

The Effects of Lombard Speech on Vowel Formant Measurements

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1 Forensic Phonetics

In the area of forensic phonetics, forensic speaker comparison (FSC) cases involve comparing a disputed sample of speech (DS) such as hoax emergency calls, bomb threats and recordings from wiretap, with a known speech sample (KS) of a police suspect in order to assess the likelihood that both have been produced by the same speaker. Using auditory and acoustic analysis forensic phoneticians compare the speech of the DS and KS along a number of parameters including fundamental frequency and vowel formants for example.

2 Lombard Reflex

The fact that we tend to speak more loudly in the presence of background noise was first discovered by Etienne Lombard in 1909. It has also been established that people show the Lombard reflex when speaking on the telephone especially the mobile phone.

3 Why Lombard Speech?

In the majority of cases the DS is an open field recording involving environmental noise and speakers tend to be more stressed, agitated and speak more loudly. In addition, 90% of DS samples are transmitted over the telephone. Taken from police interviews the KS samples on the other hand are usually produced in relatively quiet settings. Based on this we may assume that a high number of FSC cases involve comparing modal speech with Lombard speech. Consequently, it is of great importance to know the auditory and acoustic effects of Lombard speech, and in particular which parameters show reliable changes and which are less consistent between speakers.

Why Vowel Formants?

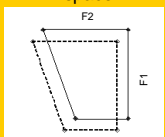
Formants carry speaker- specific information as they are dependant on the anatomy of the vocal tract. They also give insight into individuals' habits of articulation.

4 Hypothesized Patterns

- based on previous research an increase in F1 is expected
- various possible patterns could be expected for F2

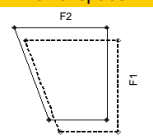
Pattern A

Fronting of vowel space



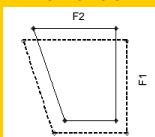
Pattern B

Retraction of vowel space



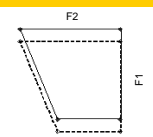
Pattern C

Peripheralisation of vowels



Pattern D

No change in F2



5 Methodology

Data:

- 10 male native German speakers from Pool 2010 corpus recorded at the BKA, Germany
- Spontaneous speech

Parameters:

- vowel formants F1, F2 and F3

Analysis:

- Acoustic analysis using Praat

Recording Conditions:

- 'Free' setting with no background noise
- Lombard setting with 80db of white noise over headphones

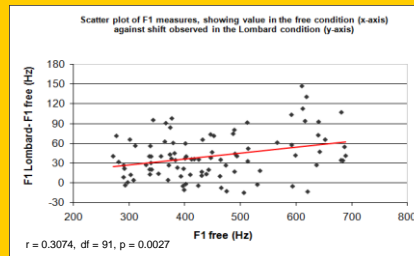
7 Implications for FSC

There is a consistent effect of Lombard speech on F1 in that it is increased when vocal effort is increased. Regarding vowel formants F2 and F3, however, the results do not offer a basis for developing a typology that captures the effects of Lombard speech and this renders the application of a normalisation procedure across modal and Lombard speech difficult. Previous research on the effects of telephone transmission on vowel formants concluded that F1 measurements are severely affected while F2 and F3 remain relatively stable across recording conditions. Consequently, caution has been advised when comparing F1 in case work. **In light of the present findings, caution is advised not only when comparing F1 but also F2 and F3.**

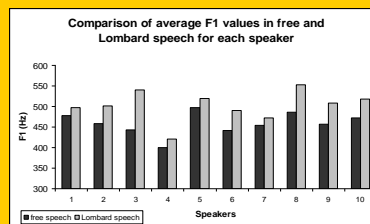
Findings

F1

- F1 tends to increase in Lombard speech
- low vowels (those with a high F1) show a larger increase in F1 when produced in Lombard speech compared to other vowels

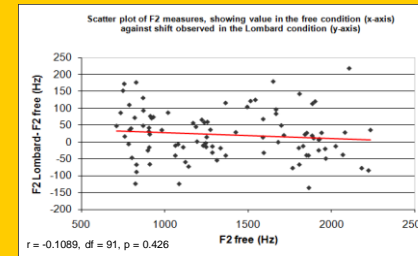


- uniform direction of change in F1 across speakers but variation in terms of size of shift e.g. speaker 3 shows an increase of 22%, speaker 4 shows no notable increase



F2

- F2 results are very variable and no general pattern emerged
- variation in terms of direction of change in F2: increasing, decreasing and no correlation



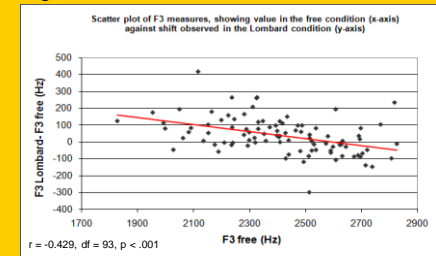
- due to intra-speaker inconsistencies it is not possible to assign each speaker to one of the hypothesized patterns. We can only draw out slight tendencies

speaker	tendency for front vowels	tendency for back vowels	overall tendency
1	decreasing	increasing	contracting
2	mixture	increasing	unclear
3	increasing	increasing	fronting
4	increasing	slightly increasing	slightly fronting
5	mixture	increasing	unclear
6	increasing	mixture	unclear
7	slightly decreasing	mixture	unclear
8	slightly increasing	slightly increasing	slightly fronting
9	slightly increasing	slightly decreasing	peripheralising
10	slightly decreasing	slightly decreasing	retracting

F3

F3 was relatively stable across speaking conditions

- tendency that low F3 values in the free condition are more likely to be increased in the Lombard condition than high F3 values



- speakers with low F3 values in free condition (3, 4, 7) have a greater increase in F3 in Lombard condition than those who already have a high F3 (1, 5, 6, 10)

