INTERSPEECH 2021
30 August – 3 September, 2021, Brno, Czechia

Voice Quality in Verbal Irony: Electroglottographic Analyses of Ironic Utterances in Standard Austrian German

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Abstract

When using verbal irony in interpersonal communication, paraverbal cues can reduce the risk of misunderstandings. Besides fundamental frequency, intensity and duration, speakers could use voice quality parameters to disambiguate between ironic and literal utterances. How these paraverbal cues are used to mark irony appears to be language- and/or culture-specific. Since the role of voice quality in ironic utterances has not yet been investigated in Austrian German, the present study addresses this issue. In addition to the acoustic signal, the vocal fold vibration is recorded via electroglottography (EGG). The detailed analysis of the EGG data as well as the acoustic data, provides insight into voice quality characteristics of ironic and literal realisations of short utterances. The analyses reveal that, in Standard Austrian German, some differences in voice quality exist between ironic and literal realisations of utterances: When being ironic, speakers' voices tend to be breathier, creakier or rougher. Differences are more pronounced in the older age group and in male speakers.

Index Terms: Electroglottography, voice quality, verbal irony, sarcasm, Standard Austrian German

1. Introduction

In everyday communication, especially in communication amongst friends, verbal irony is frequently used. However, sometimes the use of verbal irony leads to misunderstandings when the listener does not realise that an utterance was intended to be ironic. To reduce the risk of misunderstandings, most speakers apply disambiguating cues to highlight being ironic. These cues can be verbal, non-verbal, or paraverbal. With regard to paraverbal cues, it has been shown that mainly fundamental frequency (F0), intensity and durational cues are used to mark irony [e.g. 1–9]. How these cues are used is, at least partly, language specific [e.g. 4]. In general, studies on irony in German (in Germany) showed a lower average F0, smaller F0 variation, a lower mean intensity, and longer segment durations in ironic utterances as compared to literal utterances. Only a few studies analysed voice quality parameters in ironic and literal utterances in German (in Germany): By investigating amplitude differences between the first and second harmonic (H1-H2), Niebuhr [10] found a more variable, mainly breathier or tenser, voice quality for ironic utterances. However, other studies investigating harmonics-to-noise ratio (HNR) [11] or jitter and shimmer [7] did not find significant voice quality differences between ironic and literal utterances. Due to differences in the prosody between German German and Austrian German [12], these few results can not be transferred to Austrian German speakers. Until now, besides a tiny pilot study [13], no investigations of voice quality in ironic utterances of speakers of Standard Austrian German (SAG) exist. Especially, there are no investigations including the analysis of electroglottographic (EGG) recordings of SAG speakers.

In order to address this issue, the present study recorded speakers of SAG acoustically as well as via EGG. EGG allows to specifically track the vocal fold vibration characteristics. The EGG waveform reflects the vocal fold contact area: during closing, the amplitude rises, reaching the maximum when the vocal folds are completely closed; during opening the amplitude decreases, reaching the minimum when the folds are completely open. The different phases of glottal cycles and their equivalent in the EGG signal are described and analysed in [14]. An analysis of differences between EGG waveforms with respect to different voice qualities can be found in [15]: E.g. the EGG of modal voices shows a steep increase in the closing phase and an open quotient (OQ) of about 50 %; a breathy voice is mainly characterised by a long open phase and a reduced EGG amplitude [15].

The aim of the present study is to analyse whether Austrian speakers use voice quality differences to disambiguate between ironic and literal utterances.

2. Methods

Twenty speakers of Standard Austrian German (SAG; as defined by [16, 17]) were recorded using audio and EGG. They were balanced for gender (10 male, 10 female) and age (10 young: 23-31 years; 10 old: 45-60 years). For three female and two male speakers only audio recordings were available for analysis due to malfunction of the EGG device.

Targets were ten short utterances comprising two syllables in either one or two words (e.g. "Spannend!" *'Exciting!'* or "Sehr gut!" *'Very good!'*). All utterances had a literal positive meaning. In order to elicit the material for the present study, the utterances were embedded in short scenarios evoking either an ironic or a literal (= sincere; not neutral) manner of production. Audio and EGG recordings were conducted in a sound-attenuated booth (IAC-1202A). All speakers were recorded producing each utterance twice in each, literal and ironic, manner, resulting in a total of 800 utterances. Since EGG recordings can only be analysed during voiced portions of the signal, only the stressed vowel of each utterance was analysed. The acoustic data was manually annotated and segmented using STx [18]. Segment boundaries of the audio were transferred one-to-one to the EGG signal.

