**Smoothing factor and voice perturbation measurements**

A. Kahraman¹, M. A. Kiliç² and □. Yildirim³

¹Department of Otolaryngology, Malazgirt State Hospital; ²Department of Otolaryngology, Kahramanmaras Sütçü İmam University, Medical School

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**Abstract.** Smoothing factor and voice perturbation measurements. Objective: Although gradual frequency and amplitude variations originating from intonation or vocal instability are not related to voice quality, jitter and shimmer are sensitive to such variations. These parameters are therefore calculated by subtracting the average of a group of successive periods from the middle period; the period number that is averaged is called the smoothing factor. The aim of this study was to investigate the effect of smoothing factor size on frequency and amplitude perturbation measurements.

Methodology: A prospective study was designed, incorporating recorded voice samples from ten male and ten female healthy adult volunteers; samples were analyzed with the Multi Dimensional Voice Program for Multi-Speech. We used all low smoothing factor sizes up to 21, and then skipped smoothing factor sizes in steps of ten, resulting in 28 different levels.

Results: Smoothed pitch perturbation quotient and smoothed amplitude perturbation quotient values increased as the smoothing factor size increased. Smoothing factor size was correlated with smoothed pitch perturbation quotient and smoothed amplitude perturbation quotient values in males (r = 0.589 and r = 0.698, respectively) and females (r = 0.736 and r = 0.847, respectively).

Conclusion: Our study revealed an exact relationship between smoothing factor values and perturbation measures. At low smoothing factor values, perturbation measures are sensitive to short-term variations, whereas at high smoothing factor values, they are less sensitive to short-term but more sensitive to long-term variations.

**Introduction**

Computerized voice analysis is generally used in otolaryngology clinics for documentation and evaluation of patients with dysphonia and other voice disorders.1-4 For instance, measures of cycle-to-cycle variations in fundamental frequency (jitter) and variations in cycle-to-cycle amplitude (shimmer) have been useful in describing the voice characteristics of normal and pathological speakers.5,6 Since these variations adequately represent changes in glottal function, jitter and shimmer can also be used in voice patient follow-up analyses.7,9

Jitter is calculated by subtracting one period’s duration from the next period, while shimmer is calculated by subtracting one period’s amplitude from the next one. Although gradual frequency and amplitude variations originating from intonation or vocal instability are not related to voice quality, jitter and shimmer are sensitive to such variations. These parameters are therefore calculated by subtracting the average of a group of successive periods from the middle period, rather than subtracting a period’s value from the next one. The period number that is averaged is called the smoothing factor (SF).

In the Multi Dimensional Voice Program (MDVP, Kay Elemetrics), several perturbation parameters use different SF values, such as the pitch perturbation quotient (PPQ), the amplitude perturbation quotient (APQ), the smoothed pitch perturbation quotient (sPPQ), and the smoothed amplitude perturbation quotient (sAPQ).

PPQ is a relative evaluation of the period-to-period variability in pitch, measuring the short-term irregularity of the pitch period of the voice. The SF of five periods reduces the sensitivity of PPQ to pitch extraction errors. While it is less sensitive to period-to-period variations, PPQ describes the short-term pitch perturbation of the voice very well.

APQ provides the variability of the peak-to-peak amplitude at an SF value of 11 periods, measuring the short-term irregularity of the peak-to-peak amplitude of the voice. Smoothing reduces the sensitivity of APQ to pitch extraction errors. While it is less sensitive to period-to-period
amplitude variations, APQ still describes the short-term amplitude perturbation of the voice very well.

MDVP also permits the assignment of different SF size ranges from one to 199 during frequency and amplitude perturbation measurements. sPPQ is a relative evaluation of the short- or long-term variability of the pitch period within the analyzed voice sample at a user-defined SF (default value 55 periods). sAPQ is a relative evaluation of the short- or long-term variability of the peak-to-peak amplitude; this value is also user-assigned and defaults to 55 periods. sPPQ and sAPQ measure short-term variations at small SF values, and long-term variations at large SF values. The SF allows a parameter to be less sensitive to short-term, usually random variations occurring between consecutive pitch periods, and to be sensitive to medium- or long-term variations depending on the factor size. 10

Two other MDVP parameters are related to pitch and amplitude variations: fundamental frequency variation ($vF_0$) and amplitude variation ($vAm$). $vF_0$ is the relative standard deviation of the fundamental frequency, while $vAm$ is the relative standard deviation of the peak-to-peak amplitude.

