PC-phonetics: A help or a strain for the philologist?

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The title is an EITHER – OR question. The paper will probably reveal that the answer must be BOTH – AND.

In this paper a report will be given of the work with the project 'Norwegian learners' problems with English prosody. Norwegian-English intonation'.[1] The focus will be on hindrances met with, when changing from an auditive to an acoustic analysis of intonation, at the same time as there will be an attempt to show how modem research can be a help to overcome difficulties. Finally, results arrived at from a detailed study of the use of pitch range by Western Norwegians will be presented and compared with other studies.

An auditive phonetic error analysis of the intonation of Norwegian students of English was started some years ago. The material used was a selection of readings, consisting of a 3-minutes' diagnostic test for 1st term students, collected at Engelsk institutt, Universitetet i Bergen, from 1977 to 1989.

Results from the auditive analysis (of 160 samples, representing readers from all parts of the country) have been published earlier (cf. Lysne 1985, 1988). As it is generally acknowledged that to rely only on auditory analysis of speech is not satisfactory, it was tempting to test the auditive results instrumentally. However, in the literature, for instance in the works of the 'Dutch School' (cf. Willems 1982; de Pijper 1983; Collier 1989; and t'Hart et al. 1990) it is emphasized that instrumental analysis of intonation is far from satisfactory, too.[2] In brief, the 'Dutch' method of analysing intonation amounts to starting with a detailed acoustic analysis of the fundamental tone (Fo), the physical correlate of PITCH, which is what we hear as speech melody or INTONATION. By the aid of aural control and stylized resynthesized curves Collier and Terken (1987) arrive at a 'close copy' of the Fo curve by eliminating excursions in the original curve which can be deleted without affecting the auditory impression of 'sameness'/naturalness. Their 'close copy' variant 'mainly eliminates the Micro-intonational modulations from the Fo curve (cf. below) and respects whatever variation there is in the overall shape of the individual pitch movements ...' (ibid. p. 166).

This kind of research reveals that there is a great amount of irrelevant information in an acoustic representation of intonation, something also underlined by Crystal (1969) and Gibbon (1976) among others. Thus faced with instrumental analysis, the inexperienced performer can easily be confused. However, consolation is found in e.g. Collier (1989). Collier advocates the 'perceptual detour', underlining strongly that 'perceptual verificaton' is of major importance in the analysis of intonation. It is apparent that some of the information in the sound curve that may be labelled irrelevant may lie above the frequency threshold of hearing, but our perception apparatus seems to work like a filter, ignoring irrelevant signals. The computer, on the other hand, does not ignore anything, and this is where the problems lie for an only auditively trained philologist, who is used to drawing simple lines to illustrate intonation patterns (cf. fig. 1). Nevertheless, what is perceived by a trained ear, may prove to be just what is needed in a pedagogical situation. Actually, very little

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experience in studying sound curves on the PC is needed in order to understand warnings or recommendations like 'You must rely on your ear and not on what you see on the screen' (Collier, personal communication), and 'Trust your ear' (Dickson, personal communication).

