterization produces a representation in terms of an underlying model known as the rise/fall connection (RFC model). The Tilt model can be thought of as a further stage to the RFC model, in that it takes RFC parameters and produces a compact intonational representation from them. The RFC model is more fully described in Taylor (1993, 1995).

The algorithm produces a rise amplitude (A rise), a rise duration (D rise), a fall amplitude (A fall) and a fall duration (D fall). These parameters accurately encode the F0 shape of the event. If an event consists of only a rise or a fall component, the amplitude and duration of the missing part are set to be 0. The sections of contour are interpolated through events to produce a continuous intonational stream. Figure 2 shows a pitch accent with marked parameters as well as the way of measuring the duration and the pitch accent of every event in the utterance.

Figure 2: A pitch accent with marked parameters



A further set of transformations are used to produce an F0 contour by first converting them back into RFC parameters and then using mathematical equations to generate actual contours. The equations are thoroughly given in Taylor (2000) and those that are used in the present study to analyze the data are as follows:

$$\mathbf{tilt}_{amp} = \frac{|A\ rise| - |A\ fall|}{|A\ rise| + |A\ fall|} \quad (1)$$

$$\mathbf{tilt}_{\mathbf{dur}} = \frac{D_{rise} - D_{fall}}{D_{rise} + D_{fall}} \quad (2)$$

$$\text{Tilt} = \frac{|A\ rise| - |A\ fall|}{2(|A\ rise| + |A\ fall|)} + \frac{D_{rise} - D_{fall}}{2(D_{rise} + D_{fall})} \quad (3)$$

As is shown in the given equations, the Tilt parameter is calculated by averaging amplitude tilt (Equation 1) and duration tilt (Equation 2) into a single parameter (Equation 3).The pitch amplitude and the duration are referred to by A and D, respectively.

Since the Tilt model is found to be a more appropriate and powerful model for both automatic and hand speech processing, hand speech processing was used to analyze the data in the present study.

5. Data Analysis

What is noteworthy here is that the main concern of this study is to find out the acoustic correlates of the three emotions (i.e. joy, anger and sadness) compared with neutrality as a baseline. For this purpose, descriptive statistics were employed to enable us to have access to the significance level of each acoustic variable with the intended emotions. Thus, Linear Regression Test (LRT) was carried out to analyze the differences significantly.

Each utterance was analyzed in terms of the sex and emotions of the participants as independent variables, and peaks and the rise / fall half of each peak as dependent variables. The null hypothesis and the counterhypothesis were considered with regard to the correlation between the given two variables supported by descriptive and inferential statistics. The significance level given in different tables will determine the sort of the hypothesis under discussion. The significance level is set to be less than 0.05 ($p < 0.05$). A diagram of the average of each parameter in both halves of the same peak is also shown.

We restricted our work to presenting descriptive and inferential statistical results of the given variables in the first peak of one utterance (i.e. the fourth one). For limitations of space we confined our work to the results obtained for other peaks in the given utterances. It is extremely important to bear in mind that, as far as our investigation is concerned, only the first event (E1) of each utterance was measured and compared.

Notice the following sample utterances:

(1) [dZeddi migi! ʔaz ʔu da:vat be kAr kardan]
You're kidding! He was called to a job.

(2) [VAGeʔan! ʔemruz mehmun dArim]
Really! We have guests today!

(3) [be salAmat! FardA mibinamet]
Bye! See you tomorrow.

(4) [befarmAʔid! Hame montazere ΣomA budim]

Come in! everybody's been waiting for you.

(5) [javad ʔaz safar bargaΣt xune!]

Javad returned home from a trip!

In the following figures, the spectrographs of the first peak of the sample 4 for three emotions (i.e. joy , anger and sadness), compared with neutral expressions as a baseline, are given:

Figure 3: The spectrograph of the first peak [befarmAʔid] for a neutral utterance of sample 4.