While it is known that the SF influences jitter and shimmer measurements, an exact relationship has not yet been determined. The aim of this study is to investigate and document the effect of SF size on jitter and shimmer measurements in recorded human voice samples.

Methods

The subjects were 20 young adults (ten males, ten females), all volunteers from the Medical School of Kahramanmara Sütçü Imam University (aged 21-36 years; mean, 27.8 years; standard deviation, 2.8 years). Subjects were screened by questionnaire for existing or former problems with breathing, voice, neurological diseases, and structural abnormalities in the larynx, mouth, or throat, all of which constituted exclusion criteria. Volunteers exhibiting hearing loss, upper respiratory tract infections, or a headcold were not allowed.

The voice samples were recorded directly to a personal computer with a high-quality sound card (Sound Blaster Audigy 2 ZS) in an anechoic and noiseless room with an omnidirectional condenser microphone (Philips SBC ME 470) placed approximately 15 cm from the mouth. For this purpose, Adobe Audition v.1.5 software was used. Recorded samples were analyzed with MDVP for Multi-Speech. The speakers were asked to produce a sustained phonation of the vowel /a/ for three seconds at a comfortable pitch and loudness level. Voice samples were taken at least ten times. SF size was adjusted between three and 199 periods. We used all low SF sizes up to 21, and then skipped SF sizes in steps of ten, resulting in 28 different levels.

All voice samples were analyzed with the MDVP software, and sPPQ, sAPQ, $vF_0$, and $vAm$ parameters were measured. Pearson’s correlation coefficients between SF size and sPPQ and sAPQ were calculated with the SPSS software (Version 10.0). The threshold for statistical significance was set at $p < 0.01$.

Results

sPPQ and sAPQ values increased as SF size increased. The male samples exhibited significant correlations between SF size and sPPQ and sAPQ values ($r = 0.589; p < 0.000$ and $r = 0.698; p < 0.000$, respectively). Figures 1 and 2 show the estimated values of sPPQ and sAPQ as a function of SF size for males.

Stronger correlations were observed between SF size and sPPQ ($r = 0.736; p < 0.000$), and SF size and sAPQ ($r = 0.847; p < 0.000$) in females. Figures 3 and 4 display the estimated values of sPPQ and sAPQ as a function of SF size for females.

At low SF sizes, sPPQ and sAPQ correlated well with jitter and shimmer, but were not correlated with $vF_0$ and $vAm$. At high SF sizes, sPPQ and sAPQ were well correlated with $vF_0$ and $vAm$, but not with jitter and shimmer.

Discussion

In this study, we observed jitter and shimmer values increased as SF sizes increased. While sPPQ and sAPQ were correlated with jitter and shimmer at low SF sizes, they were correlated with $vF_0$ and $vAm$ at high SF sizes. As SF sizes increase, sPPQ and sAPQ become more susceptible to long-term changes rather than short-term changes. At high SF sizes, sPPQ correlates with the intensity of the long-term pitch period variations. 11

Few published studies have used sPPQ and sAPQ (jitter and shimmer parameters with high smoothing factor values) as voice quality parameters. 12,13 When the sPPQ SF sizes were set between 45 and 65, sPPQ was more sensitive to long-term pitch variations while SF sizes increased in patients with spasmodic dysphonia. 14
Smoothing factors and voice perturbations

Investigations of the acoustic correlates of aging in females indicated that the factors most correlated with amplitude perturbations and age were APQ and sAPQ (SF = 55); APQ alone was able to explain only one-third of the variance of the age values. Furthermore, the correlations may be improved by choosing a SF between 5 and 55 cycles.

Conclusion

Perturbation measures are sensitive to short-term variations at low SF values, whereas high SF sizes result in lower sensitivity to short-term variations and more sensitivity to long-term variations. We conclude that clinicians should consider these differences when treating voice patients. Clinicians can choose low SF sizes while determining random voice perturbations in spasmodic disphonia patients, or they can choose high SF values while determining the perturbation caused by patient intonation.

References

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Dr. Ali Kahraman
Malazgirt State Hospital Otolaryngology Department
Turkey
Tel.: 00 90 505 334 41 57
E-mail: alikahraman6@hotmail.com