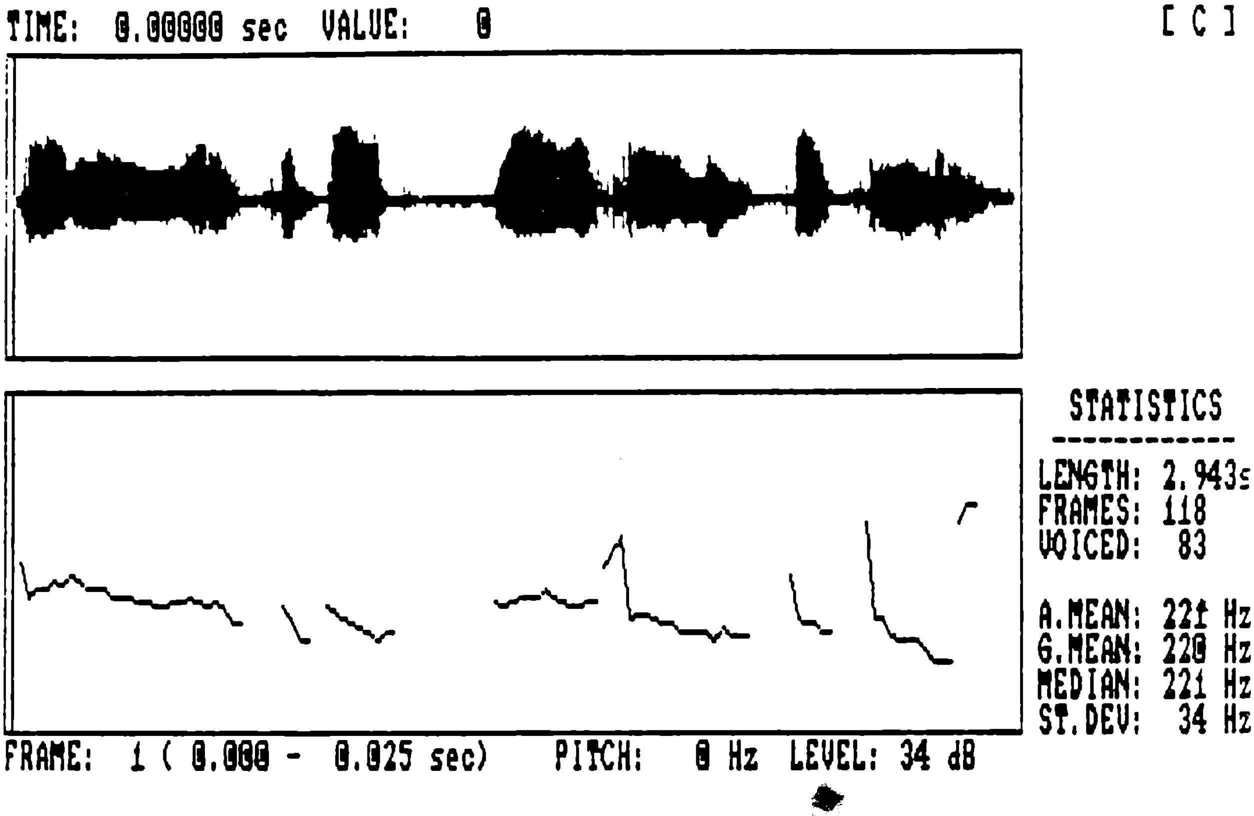

Figure 1: MSLPITCH curve representing 'William went to bed very early that evening' (not cleane or repaired).

Extralinguistic and practical problems

Before looking at what is perceived of the speech signal (or how we perceive), it might be useful to look at extralinguistic and practical hindrances encountered in digitizing speech (and in acoustic analysis):

At the worst, signals digitized and appearing on the screen might represent noise from the equipment used. Further, unsatisfactory quality of the original tape recording might be a problem in case the material was not meant to be used for acoustic analysis.[3] Wrong clock speed of the PC in relation to speech tempo might be another problem.[4] In this last case cautious adjustment is essential in order to secure correct and identical processing of all the material. It is the digitizing-process which is sensitive to correct clock speed, the process of analysis of data is not affected.

The Fo limits of the normal human voice are well known, as are also the perceptual limits of tonal frequency (cf. Ladefoged 1972). However, in relation to the perception of running speech Clark and Yallop (1990) strongly underline that perception is relative. This also applies to 'the perception of sound, studied under the heading of PSYCHOACOUSTICS' (ibid. p.208). Concerning this problem t'Hart et al. (1990:10) maintain that '...the psychoacoustically defined thresholds do not account for the selective sensitivity of the listener when extracting pitch information from the speech signal. ... the listener applies selective attention in the perception of pitch in speech'.

From what has been said above one might conclude that the computer with its acoustic analysis brings forth and shows details in an Fo curve which are linguistically irrelevant and which we are liable to ignore as listeners.