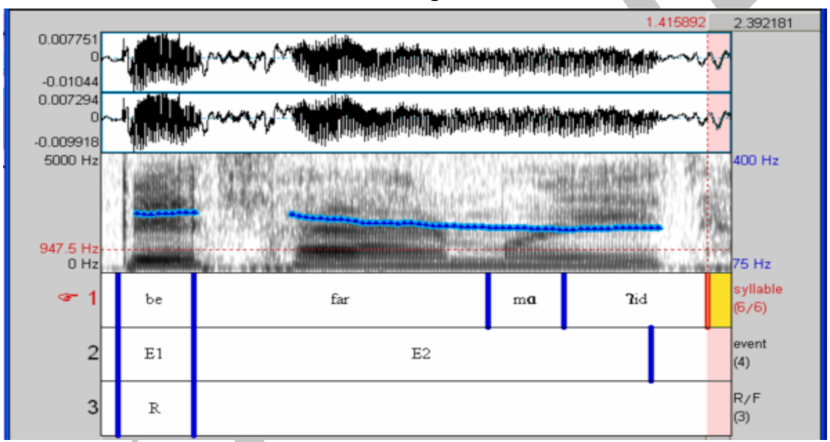


Figure 4: The spectrograph of the first peak [befarmAʔid] for sadness expression of sample 4.

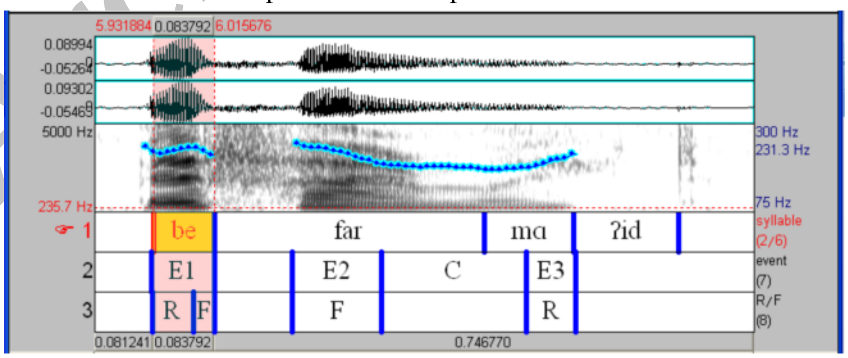


Figure 5: The spectrograph of the first peak [befarmAʔid] for the expression of anger in sample 4.

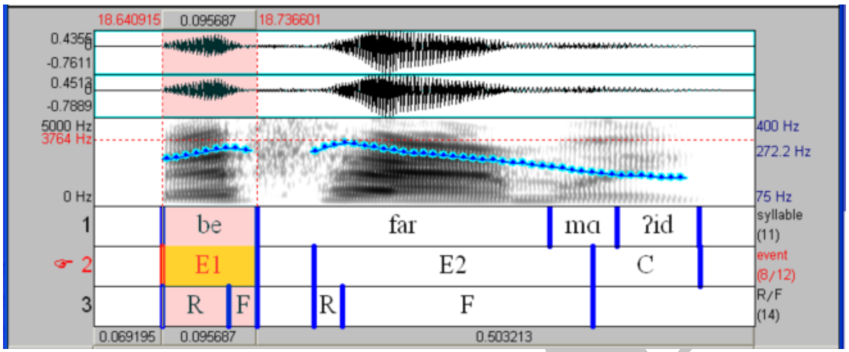
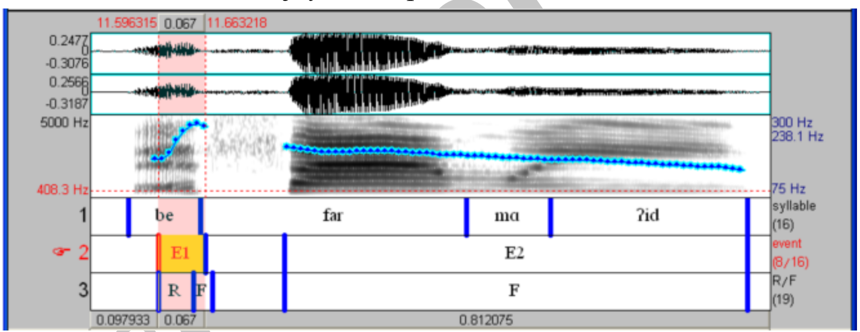


Figure 6: The spectrograph of the first peak [befarmAʔid] for the expression of joy in sample 4.



