

## The Dysphonia Severity Index Used With a Percentage Scale

Jan Raes<sup>1</sup>, Floris L. Wuyts<sup>2</sup>, Marc de Bodt<sup>2</sup> & Peter Clement<sup>1</sup>

<sup>1</sup>*Department of Otorhinolaryngology, University Hospital, Free University of Brussels (A.Z.-V.U.B.), Brussels, Belgium*

<sup>2</sup>*Department of Otorhinolaryngology, Antwerp University Hospital, Edegem, Belgium*

The Dysphonia Severity Index (DSI), developed by Wuyts et al. (2000a, 2000b) quantifies perceived voice quality objectively and numerically. As originally designed, the mean DSI for severely dysphonic voices equals -5, and for normal voices +5. Mathematically, this scale can be easily modified into a percentage scale where 0 % corresponds to the average DSI for severely dysphonic voices, and 100 % to the average DSI for normal voices. This DSI expressed as a percentage, is noted as DSI%. The lower the patient's index, on either the original or the percentual scale, the worse is his or her voice quality. A cutting point separating normal from abnormal voices is added to the DSI scale. The practical advantages of the renewed DSI% scale are illustrated by presenting three voice cases studied with it.

### 1. Introduction

At many voice centres all over the world, voice quality is perceptually evaluated by using the GRBAS scale, proposed by the Japan Society of Logopaedics and Phoniatics (Hirano, 1981). This scale grades five aspects of voice (G = grade of hoarseness, R = roughness, B = breathiness, A = asthenicity, and S = strain) on a four point scale ranging from 0 to 3 (0 = normal, 1 = slight, 2 = moderate, 3 = severe). This perceptual evaluation system has the advantage of being very short and practical, so that it can be easily used by phoniaticians, otorhinolaryngologists and speech pathologists, but it has the disadvantage of involving a great deal of subjectivity. Consequently, most of its users felt the need for an objective measure of dysphonia, correlating well with the general grade of perceived hoarseness, i.e. with the G factor from the GRBAS scale.

This need was also felt by the members of the Belgian Study Group on Voice Disorders (BSGVD), who satisfied it by constructing the Dysphonia Severity Index (DSI), being an objective and quantitative correlate of the voice quality auditorily perceived as G0, G1, G2 or G3. As a first step towards the construction of the DSI, the multicenter, multidisciplinary research group BSGVD (Van de Heyning et al.,

1996, 1999) collected normative data for more than 30 perceptual, aerodynamic, phonetographic and acoustic voice parameters studied in about one hundred normal control subjects and in approximately one thousand voice patients representative for the main classes of vocal pathology. In a second phase, the research team (Wuyts et al., 1999, 2000a, 2000b) used a stepwise logistic regression procedure to select, from the main parameters studied, the four voice measurements most sensitive to vocal pathology in a population of 387 adults extracted from the original database. These four most sensitive parameters turned out to be the maximum phonation time (MPT in s), the jitter value (%), the highest frequency ( $F_0$ -High in Hz), and the lowest intensity (I-Low in dB), and were used for the calculation of the Dysphonia Severity Index (DSI) with the following equation :  $DSI = 0.13 \times MPT (s) + 0.0053 \times F_0\text{-High (Hz)} - 0.26 \times I\text{-Low (dB)} - 1.18 \times \text{Jitter (\%)} + 12.4$ .

An Excel spreadsheet, having been equipped with this equation, makes the DSI immediately available, after having typed in the numerical values for its four above-mentioned determinants. For perceptually normal voices, having obtained a G0 score on the GRBAS scale, the mean DSI calculated, equals +5, and for perceptually very dysphonic voices, having received a G3 score on the GRBAS scale, it equals -5. Voices with a perceptual G1 score have an average DSI of 1.02, and voices with a perceptual G2 score an average DSI of -1.4. The standard deviation belonging to the mean DSI value +5 is 1.72.

This DSI scale is very practical for voice clinicians; they can easily and quickly interpret any DSI value obtained. If a dysphonic patient generates a DSI of e.g. +0.5, the clinician immediately understands that he or she is dealing with a slightly decreased voice, the quality of which is located somewhat underneath the lower limit of normality. When a DSI result such as +0.5 is communicated to a patient, or to another layman in the field of voice evaluation, be it a family physician or a forensic expert, however, he or she will be unable to understand what it means without receiving additional explanations from the clinician. The authors' ongoing clinical experience with the multiparameter index, however, learned that two slight modifications to the DSI rating scale, leaving the original scale basically unaltered, facilitate the communication of the DSI results, so that additional explanations by the clinician become superfluous. It is the purpose of the present contribution to describe these two methodological modifications, and to illustrate their practical utility by presenting three voice cases they have been applied to.

## 2. Methods

The first modification needed is the transformation of the DSI value as it results from the original, above-mentioned equation, into a percentage value, noted as DSI%. This transformation is very easily achieved by adding 5 to the DSI value obtained from the DSI equation, and subsequently multiplying the result by 10, or:  $DSI\% = (DSI + 5) \times 10$ . By doing so, the mean DSI% for perceptually very dysphonic

voices yields  $(-5 + 5) \times 10 = 0$ , and the mean DSI% for perceptually normal voices becomes  $(5 + 5) \times 10 = 100$ . In other terms, the original DSI scale ranging from  $-5$  to  $+5$  as mean values, is turned into a percentual scale ranging from 0 % to 100 % as mean values. Remind that the scores  $+5$  and  $-5$  on the original DSI scale correspond to the average DSI of subjects with a G0 and G3 voice quality respectively. This implies that for a number of subjects the DSI will range beyond  $+5$  or  $-5$ . Therefore, it is perfectly mathematically sound that the rescaled DSI% can either have values exceeding 100% as well as negative percentages. As such, this can be compared to hearing levels in audiology, where some subjects can hear e.g.  $-10$  dB, since they perform better than average (what corresponds to 0 dB).