What we perceive of tone in speech depends on several factors. Quantity/timing is a decisive factor.[5] According to Fay (1966:16) 'Time... is extensively involved in the many phases of the total auditory process.' Gibbon (1976:52) says 'Prosodic features ... are generally defined with reference to the time dimension, ... which leads to the vexed question of the linguistic relevance of static trajectories or points in trajectories compared with dynamic trajectories'. Gibbon (ibid. p. 55) also says 'pitch perception requires at least 20 – 25 msecs even for static trajectories ..., and thus cannot be abstracted from the time dimension'. Gibbon's 'vexed question' refers to the fact that if a moving tone ('dynamic trajectory') occurs immediately before or after a level tone ('static trajectory') it is the relative duration of the trajectories which determines whether we hear a moving tone or a level tone (cf. Brandt 1976). A sudden peak of short duration is not heard in a smooth sequence.

In the present study it has been necessary to take into account the time dimension especially when cleaning Fo curves. This is necessary in cases where the shape of the curve does not correspond with what we hear of TONE when listening to the signal. From what has been stated so far it should be clear that it might be necessary fairly often to repair or clean the acoustic curve, which can contain such a lot of faulty information, in order to make it appear more like what it sounds. Obvious noise is easily detected and deleted, and so is strong aspiration and breath wrongly computed as voiced (cf. figs. 1 and 2). Further, we find the so-called OCTAVE JUMPS: If Fo lacks intensity one of the HARMONICS might show up instead[6] (cf. end of fig.1). The pitch perceived will still be that of the fundamental, which means that we hear a lower tone than the one appearing in the Fo curve, and reparation is necessary (cf. fig. 2).[7] This is often the case in **weakly pronounced endings**: A low tone is heard and the signal is registered to have a higher Hz-value, (sometimes showing a sharp rise which is not there – and 'which we cannot make or hear' (Henning Reetz, personal communication).[8]

WEAK ENDINGS posed a great unforeseen problem in the pitch-range analysis. Here one has to find the highest and the lowest Hz-value in the unit, and the lowest value will occur at the end of a long unit, especially so in a statement conveying new information. Sørensen and Cooper (1980:407) affirm that 'The general direction of Fo in a sentence is downward. ...This general fall has been termed Fo declination.' Clark and Yallop (1990:285, 286) say that there 'appears to be an almost universal tendency in language, namely a moderate progressive fall in pitch from the beginning to the end of any sequence of speech of appreciable length... . There has been considerable debate about the status and causes of declination. It has also been suggested that declination effects are observed mainly in reading aloud,... and that they are much less noticeable in the patterns of informal speech'.[9] An important point in this discussion would be that the linguistic units in informal speech will be shorter than sentences (cf. Brown and Yule 1983). Thus it is reasonable that we will get longer units in reading, which is based on written text containing complete sentences. This would make the downdrift more noticeable in reading. According to Lehiste (personal communication) 'The longer the unit the higher the onset has to be.' Sørensen and Cooper (1980) verify that there is a tendency for Fo to start higher at the beginning of a longer constituent. Cf. also Brown et al. (1980:132): '... it does seem that when the speaker has more ground to cover she begins higher'.

MICRO INTONATION (cf. p.1 above) has to be tackled as a special phenomenon. The term refers to **segmental influence on the Fo curve** of which there are two types: the intrinsic pitch of vowels and the influence of a consonant on the pitch of a following vowel (cf. Lehiste 1970, Ladd and Silverman 1984, and Reinholt Petersen 1986). Close vowels will have higher pitches than open vowels. 'Inherent Fo' is another term for this (Scheffers, personal communication). According to

Lehiste (ibid.) intrinsic pitch appears to be a physiologically conditioned universal. The pitch of a vowel will in addition be increased by a preceding voiceless consonant and lowered by a voiced consonant in the same position. This type is referred to as 'contextual Fo' (Scheffers, ibid.), and 'coarticulatory Fo fluctuations' (Reinholt Petersen, ibid.). Clark and Yallop (1990:282) state that 'The reasons for this conditioning of pitch are not fully understood.' And t'Hart et al. (1990:14-15) contend that micro intonation 'causes perturbations, not intended by the speaker. Evidently, such perturbations ... cannot be considered as constituents of the pitch contour as a linguistic entity; but they make the interpretation of Fo curves in terms of underlying intonation patterns all the more difficult.'