In what follows, the correlation between ‘duration’, ‘pitch range’ and ‘tilt’ on the one hand, and the intended emotions on the other hand are examined separately.

5.1 Duration and its correlation with the emotions

As was mentioned in section 5, for limitations of space, we will confine our work to presenting the statistical results of the variables of one peak in the same (i.e. the fourth) utterance for all intended emotions. Then, the total results of all samples will be graphically presented.

The Null hypothesis about the duration: the duration of utterance in the first peak (first / second half) of the fourth sample associated with emotions (i.e. sadness, joy and anger) in males and females showed no significant difference.

The counterhypothesis: the duration in the first peak (first / second half) of the same utterance related to the specified emotions in both sexes showed a significant difference.

The descriptive statistics of the duration in the first peak of the fourth utterance [befarmA?id! hame montazere ΣomA budim] is given in the table below.

Table 1: Descriptive statistics of duration and its correlation with intended emotions in the first peak of the utterance 4:

half	sex	neutral	emotion	estimation of coefficient	variance of estimation	standardized coefficient	statistical hypothesis	significance level
first half	Female	.620	sadness	- .226	.063	- .587	- 3.559	.007
			Joy	- .302	.063	- .785	- 4.761	.001
			anger	- .423	.063	- 1.098	- 6.656	.000
	Male	.557	sadness	- .170	.178	- .325	- .957	.366
			joy	- .239	.178	- .457	- 1.348	.215
			anger	- .392	.178	- .749	- 2.210	.058
second half	Female	.130	sadness	.342	.103	.810	3.326	.010
			joy	.386	.103	.915	3.754	.006
			anger	.192	.103	.454	1.864	.099
	Male	.706	sadness	- .410	.182	- . 725	- 2.259	.054
			joy	- .327	.182	- .578	- 1.800	.110
			anger	- .382	.182	- .675	- 2.101	.069

As can be seen in Table 1, considering the level of significance, the following total result can be made:

A significant difference was found between the duration and the expressions of sadness, joy and anger in females in the first peak of the fourth sample.

Figures 7 & 8 show the average of duration in the fourth utterance.

Figure 7: Average of the duration of utterance 4, the first half of the first peak

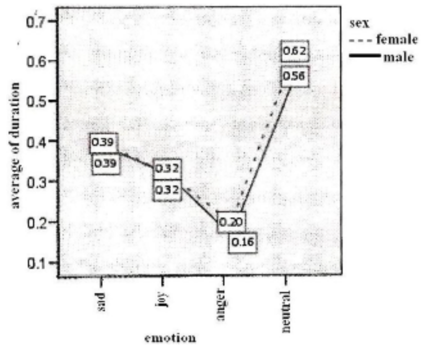
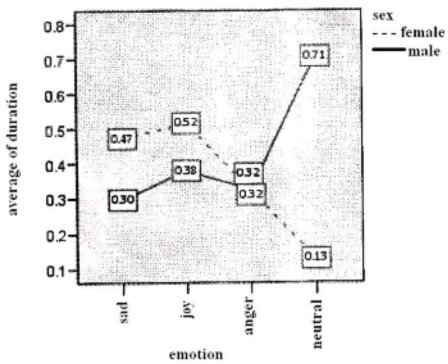


Figure 8: Average of the duration of utterance 4, the second half of the first peak



The findings summarized in Table 2 illustrate the general results of the significant correlation between the two given variables.