In a first step, the EGG data was analysed in Praat [19] using an adapted version of the script Praatdet [20]. Originally, the script extracts the following values from EGG signals:

http://dx.doi.org/10.21437/Interspeech.2021-452

- Start and end of each period (start = peak in the first derivative of the EGG signal (DEGG) = closing peak (T1 in Figure 1); end of period = next closing peak in DEGG (T4 in Figure 1)),
- F0 calculated from the length of period,
- Open quotient (directly calculated from the durations).
- Open quotient calculated by the Howard method [21].

In addition to this, the script was adapted to export the following values for each period:

- Time of the negative peak (= opening peak) in DEGG (T3 in Figure 1),
- Time point of the maximum amplitude of each glottal cycle in the EGG (maximum contact) (T2 in Figure 1),
- Amplitude of the DEGG closing peak (T1 in Figure 1).

All automatically determined time points of the maxima and minima of each segment were manually checked. If necessary, the positions of the time points were corrected. In total, 10982 glottal cycles were analysed.

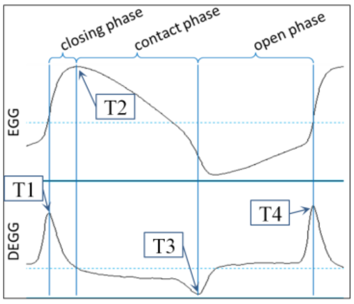

Figure 1: *Phases of a glottal period in the EGG and DEGG signal (T1: closing peak, T2: time of maximum contact, T3: opening peak, T4: next closing peak)*

One glottal cycle goes from a positive peak in the DEGG to the next positive peak in the DEGG. As shown in Figure 1, the closing phase starts at the first DEGG peak (T1) and ends at the maximum of the EGG signal within the period (T2). The contact phase starts at the maximum of the EGG signal (T2) and ends at the negative DEGG peak (T3). There the open phase starts, which ends at the next DEGG peak (T4). From these durations, the following parameters were calculated:

- Open quotient (OQ = open phase ⁄ period duration),
- Relative duration of the contact phase (contact phase ⁄ period duration),
- Relative closing duration (closing phase ⁄ period duration),
- Relative closing slope duration (closing phase ⁄ (closing phase + contacts phase)).

Moreover, the EGG and the acoustic signal were analysed using Voicesauce [22], extracting the following parameters:

- Amplitude differences between the first and second harmonic (H1-H2; corrected and uncorrected),
- Harmonics-to-noise ratio (HNR, bandwidth 0-3500 Hz).

The analysis resulted in 114543 measurement points for the acoustic data and 86754 measurement points for the EGG data. Since H1-H2 measurements are highly sensitive to an influence of formant frequencies [23], corrected H1-H2 values were used for the analyses of the acoustic signal. Moreover, uncorrected H1-H2 measurements of the EGG signal were used to have direct H1-H2 values of the source signal.

In addition, a slightly modified version of the Praat script voice-report [24] was used to extract from both, the acoustic signal and the EGG signal, the following variables:

- Jitter (microvariations in F0; relative average perturbation (RAP)),
- Shimmer (microvariations of the amplitude; 5-point amplitude perturbation quotient (APQ5)).

The data was analysed statistically with R [25] by fitting linear mixed-effects models (lme4 package [26]) followed by post hoc tests (emmeans package [27]), when necessary. F-statistics and *p*-values were obtained by using the anova function of the lmerTest package [28]. The models were fitted using a forward approach: Effects were added one by one. Based on the p-value (threshold: *p*=0.1), it was decided to keep the variable or interaction in the model or to exclude it. Participant and word were included in the models as random factors. The independent variables and control variables were: manner, age group, gender, vowel, repetition, F0 of the vowel, and vowel duration. These variables and possible interaction of the variables were included in the model, whenever they had an effect on the dependent variable. Models were fitted for the following dependent variables: period duration, SD of period duration, open quotient, Howard open quotient, relative contact duration, relative closing duration, relative closing slope duration, DEGG amplitude, $\text{H1-H2}_{\text{EGG}}$, $\text{H1-H2}_{\text{acoustic}}$, HNR_{EGG}, $\text{HNR}_{\text{acoustic}}$, $\text{jitter}_{\text{EGG}}$, $\text{jitter}_{\text{acoustic}}$, $\text{shimmer}_{\text{EGG}}$, and $\text{shimmer}_{\text{acoustic}}$. To avoid an influence of large differences in the number of glottal periods or analysis points per vowel due to differences in vowel length (range: 39.81ms – 789.81ms; mean: 150.67ms, SD: 76.63ms) and F0 (range: 51.44 Hz – 552.30 Hz; mean: 177.21 Hz, SD: 79.22 Hz), for each extracted parameter of each utterance realisation, mean and standard deviation (SD) were calculated.

