Speak up please: towards stimulating vocal effort changes in the recording of suspect material

*Michael Jessen*
Department of Speaker Identification and Audio Analysis, Bundeskriminalamt, Germany

*Marianne Jessen*
Voicetrace, Wiesbaden, Germany

www.stimmenvergleich.de
Dr.M.Jessen@stimmenvergleich.de

www.voicetrace.de
info@voicetrace.de
## Phonetic correlates of loud speech

<table>
<thead>
<tr>
<th></th>
<th>increased vocal effort</th>
<th>shouted speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>overall amplitude</td>
<td>raised from ca. 60 dB\textsubscript{SPL} to ca. 65-80 dB\textsubscript{SPL}</td>
<td>raised to ca. 95 dB\textsubscript{SPL}</td>
</tr>
<tr>
<td>spectral tilt</td>
<td>relative amplitude increase in higher frequencies</td>
<td>relative amplitude increase in higher frequencies up to a saturation point</td>
</tr>
<tr>
<td>average f0</td>
<td>raised from ca. 120 Hz to ca. 160 (men)</td>
<td>raised to ca. 350 Hz (men)</td>
</tr>
<tr>
<td>formant frequencies</td>
<td>raised F1 (due to jaw lowering)</td>
<td>raised F1, but formants difficult to measure due to substantial f0 increase</td>
</tr>
<tr>
<td>intelligibility</td>
<td>increased</td>
<td>decreased</td>
</tr>
</tbody>
</table>
Vocal effort in forensics

• Vocal effort is not a speaker-specific feature, but it influences other speaker-specific features, such as f0.
• Therefore it is legitimate to stimulate a suspect speaker to produce a loudness level that is similar to that of the unknown speaker.
• Standard method (e.g. BKA instructions): instruction to speak up. Problems:
  ➢ Soon after loudness increase, return to normal
  ➢ Uncooperative speakers: instruction is ignored or counteracted
• Therefore, searching for other methods with the properties
  ➢ Stability of change over time
  ➢ Conscious control impossible or difficult
Methods to elicit loud (and soft) speech

increased vocal effort
• Instruction to speak louder / x-times as loud (soft)
• Lombard experiment
• Increasing distance to partner
• Level meter reading above (below) given threshold
• natural settings with stress or emotions

shouted speech
• Instruction to be as loud (soft) as possible (e.g. in phonetograms / voice range profiles)
• natural settings with stress or emotions
Case 1: Insurance fraud

Anonymous call at police station, implicating another person of insurance fraud.

Vocal effort levels changed during the course of this call.

In order to stimulate increased vocal effort levels, a „mobile“ Lombard experiment was conducted as part of a court session.
Window 1: presenting white noise over closed headphone

Window 2: Recording of suspect, with constant microphone distance and input gains
### Case 1: Insurance Fraud

<table>
<thead>
<tr>
<th>Vocal effort</th>
<th>Mean f0</th>
<th>Suspect:</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>119 Hz</td>
<td>102 Hz spont. below normal</td>
</tr>
<tr>
<td>raised</td>
<td>148 Hz</td>
<td>106 Hz reading under Lombard slightly raised</td>
</tr>
<tr>
<td>loud</td>
<td>220 Hz</td>
<td>129 Hz spont. emotional raised</td>
</tr>
<tr>
<td></td>
<td></td>
<td>104 Hz reading normal</td>
</tr>
</tbody>
</table>
Case 1: f0 and amplitude relative to population data (Pool 2010)

Increase due to Lombard condition in this case
Case 1: results

- Suspect belongs to those speakers who react to the Lombard condition with only a slight increase in vocal effort. Furthermore, the increase of f0 relative to this loudness increase is surprisingly small.
  - can the Lombard effect and its influence on f0 be consciously suppressed?

- Even when vocal effort is the same, the f0 values are somewhat higher for the questioned speaker than the suspect. Influence of stress?

Result: non-liquet regarding f0, i.e. neither sufficient evidence for nor against identity
Case 2: Threat by Neo-Nazi

Mean f0 at 396 Hz (after correcting errors)

This is high compared to other studies on shouted speech (Barfs, 2005; Rostolland, 1982; Nawka et al., 1997).
Case 2: Recording of suspect

- The original intention was to stimulate shouted speech.
- Soon it was clear that the amount of cooperation required for such a task was not there. Instead, the following methods were used to stimulate any increase in vocal effort:
  - Distance method (a large room was requested in advance)
  - Provocation (speaking louder due to stress and emotion)
Case 2: suspect recording in amplitude-f0 plot

- Large distance to microphone
- Slightly raised distance to microphone
- Normal distance to microphone
Increase ST/dB is larger in speech with strongly raised than with normal to weakly raised vocal effort (cf. Buekers & Kingma, 1997).
Case 2: Result

• Questioned: above-average f0 for shouted speech

• Suspect: above-average slope ST per dB. (In Buekers & Kingma, 1997 on average only 3 ST/10dB or 4.5 ST/10dB with higher vocal effort)

• These two observations are consistent: above-average f0 in shouted speech can be interpreted as extrapolation of above-average slope ST/dB (identity at least possible).
Case 3: Rape

17-year old rape victim talks to presumed rapist, who speaks softly in the background.

Questioned material was very short and of low quality. F0 was nearly the only information that could be analysed (slightly below 100 Hz).

The issue raised by the court was whether identity was possible at all.
Case 3: Suspect recording

The goal was to elicit speech at both normal vocal effort and speech at a softer level.

From a previous statement the defence was aware that f0 behaviour was at issue. It was possible that the suspect would speak unnaturally and avoid soft voice.

Methods:

- Meter reading in combination with
- Loud feedback („Sidetone Amplification“; Siegel & Pick, 1974)
Case 3: amplitude-f0 plot

![Graph showing a plot of amplitude vs. mean f0, with data points and a trend line.](image-url)
Case 3: Experiment with unrelated speakers

F0 values of the suspect were comparatively low
Case 3: Results

• Meter readings have successfully stimulated a variety of vocal effort levels. The effect of loud feedback (sidetone amplification) was probably less deciding.

• Contrary to what might have happened, the suspect spoke with normal and partially soft voice even without the experiment.

• Mean f0 was similar and below average (below 100 Hz) both in the questioned and the suspect material. Their identity could not be ruled out.
Conclusions

- The Lombard experiment is a good and established method of stimulating increased vocal effort. However, more research is necessary on whether and in what ways the effect can be influenced consciously.

- **Meter reading** is an effective way of stimulating a whole „staircase“ of vocal effort levels. But the visual channel is occupied (reading not possible) and spontaneous speaking along with meter reading is probably too difficult cognitively. More methodological research is necessary.

- **Natural stress and emotion** can influence vocal effort effectively but is difficult to stimulate and control, and it might have its independent influence on f0. But it is the sort of thing that is frequently found in questioned recordings, so it is useful to have samples from this speech style available for comparison.