Table 2: Statistics of the total significant correlation between the duration and intended emotions in three peaks of all samples:

Utterance	Peak	Half	Sex	Emotion	Neutral	Coefficient	Standardized Coefficient	Significance Level
1	2	2	Female	Joy	.219	.157	.796	.030
1	3	1	Female	Anger	.428	-.237	-.696	.027
2	1	1	Female	Joy	.188	.475	.833	.019
2	1	1	Female	Anger	.188	.413	.723	.034
2	2	1	Female	Sadness	.132	.209	.920	.011
3	2	1	Male	Sadness	.137	.191	.985	.000
3	3	1	Male	Sadness	.141	.294	.727	.041
4	1	1	Female	Sadness	.620	-.226	-.587	.007
4	1	1	Female	Joy	.620	-.302	-.785	.001
4	1	1	Female	Anger	.620	-.423	-1.098	.000
4	1	2	Female	Sadness	.130	.342	.810	.010

Utterance	Peak	Half	Sex	Emotion	Neutral	Coefficient	Standardized Coefficient	Significance Level
4	1	2	Female	Joy	.130	.386	.915	.006
4	3	2	Female	Sadness	.168	.354	.928	.011
5	1	1	Female	Anger	.188	.224	.997	.004
5	1	1	Male	Joy	.354	-.057	-.529	.034
5	1	1	Male	Anger	.354	-.116	-1.070	.001
5	3	2	Male	Sadness	.213	-.094	-.902	.005
5	3	2	Male	Joy	.213	-.062	-.600	.032
5	3	2	Male	Anger	.213	-.093	-.892	.005

As can be observed and according to the test done on the correlation between the duration and the emotions, there is a significant correlation between the two variables in the given samples. So, the null hypothesis was rejected.

The total findings show that the differences statistically considered to be significant are not the same for all utterances. A significant difference was only found for 25% of the related cases which were mostly observable for the emotions of joy and anger in females.

5.2 Pitch range and its correlation with the intended emotions

In what follows the correlation between the pitch range and the given emotions in the fourth utterance will be explored.

The null hypothesis about the pitch range: the pitch range of the utterance in the first peak (first / second half) of the fourth sample expressing emotions (i.e. sadness, joy and anger) in males and females showed no significant differences.

The counterhypothesis: the pitch range in the first peak (first / second half) of the same utterance expressing the said emotions in males and females showed a significant difference.

The following table shows the descriptive statistics of the pitch range and its correlation with the intended emotions in the first peak of utterance 4.

Table 3: Descriptive statistics of the pitch range and its correlation with the intended emotions in the first peak of utterance 4:

half	sex	neutral	emotion	estimation of coefficient	variance of estimation	standardized coefficient	statistical hypothesis	significance level
first half	Female	83.850	sadness	4.985	29.331	.023	.170	.869
			Joy	200.417	29.331	.933	6.833	.000
			Anger	-13.683	29.331	-.064	-.467	.653
	Male	30.405	sadness	-12.205	11.400	-.268	-1.071	.316
			Joy	12.728	11.400	.279	1.116	.297
			Anger	31.295	11.400	.687	2.745	.025
second half	Female	35.467	Sadness	93.000	66.543	.388	1.398	.200
			Joy	221.800	66.543	.926	3.333	.010
			Anger	131.000	66.543	.547	1.969	.085
	Male	22.567	sadness	17.933	13.404	.274	1.338	.218
			Joy	26.000	13.404	.398	1.940	.088
			Anger	67.933	13.404	1.040	5.068	.001

As shown in Table 3, the difference between the pitch range and the emotions (i.e. joy and anger) for females and males in the first and second half of the fourth utterance is significant; thus, the null hypothesis is refuted and the given parameter is statistically significant. The average of the pitch range and its different degrees of correlation is shown in Figures 9 and 10 below.

The results summarized in Table 4, attached as Appendix, reveal

Figure 9: Average of the pitch range of sample 4, the first half of the first peak

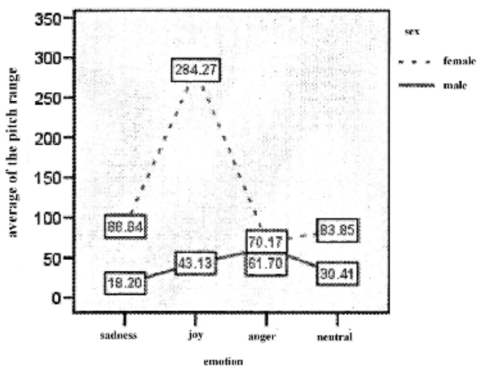
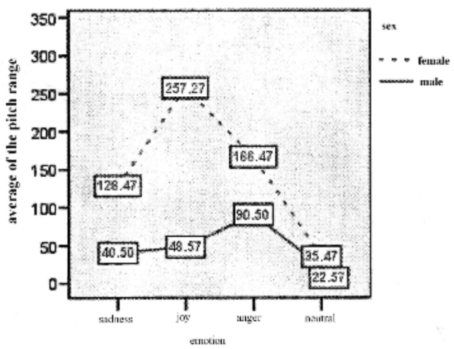