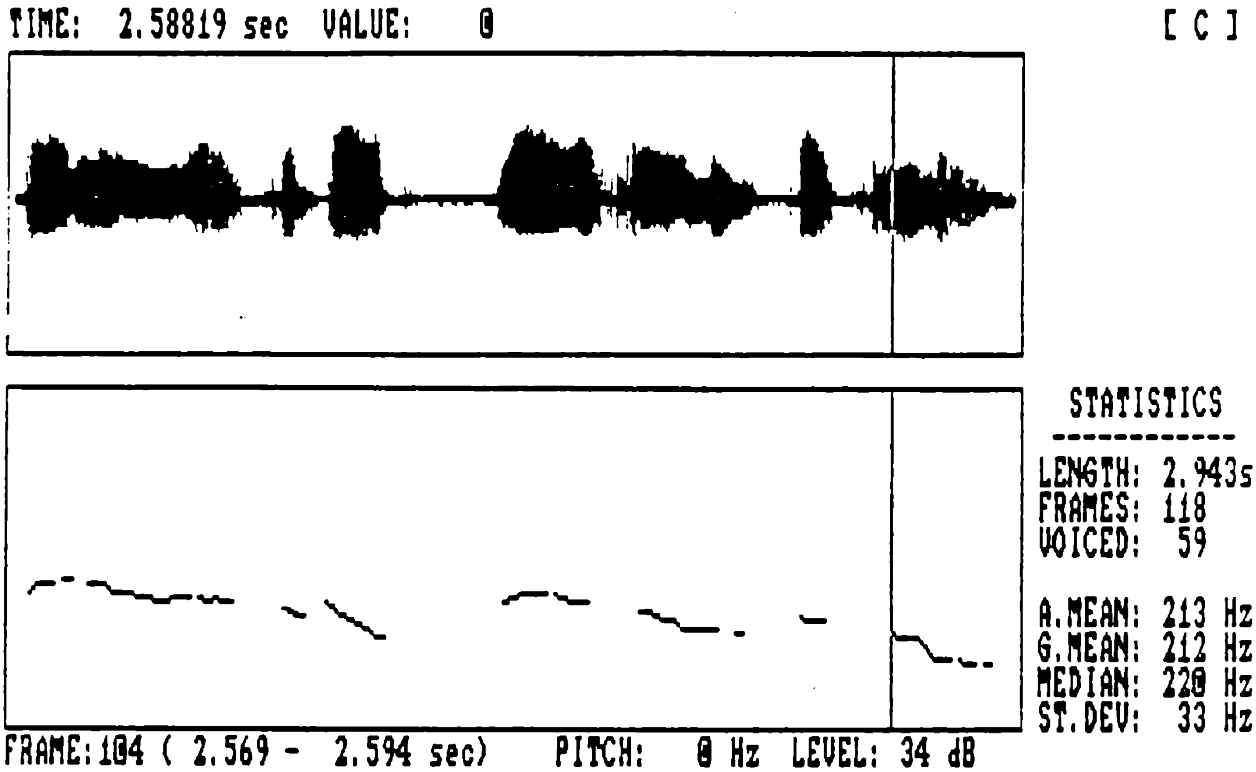

Figure 2: MSLPITCH curve representing 'William went to bed very early that evening' after being cleaned and repaired.