3. Results

3.1. Period duration

The fitted mixed-effects model for the period duration resulted in a significant effect of the vowel of the utterance (F(5,8)=24.350, *p*<0.001) and a significant interaction between gender and manner of realisation (ironic vs. literal) (F(1,557)=5.662, *p*=0.018). Post hoc analyses revealed an effect of manner with longer period durations in the ironic realisations for both, male and female speakers (female: t(559)=5.020, *p*<0.001; male: t(559)=8.848, *p*<0.001). Concerning the SD of the period duration, no effect of manner was found (F(1,573)=0.107, *p*=0.744).

3.2. Open quotient

With regard to the open quotient (OQ), the statistical analyses showed an interaction between age group and manner (F(1,566)=4.301, *p*=0.039), significant effects for F0 (F(1,404)=27.681, *p*<0.001; higher OQ for higher F0), repetition (F(1,566)=9.525, *p*=0.002; higher OQ in the first realisation), and vowel (F(5,571)=4.104, *p*=0.001). The post hoc analyses of the interaction revealed a significant effect only for the older age group with higher OQ for the ironic realisations of the utterances (older: t(574)=2.653, *p*=0.008; younger: t(573)=0.100, *p*=0.920) (Figure 2). Since the Praatdet script [20] additionally provides open quotient data calculated by the Howard method, this data was equally analysed. The results were similar to the aforementioned results.

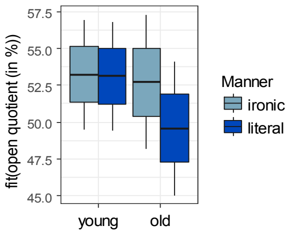

Figure 2: *Fitted open quotient values – manner*age interaction*

3.3. Relative contact duration

With respect to the relative duration of the contact phase, significant effects of F0 (F(1,437)=47.722, p<0.001; shorter contact phase for higher F0), repetition (F(1,567)=10.555, p=0.001; longer durations in the second round) and vowel (F(5,9)=4.260, p=0.027) occurred. For manner of realisation, no significant effect was found (F(1,570)=2.105, p=0.147).

3.4. Relative closing duration

Concerning the relative duration of the closing phase (in relation to each glottal cycle), the fitted mixed-effects model revealed a significant effect of F0 (F(1,138)=9.316, p=0.003; longer closing duration for higher F0) and gender (F(1,17)=11.571, p=0.003; longer closing duration for female speakers). The manner of realisation had no significant effect on the relative closing duration (F(1,560)=1.032, p=0.301).

3.5. Relative closing slope duration

The fitted mixed-effects model for the relative duration of the closing slope resulted in a significant effect of F0 (F(1,580) =53.446, p<0.001; steeper closing slope for lower F0), gender (F(1,18)=10.249, p=0.005; steeper closing slopes in male speakers), and vowel (F(5,567)=2.684, p=0.021. The manner of realisation did not have a significant effect on the relative duration of the closing slope (F(1,570)=0.306, p=0.580).

3.6. Amplitude of DEGG peak

For the amplitude of the DEGG opening peak, an effect of repetition (F(1,575)=11.295, p<0.001; higher DEGG amplitudes in the second round), of vowel (F(5,575)=21.278, p<0.001), and a manner*gender interaction (F(1,575)=7.583, p=0.006) were found. Post hoc analyses revealed a significant effect of manner only for male speakers with a higher peak in literal utterances than in ironic utterances (male: t(570)=-2.346, p=0.019; female: t(570)=1.550, p=0.122) (Figure 3).

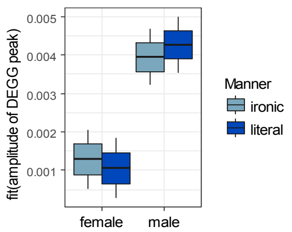

Figure 3: *Fitted DEGG amplitude – gender*manner interaction*

3.7. Jitter

In the EGG signal, the analyses of the jitter$_{EGG}$ values revealed a tendency for an interaction of gender and manner (F(1,548)= 3.335, p=0.068). Post hoc tests showed only for female speakers a tendency for a higher jitter in literal utterances (female: t(544)=-1.819, p=0.070: male: t(545)=0.717, p=0.474) (Figure 4 left). In addition, significant effects of repetition (F(1,548)=6.139, p=0.014; higher jitter values in the first realisation), and vowel (F(5,548)=5.595, p<0.001) emerged.