Figure 10: Average of the pitch range of sample 4, the second half of the first peak



some further cases of correlation between the pitch range and the intended emotions in the three peaks of all given samples.

As can be seen in Table 4, in contrast to duration differences, the pitch range parameter is significant in most cases of intended emotions. The results summarized in the table indicate that the emotional changes significantly affect the pitch range parameter. More importantly, a statistically significant effect was found for females in expressing the intended emotions. The total results indicate that there are at least 90% of cases which show statistically significant differences between the two variables in females. So, the null hypothesis is rejected and hence the counterhypothesis is confirmed.

In contrast to sadness, anger and joy showed more statistically significant difference with the pitch range. There exists a significant correlation between anger and the given parameter in 25% of the samples. Most cases of anger were indicated in males.

5.3 Tilt and its correlation with the emotions

We have previously stated in section 5 how the Tilt parameters for each of the events are derived and calculated.

The null hypothesis about the tilt: the tilt of utterance in the first peak (first / second half) of the fourth sample bound to emotions (i.e.

sadness, joy and anger) in males and females showed no significant difference.

The counterhypothesis: the tilt in the first peak (first / second half) of the same utterance related to the emotions sadness, joy and anger in males and females showed significant difference.

The following table shows the descriptive statistics of the tilt and its effect on the intended emotions.

Table 5: Descriptive statistics of the tilt (rise/fall) and its significant correlation with emotions in the first peak of the utterance 4:

half	sex	neutral	emotion	estimation of coefficient	variance of estimation	standardized coefficient	statistical hypothesis	significance level
rise (tilt)	Female	.383	sadness	- .499	.193	- .613	- 2.590	.032
			Joy	- .297	.193	- .366	- 1.544	.161
			anger	- .809	.193	- .995	- 4.201	.003
	Male	.086	sadness	- .509	.182	- .849	- 2.802	.023
			joy	- .158	.182	- .264	- .872	.409
			anger	- .273	.182	- .455	- 1.501	.172
fall (tilt)	Female	.651	sadness	- .722	.127	- .815	- 5.677	.000
			joy	- .876	.127	- .988	- 6.881	.000
			anger	- .874	.127	- .986	- 6.871	.000
	Male	- .085	sadness	.144	.298	.191	.483	.642
			joy	- .001	.298	- .002	- .004	.997
			anger	- .223	.298	- .297	- .749	.475

Table 5 shows that there exists a correlation between the given variables. The statistical results indicate that the difference between the tilt and the expression of all emotions in both halves of the first peak of utterance 4 in both sexes is significant. Thus the null hypothesis is rejected; that is, counterhypothesis is confirmed.

The average of the tilt and its correlation with the given emotions in sample 4 is represented in the Figures 11 and 12 below.

Figure 11: Average of the tilt of sample 4 in the rise half of the first peak

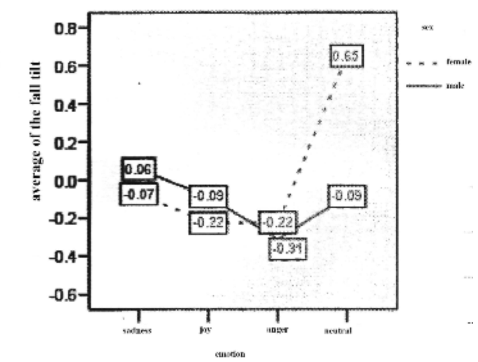
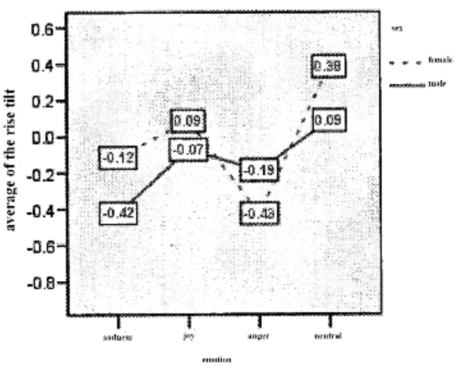