Inexperienced in the field of acoustics I welcomed the following statements on micro intonation by M. Scheffers (ibid.), 'These effects are relatively small in size (some percent) and difficult to distinguish in the Fo contour of a phrase because they are of the same order of magnitude as the inaccuracy of the Fo analysis method. ... no analysis method is perfect' and 'you have to learn to detect errors in Fo measurements. ... In teaching intonation in a foreign language, however, you can safely ignore these minor Fo excursions since it is generally agreed that they are involuntary and physiologically driven'. Obviously, in a learning situation anything physiologically driven will come naturally. In my analysis I have followed Collier and Terken (1987) deleting signals which are impossible to detect auditively (cf. fig. 1). (However, in one of my sentences (nr 7) it seems as if intrinsic pitch and co-articulatory Fo might have an impact to be counted with (cf. below).

We shall now turn to a more detailed presentation of a survey of the use of pitch range (PR) of students of English from Western Norway (Hordaland more precisely; 47 male and 74 female informants). As stated above, findings from the earlier auditive analysis were to be controlled by looking at the acoustic features of problems observed and listed.[10] The reasons for looking into PR first were mainly practical. Intonation studies demand units covering a certain stretch of speech. And thus the first sentence of the story read was digitized, representing an 'intonation unit' in most of the readings.[11] Intonational 'errors' listed (cf. note 10) were expected to appear within the unit. (To start with digitizing this sentence was a part of learning to use the MSL programme. In addition it was a way of becoming familiar with the unknown activities of digitizing speech and analysing acoustic sound curves).

Even at a very early stage I had a notion that analysing only the first sentence would be unsatisfactory as a basis for PR-studies. Therefore, for some informants two similar sentences (4 and 6) were digitized as well.[12] These have not been systematically analysed yet. Professor Lehiste (personal communication) suggested that looking at two more sentences (7 and 12) might be interesting. The reasons given were that sentence 7 represents a yes-no question, and sentence 12 would give the lowest possible Fo value, marking finality.[13] Actually, as for sentence 7 an extra high onset might be expected, caused by a maximum effect of micro intonation: a voiceless fricative /ʃ/ preceding the close vowel /i:/. But, seen in relation to sentence 1, the PR-value of sentence 7 varies from informant to informant as 'The effect of vowel intrinsic pitch is negligible in unaccented syllables' (Ladd and Silverman 1984:31). And some readers have stressed *she* whereas others have not.[14]

It is worth noting that the readings used for the auditive analysis (five from each area) were not all suitable for instrumental analysis. In spite of the fact that these had been carefully selected as 'good readings' and fit for auditive analysis, very few could be used for acoustic analysis. Therefore, the final results reported here cover quite a few other informants, and many more informants from each area. According to Professor Victor Zue, MIT, (lecture, Edinburgh, 1988) one needs a great amount of data in order to draw conclusions from acoustic measurements.[15] Thus the plan of using readings by native RP speakers among our students for comparison had to be dropped for lack of enough data. The UCL study (Barry et al. 1989; cf. fig. 3) was welcomed for comparison.[16]

Results of the study reported here compared with those of the UCL-study are illustrated in fig.4. The histogrammes illustrate a marked difference in the use of pitch range of the Norwegian students from Hordaland and RP speakers.

Table 2a. 90% range in octaves from 1st-order Dx analysis for 2 male and 2 female native speakers in 6 languages

	Speakers			
	F.1	***F.2***	***M.1***	***M.2***
Danish	**0.67**	**0.59**	**0.51**	**0.47**
Dutch*	**0.71**	**0.67**	**0.47**	
English	**1.30**	**1.15**	**1.03**	**1.03**
French	**0.47**	**0.99**	**0.55**	**0.79**
German	**0.71**	**0.55**	**0.59**	**0.51**
Italian	**0.83**	**0.67**	**0.71**	

Figure 3. Table borrowed from Barry et al. 1989.