For the acoustic signal, the mixed-effects model revealed a significant effect of manner (F(1,755)=7.228, p=0.007) with higher jitter$_{acoustic}$ values in the ironic realisations of the utterances as compared to their literal counterparts (Figure 4 right). Moreover, main effects of gender (F(1,20)=6.435, p=0.020) and repetition (F(1,755)=4.383, p=0.037) occurred.

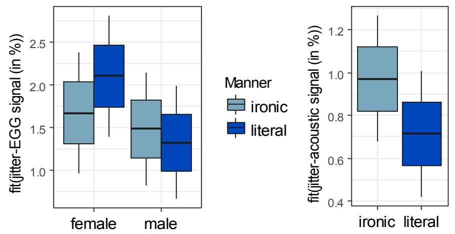

Figure 4: *Fitted jitter values in EGG: gender*manner interaction (left) and jitter values in the acoustic signal: main effect of manner (right)*

3.8. Shimmer

Concerning the microvariations of the amplitude in the EGG signal, the mixed-effects model revealed no significant effect of the manner of realisation (F(1,510)=0.415, p=0.520), but effects of gender (F(1,20)=15.079, p<0.001), vowel (F(5,508) =8.457, p<0.001), and F0 (F(1,521)=8.566, p=0.004).

In the acoustic signal, besides effects of gender (F(1,26)=21.273, p<0.001), F0 (F(1,722)=19.913, p<0.001), and vowel (F(5,10)=4.390, p=0.023), a significant interaction between manner and age group was found (F(1,697)=6.566, p=0.011). Post hoc analyses showed no effect for the younger age group (t(702)=-0.450, p=0.653), but a significant effect for the older age group (t(705)=3.042, p=0.002; higher shimmer$_{acoustic}$ values in ironic realisations).

3.9. H1-H2

The difference in the amplitude between the first two harmonics of the EGG signal (H1-H2$_{EGG}$) was found to be significantly influenced by F0 (F(1,228)=9.586, p=0.002) and by an age*manner interaction (F(1,558)=4.301, p=0.039). Post hoc analyses revealed only for the older age group higher H1-H2$_{EGG}$ values in the literal realisations (older: t(577)=-2.945, p=0.003; younger: t(575)=-0.429, p=0.668) (Figure 5).

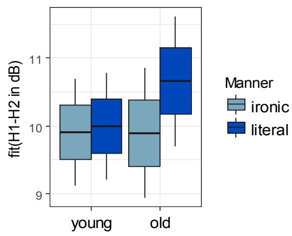

Figure 5: *Fitted H1-H2 values in the EGG signal – age*manner interaction*

For the corrected H1-H2 values of the acoustic signal, a tendency for an effect of F0 (F(1,170)=3.033, p=0.083) and a significant manner*age*gender interaction emerged ($F(1,747)=9.001$, $p=0.003$). Post hoc analyses revealed higher H1-$H2_{acoustic}$ values in literal realisations of male speakers in the younger age group and female speaker in the older age group (young male: $t(757)=-3.442$, $p<0.001$; old female: $t(762)=-2.828$, $p=0.005$), but not for the other groups (young female: $t(764)=0.111$, $p=0.912$; old male: $t(757)=-0.575$, $p=0.566$).

3.10. Harmonics-to-noise ratio

With respect to the HNR values of the EGG signal (HNR_{EGG}), a significant effect of period duration ($F(1,565)=14.376$, $p<0.001$) and an interaction between gender and manner of realisation ($F(1,555)=4.765$, $p=0.029$) occurred. In post hoc analyses, neither for female speakers ($t(556)=1.645$, $p=0.101$) nor for male speakers ($t(559)=-1.343$, $p=0.180$) the difference between ironic and literal realisations reached significance.

Concerning the $HNR_{acoustic}$, a three-way interaction between manner, gender and age was found ($F(1,747)=6.449$, $p=0.011$). Post hoc analyses resulted in significantly higher $HNR_{acoustic}$ values of the ironic realisations compared to the literal realisations in the group of younger female speakers ($t(758)=5.197$, $p<0.001$). Moreover, a significant interaction between manner and repetition ($F(1,747)=5.284$, $p=0.022$) revealed in post hoc analyses only for the second realisation higher HNR values in ironic utterances as compared to literal utterances ($t(765)=3.802$, $p<0.001$).