Figure 12: Average of the tilt of sample 4 in the fall half of the first peak



The given figures show the deviation from neutrality toward the intended emotions (i.e. anger, joy and sadness) in the fall and rise halves of the first peak in sample 4. The total findings in Table 6 show more cases of correlation between the tilt and the intended emotions.

Table 6: Statistics of the total significant correlation between the tilt and the emotions: sadness, joy and anger in all samples:

Utterance	Peak	Tilt	Sex	Emotion	Neutral	Variance of Coefficient	Standardized Coefficient	Significance Level
1	1	Rising	Female	Sadness	.576	-.564	-.734	.041
1	1	Rising	Female	Anger	.576	-.581	-.755	.037
1	3	Rising	Female	Sadness	.407	-.572	-1.000	.002
1	3	Rising	Female	Anger	.407	-.402	-.703	.016
1	3	Falling	Female	Anger	.367	-.504	-.771	.039

Utterance	Peak	Tilt	Sex	Emotion	Neutral	Variance of Coefficient	Standardized Coefficient	Significance Level
3	1	Rising	Female	Joy	-.888	.838	.870	.010
3	1	Rising	Female	Anger	-.888	.653	.678	.032
3	1	Rising	Male	Sadness	-.574	.934	.712	.044
3	1	Rising	Male	Anger	-.574	1.058	.806	.027
3	3	Rising	Female	Sadness	-.534	.568	.909	.009
3	3	Rising	Female	Joy	-.534	.452	.723	.026
4	1	Rising	Female	Sadness	.383	-.499	-.613	.032
4	1	Rising	Female	Anger	.383	-.809	-.995	.003
4	1	Rising	Male	Sadness	.086	-.509	-.849	.023
4	1	Falling	Female	Sadness	.651	-.722	-.815	.000
4	1	Falling	Female	Joy	.651	-.876	-.988	.000
4	1	Falling	Female	Anger	.651	-.874	-.986	.000
4	3	Rising	Male	Sadness	-.127	-.374	-.537	.004
4	3	Rising	Male	Joy	-.127	.342	.491	.006
4	3	Rising	Male	Anger	-.127	.303	.435	.011
5	1	Falling	Female	Anger	-.396	.634	.731	.048
5	2	Rising	Female	Joy	.308	-.356	-.798	.019
5	2	Rising	Female	Anger	.308	-.379	-.850	.014

The findings summarized in Table 6 indicate that the differences statistically regarded as being significant are not the same for all samples. Significant difference was only found for 26% of the related cases, which was generally observable for the intended emotions (i.e.. sadness, joy and anger). As can be seen in Table 6, there exists a significant correlation between the tilt (rise), rather than the tilt (fall) and the given emotions in all samples. Hence, the null hypothesis is rejected. In 64% of the other related cases no statistically significant difference was found between the tilt (rise/fall) and the intended emotions.

6. Results and Discussion

The study revealed that pitch range conveys substantial information about intended emotional states (i.e. joy and anger) and that this parameter is more important than duration and tilt. Thus, among the given prosodic features, pitch range is shown to be pivotal in that it introduces the function of these features as a kind of paralinguistic behavior. In the overwhelming majority of cases (90%), the pitch range parameter was statistically meaningful in the sense that it deviated from neutral emotion toward joy and anger. The duration in 25% and the tilt in 26% of the cases showed significant difference with the intended emotions in this research. These results are partly in accordance with the results of Mozziconacci (1995) and Scherer (1990), which showed that joy and anger correlated with a higher pitch range in emotional speech in Dutch and Hungarian.