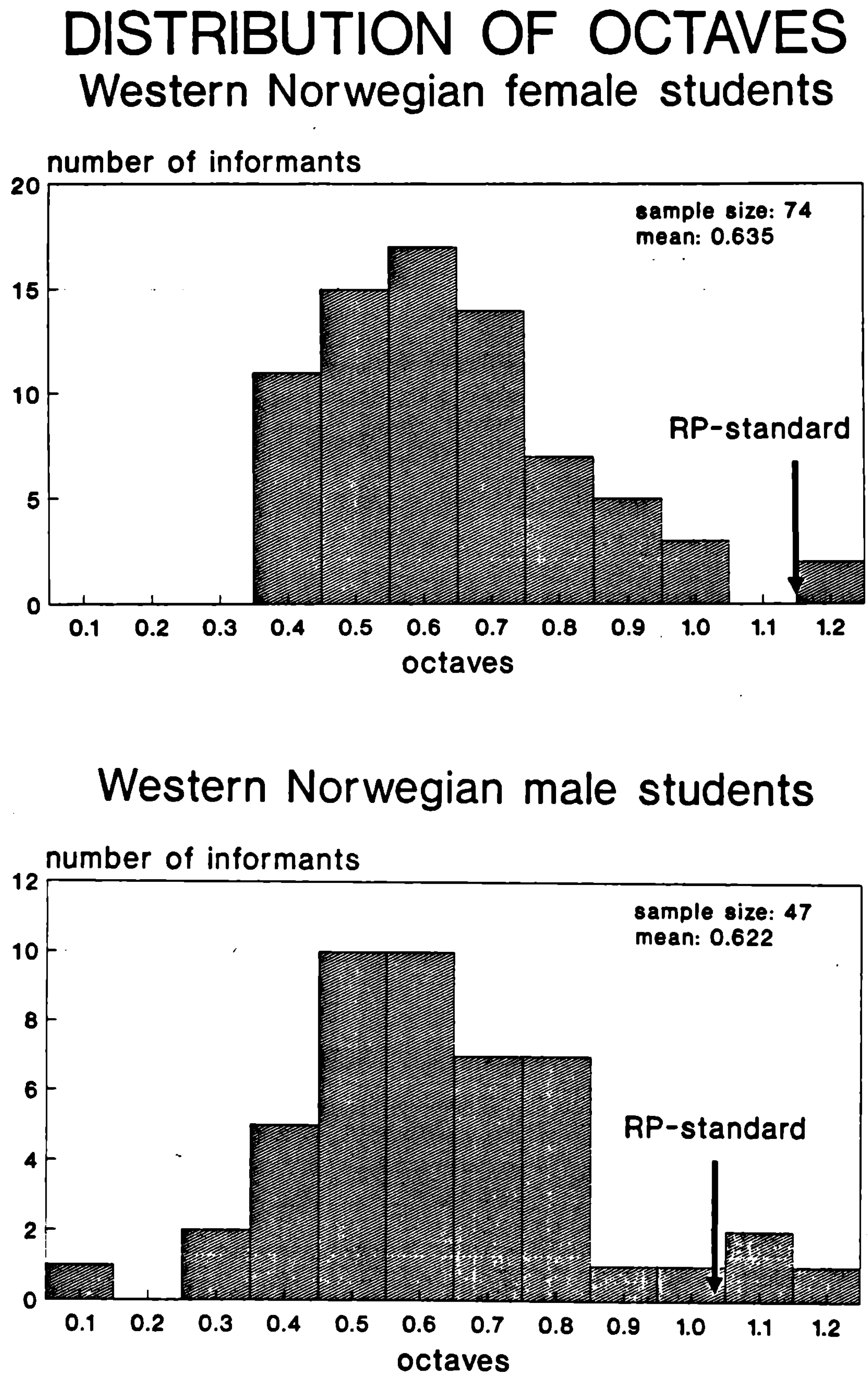

Figure 4: The lower values given for English (RP) (fig. 3) are indicated here. Both histogrammes show that more than 90% of the Norwegian informants use a pitch rang lower than that indicated for English. (A few falsetto voices cause the mean value in the male-student histogramme to appear too high).

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It is also interesting to see that the octave values for Danish in fig. 3 come very close to the mean PR values of the present study of Norwegian speakers.

The validity and value of the work referred to can be discussed. The problem of the use of only the 1st sentence (so far) is one point in question (cf. notes 11 and 13).