4. Summary and discussion

In the present exploratory study, a broad set of parameters was investigated in order to address the question whether, in Standard Austrian German, voice quality differences are used to disambiguate between ironic and literal utterances.

With respect to differences between literal and ironic realisations, the EGG measurements of the stressed vowels of the utterances revealed, first of all, a significant difference in period duration with longer periods in ironic utterances, which equals a lower F0. This finding corresponds to all former studies on irony in German showing that F0 is lower in ironic utterances compared to literal utterances [6, 10, 11, 29]. Concerning voice quality, a lower F0 could, amongst others, emerge from more creaky realisations of ironic utterances. Equally, the jitter values of the acoustic signal indicate creakier or rougher realisations of the ironic utterances as compared to their literal counterparts. In contrast to this, the jitter measurements of the EGG signal showed a tendency for a creakier or rougher voice quality in the literal realisations of female speakers. H1-H2 values of the acoustic signal hint at more creaky realisations [30] of the ironic utterances in the group of young male speakers.

Other parameters point to more breathy realisations of ironic utterances when realised by the older speakers: The open quotient hint at modal realisations of literal utterances and slightly breathier realisations of ironic utterances (OQ above 50 % [15]). Moreover, the shimmer values of the acoustic data indicate a more breathy or rough voice quality of the ironic utterances in the older age group. The OQ values of the younger speakers revealed a slightly breathy voice quality for both, ironic and literal realisations of the utterances.

For the amplitude of the DEGG peak, the analyses showed, for male speakers, lower values in ironic realisations as compared to literal realisations. The amplitude of the DEGG peak correlates with the steepness of the closure phase in the EGG signal. Thus, lower DEGG amplitudes in ironic realisations arise from a slower closing of the vocal folds, pointing to a rougher voice quality [15].

For the amplitude differences between the first and second harmonic (H1-$H2_{EGG}$) in the EGG signal a significant difference between ironic and literal realisations was found for the older age group: Ironic realisations had a lower H1-$H2_{EGG}$ value. Since the differences are quite small, they are assumed not to result in noticeable voice quality differences [31]. As a significant manner*gender interaction for the HNR_{EGG} did not result in any significant differences between ironic and literal realisations in the post hoc tests, no evidence for voice quality related differences between the manners of realisation could be found in HNR_{EGG}. In the acoustic signal, higher H1-$H2_{acoustic}$ values in the group of older female speakers and lower $HNR_{acoustic}$ values in the group of younger female speakers hint at breathier realisations of literal utterances.

Former studies revealed for ironic utterances in German in Germany a more variable, mainly breathier or tenser voice quality [10], or no significant differences in HNR [11], jitter and shimmer measurements [7]. The present study did not only analyse the acoustic signal, but additionally looks directly at the source signal by analysing the EGG signal during phonation. Similar to [10], the present results on SAG point to a breathier realisation of ironic utterances by most speakers. A rougher or creakier realisation is also possible, supporting the finding of a more variable voice quality in ironic utterances [10]. In contrast to [11] and [7], the present study did find some significant effects in HNR, jitter and shimmer of the acoustic signal, pointing to voice quality specific differences between ironic and literal realisations of utterances in Standard Austrian German. Due to methodological differences between the studies and the lack of a profound investigation of voice quality in irony in German German, the present study can not conclude on similarities or differences in irony marking between German German and SAG, but, it can be concluded that SAG speakers tend to use, beside others [29], voice quality parameters to mark verbal irony.

The interpretability of the results is slightly limited due to the fact that, on the one hand, the analysed vowels were quite short for voice quality analyses (duration range: 39.81ms – 789.81ms), on the other hand, some of the participants had to be excluded from the EGG analyses due to problems with the recordings. Since the production of sustained ironic and literal vowels is not possible, the available material should suffice for conclusive results. The second issue could be circumvented in future investigations by recording additional speakers. However, due to the highly time consuming analysis process (a test of an automatic analysis with EggWorks [32] resulted in several impossible values) and a high error susceptibility and technical limitations of EGG recordings, it was not possible to collect more data for the present study. Furthermore, the main focus of the recording session was not the collection of EGG data. Therefore, the author refrained from recording additional participants.

5. Conclusion

The present study showed that, in Standard Austrian German, ironic utterances tend to be realised with a slightly creakier, breathier and/or rougher voice quality as compared to literal utterances. These differences between ironic and literal realisations of utterances were more pronounced in the older age group and in male speakers.

6. References

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