Turning to the results and total findings of the present study, it can therefore be concluded that among the prosodic features, pitch range and tilt, respectively, and, to a lesser extent, duration showed statistically significant difference with the intended emotions.

The results of the study also showed that anger and joy on the one hand, and sadness and neutrality on the other hand, have similar acoustic cues.

It is worth noting that in some cases no significant difference was found between the intended emotions and the given parameters. This may account for the fact that all emotions are dependent, more or less, on context for their interpretation. As Scherer (1995) says, it is not to be expected that all the information about emotion is present in the acoustic signal. Rather, it is acoustic features that play a key role in emotional speech.

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Appendix

Table 4: Statistics of the total significant correlation between the pitch range and the intended emotions in all given samples:

Utterance	Peak	Half	Sex	Emotion	Neutral	Variance of Coefficient	Standardized Coefficient	Significance Level
1	1	1	Female	Joy	127.567	207.657	.738	.015
1	1	2	Female	Joy	29.133	280.567	.906	.007
1	2	1	Female	Joy	44.481	198.219	.932	.003
1	2	1	Male	Anger	16.250	62.350	.909	.006
1	2	2	Female	Joy	63.867	180.867	.742	.020
1	2	2	Female	Anger	63.867	158.467	.650	.035
1	2	2	Male	Anger	23.100	82.333	.765	.023
1	3	1	Male	Anger	19.450	79.083	.988	.000
1	3	2	Male	Anger	21.800	31.667	.740	.027
2	1	1	Female	Joy	45.443	137.157	.809	.003
2	1	1	Female	Anger	45.443	152.190	.897	.002
2	1	1	Male	Anger	44.115	53.852	.782	.046
2	1	2	Female	Joy	26.467	153.067	.943	.000
2	1	2	Female	Anger	26.467	123.283	.760	.001
2	1	2	Male	Anger	23.067	47.000	.835	.028
2	2	1	Female	Sadness	35.199	77.035	.523	.033
2	2	1	Female	Joy	35.199	156.168	1.061	.001
2	2	1	Female	Anger	35.199	103.068	.700	.009
2	3	1	Female	Joy	25.667	154.600	.724	.039
2	3	1	Female	Anger	25.667	175.567	.822	.023
2	3	2	Female	Joy	22.867	139.833	.731	.034
2	3	2	Female	Anger	22.867	161.833	.846	.018
2	3	2	Male	Anger	20.633	71.100	.896	.008
3	1	1	Female	Joy	10.100	55.433	.915	.005
3	1	1	Male	Joy	6.733	24.133	.715	.012
3	1	1	Male	Anger	6.733	32.600	.966	.002

Utterance	Peak	Half	Sex	Emotion	Neutral	Variance of Coefficient	Standardized Coefficient	Significance Level
3	2	2	Female	Joy	29.433	136.467	.738	.047
3	3	1	Female	Sadness	9.150	96.950	.430	.037
3	3	1	Female	Joy	9.150	241.783	1.073	.000
3	3	2	Female	Joy	33.933	263.233	1.069	.000
4	1	1	Female	Joy	83.850	200.417	.933	.000
4	1	1	Male	Anger	30.405	31.295	.687	.025
4	1	2	Female	Joy	35.467	221.800	.926	.010
4	1	2	Male	Anger	22.567	67.933	1.040	.001
4	2	1	Female	Joy	69.788	142.645	.772	.042
4	3	1	Female	Sadness	32.350	81.750	.623	.030
4	3	1	Female	Joy	32.350	133.150	1.014	.003
4	3	2	Female	Joy	16.933	155.000	.995	.004
5	1	1	Female	Joy	21.900	118.967	.998	.001
5	1	1	Male	Joy	36.343	65.120	.991	.000
5	2	1	Female	Joy	38.678	101.089	.918	.009
5	2	2	Female	Joy	20.500	124.800	1.042	.001
5	2	2	Female	Anger	20.500	77.300	.646	.011
5	3	1	Female	Joy	25.367	89.567	.914	.005
5	3	2	Female	Joy	20.733	73.567	.946	.003
5	3	2	Female	Anger	20.733	57.467	.739	.010