Pitch range will vary in the use of one and the same speaker at the same time as it is obviously language specific. Hall (1972) states that the use of a wide PR is one of the most characteristic features of British English. Further de Pijper (1983:91) points to the difference between British English and Dutch in the total PR covered, indicating a ratio of 12:6 semitones, i.e. 1:1/2 octave.

PR is recognized as a paralinguistic feature; nevertheless, according to Esling and Wong (1983) it can influence intelligibility. A too narrow range gives an impression of weariness (cf. Abe 1980). Thus lack of interest, which might amount to impoliteness, could be demonstrated unintentionally by a Norwegian speaking English. According to Crystal (1969) PR is a regular and important means of emotional expression. In spite of Professor Lehiste's contention that PR is is of no interest linguistically (personal communication), it must be said to be of interst communicatively. In a symposium on 'Intonation: models and parameters' at the XII International Congress of the Phonetic Sciences, Aix-en-Provence, August, 1991, Professor Nooteboom claimed that phoneticians still know too little about the so-called paralinguistic features. The point is that synthetic speech reveals what features are vital for 'naturalness'. Thus knowledge about PR differences must also be of interest pedagogically.

Finally, a few concluding remarks are in order.

The PC has made phonetic research more accessible, as such studies can be pursued without assistance and access to a laboratory. How demanding this is will depend on the background of the analyst. It is difficult to be a multi-specialist. I would like to contend that thorough linguistic and phonetic knowledge of the language to be studied is a must, as this takes a long time to acquire. The acoustics of speech must be said to be a more limited area. It seems a less time-consuming task to acquire the knowledge of acoustics needed to be able to use the programmes available today for this kind of research. Nevertheless, a visit to a phonetic laboratory would no doubt be useful. To be acquainted with studies in speech perception is a necessity. Here help is to be found in recent literature on the subject.

Notes

1. *Prosody* comprises suprasegmental features of speech such as *stress*, *tone*, and *quantity*. The term *intonation* refers to the tonal movement of an utterance, i.e. variations in *pitch*, of which the fundamental tone (Fo) is the physical correlate. The Fo curve pictures the frequency of the vibrations of the vocal cords. For this project sound curves have been produced on the PC screen by the aid of the digitizing programme MSL (cf. Dickson 1985; Lysne 1989). The sound signal was transferred from a JVC cassette recorder/player. Detailed Fo analysis has been performed by the additional programme MSLPITCH (cf. Dickson 1987).

   Sentences digitized for analysis:
   1. William went to bed very early that evening.
   4. He hadn't heard from Jane since he sent her the wire.
   6. He had said something about a missing coat.
   7. Could she have found out so soon?
   12. After all it didn't matter.
2. Cf. t'Hart et al. 1990:24: 'The satisfaction which phoneticians may feel with the enormous progress made during the last decade in the automatic determination of Fo is overshadowed by

the fact that the finer the performance of the techniques applied, the more it becomes apparent how irregularly the vocal folds vibrate'.

3. The recordings used as material here (a by-product of a diagnostic test) were actually recorded in a speech-lab (class room) with 20 booths/readers). The equipment was the cassette recorder of Tandberg IS8, type: TCR 5500, 2 tracks, with attached headphone.
4. In the MSL-programme this is corrected by adjusting the "configuration file" as one listens in while changing/rectifying the appropriate values. In our case this was necessary when changing to a computer with greater capacity than the one first applied.
5. Cf. comment heard in a Norwegian radio (NRK) programme on music: 'Tid er musikkens verktøy' (= time is the tool of music). This might also apply to speech and hearing.
6. Very often this will be the second harmonic (with a frequency like Fo multiplied by 2, which will be the same as the OCTAVE VALUE of the fundamental (cf. Clark and Yallop 1990:210: 'Complex sounds pose a curious problem. ...It does not matter what the amplitude of that fundamental is in relation to the other harmonic components of the sound. ... even if the fundamental is removed by some form of electronic processing..., a pitch corresponding to the fundamental, known as the 'phantom fundamental,' will still be perceived ... .
7. What is originally digitized by the MSL programme will still be in the file. Cleaning/repairing an Fo curve in MSLPITCH affects only the visual curve, and the statistics conforms to this. (The original signal can always be reloaded and analyse again e.g. with changed parameters).
8. At an early stage in my work I blamed this 'end-problem' on poor recordings. However, the fact seems to be that this is a general problem in accoustic research of speech, as endings, especially in longer units, are very often weak because of lack of intensity.
9. According to Collier (1989) this downdrift was named DECLINATION by Cohen and t'Hart (1965); cf. also Thorsen (1980); Cohen, Collier, and t'Hart (1982); de Pijper (1983); t'Hart, Collier, and Cohen (1990).
10. The most frequent problems detected and listed as interesting were:
    1. The un-English finishing off of an intonation unit. What can be wrong with the fall/rise of a Norwegian speaking English?
    2. The starting-point/'onset' is not high enough (as verified by teaching experience).
    3. Is there a lack of use of 'pitch range' in 'Norwegian English'? (a phenomenon closely related to point 2; also verified by teaching experience).
    4. The overall tone pattern in a unit is not particularly English; do we move about/jump up on unstressed syllables where native speakers keep a steady course?
    5. What are the reasons for un-English rythm in 'Norwegian English'? (Is this a question of timing/lack of deaccenting?)
11. The choice of the first sentence for PR-studies has been questioned by experts, as the first sentence will normally be pronounced on a higher pitch than what follows (Noven, Slethei, and Lehiste) (personal communication). But in the recording-situation the informants had to read a sentence in Norwegian introducing themselves as a start. (Ex.: "Dette er student nr B 18 V 79." (10-12 sylls, statement, new information; as for the code see below). How far this introduction in Norwegian influenced the immediately following performance in English will be left here as an open question).

    However, considering the fact of the higher pitch of the first unit, this cannot be said to be negative, or make the work presented here particularly unreliable, as it does not support, but rather refute the underlying hypothesis and findings of this study: that Norwegians, westerners in particular, do not use enough PR when speaking English as their onset is not high enough.

    The original code of the student/reader is used as filename in the PC directory: B refers to lab-number, *18* to the booth, *V79* refers to term (Spring 1979). The number of the sentence is added to this: B18V791 will be the filename of the sentence 'William went to bed very early that evening' of a reading that can be traced back to the tape.

12. Similarity here refers to kind of information, length, and grammatical structure.
13. It would be enormously time consuming and demanding as for PC-capacity to go into all these sentences in detail. Therefor, only a few spot checks have been made, revealing PR-values slightly different from those of sentence 1 as expected; but so far the hypothesis behind this work has not been disproved. Octave values of other units (sentences 4, 6, 7, and 12) analysed so far (about 20 in number) have been below those reported for RP (cf. fig. 4.)
14. 'As for vowel-intrinsic pitch, the difference in Fo between close and open vowels may amount to three semitones (0.25 octave). Thus, it is plausible that such a difference can be perceived, even in the dynamic situation of speech melody, and even though it has been reported ... that listeners tend to at least partially compensate for the effect' (t'Hart et al. 1990).
15. Professor Fry (UCL, 1976, personal communication) suggested three informants per area for aural analysis of speech. Here one need not distinguish between male and female speakers. In an acoustic analysis, on the other hand, these have to be kept apart, because of physiological differences. In this study I aimed at five male and five female voices from each area. For some areas the number is lower because of the lack of acceptable recordings.
16. This study was approved of by Professor Lehiste as valid for comparison (personal communication). Very little is to be found about PR in the literature. The reason for this is easy to see, as this kind work would be difficult to do without the computer. Experts only would be able to appreciate the amount of work behind such a study. It is particularly interesting that at the European Conference on Speech Technology, Edinburgh, September 1987, my inquiries about PR studies in English yielded no results. Two years later at the European Conference on Speech Communication and Technology, Paris, September 1989, the UCL study was reported.

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