The second modification concerns the introduction into the DSI scale of a percentual cutting point separating normal from abnormal voices. The lower limit of the DSI prediction interval for G0 voices, i.e. the value obtained by decreasing the mean DSI value for perceptually normal voices by 1.96 times its standard deviation, is chosen as the cutting point. In the original DSI scale, the standard deviation belonging to the mean, normal DSI value  $+5$  is 1.72, and hence a DSI value of  $+5 - (1.72 \times 1.96) = +1.6288$  forms the cutting point between normal and abnormal voice quality. This DSI cutting point of (rounded off) 1.6, transformed according to the simple, mathematical method outlined in the previous paragraph, corresponds to a value of 66 % in the new DSI% scale.

In short, as a result of the two modifications just described, the original DSI scale ranging from  $-5$  to  $+5$ , becomes a DSI% scale ranging from 0 % to 100 % as mean values, with 66 % as the cutting point between vocal normality and vocal abnormality.

### 3. Results

The three voice cases described underneath will illustrate the practical advantages of this percentual DSI scale.

#### 3.1. Case one

The first case was 71-year-old male patient with a severe dysphonia due to an idiopathic paralysis of the left vocal fold. The dysphonia was phonosurgically treated with a vocal fold medialization, involving a thyroplasty Isshiki type I and the use of a silastic implant Koufman type B.

The patient's voice was evaluated three times : once presurgery, and twice post-surgery. Table 1 presents the DSI-related results from each of those clinical voice evaluations : the G score, the values for the four DSI determinants, and those for the DSI itself. Each DSI result is expressed both in points according to the original scale, and as a percentage value according to the scale introduced in the present paper. It can be seen that the DSI improved considerably, from an original value of  $-3.5$  (15 %) before surgery, to a value of  $+3.5$  (85 %) four months after the phonosurgery.

Table 1. Follow-up of case one, a 71 year old man with a phonosurgically treated paralysis of the left vocal fold. Time indications : (1) before surgery, (2) 4 weeks postsurgery, (3) 4 months postsurgery.

Time	G score	Jitter (%)	Fo-High (Hz)	I-Low (dB)	MPT (s)	DSI (points)	DSI%
1	3	3.1	415	57	4.5	-3.5	15
2	1	0.9	466	55	12.4	1.3	63
3	1	0.8	690	55	17.4	3.5	85

At the initial voice evaluation, it was explained to the patient that his voice quality was characterized by a Dysphonia Severity Index of  $-3.5$ , but he did not understand what this meant, and asked the examiner to give him further information. When he was then informed that a DSI of  $-3.5$  indicates that his vocal quality equalled 15 % of the quality of an average, normal voice, the DSI result became clear to him immediately. At the second evaluation, the patient was told that his voice quality had improved to 63 %, and was only 3 % underneath the value of 66 %, forming the boundary-line between abnormal and normal voices. This information instantaneously made him aware of the fact that the surgery had brought an 48 % improvement to his voice. Three months later, the final DSI result of 85 % made him realize at once that his voice had further improved so considerably that it was situated only 15 % below an average normal voice, and even 19 % above the lower limit of vocal normality.

### 3.2. Case two

The second case was an 11-year-old boy when he was diagnosed to have dysphonia due to vocal nodules, caused by vocal abuse (yelling, speaking too loudly, hard voice onset, whispering, coughing, clearing the throat) and to a poor speaking technique concerning articulation as well as respiration. After the initial voice evaluation, he was referred for functional voice therapy to a speech pathologist having a private practice in the village where he lived with his parents. The therapy was provided to him with a frequency of one or two sessions a week over a period of almost two years. In the course of this period, the patient received five follow up voice examinations, each a.o. including a DSI determination.

As can be seen from Table 2, the patient's voice was evaluated six times in total, and turned out to be better at each successive evaluation, except at the last one. Starting from a DSI value of  $-1.4$  (36 %) the voice gradually improved to a DSI value of  $+6.0$  (110 %) at the follow up voice examination performed 15 months after the start of functional voice therapy. At that moment, the boy's voice quality was 10 % better than the average, normal voice quality, but at the last voice evaluation performed 8 months later, it had decreased somewhat to a level only 1 % above the one of a mean, perceptually normal voice (DSI  $+5.1$ , or 101 %). In any case, the last two voice evaluations revealed a normal DSI, corresponding very well with the fact that the boy's mother subjectively reported her son's voice to have normalized. The normalized DSI values, however, did not fully reflect the status of the vocal fold nodules : a video-

laryngostroboscopy performed during the last and second but last follow up voice examinations revealed that the nodule on the left vocal fold had subsided, but that the one on the right vocal fold still partly persisted.

Table 2. Follow-up of case two, a boy with dysphonia due to vocal nodules. Time indications = number of months after the beginning of functional voice therapy. Time

Time (months)	G score	Jitter (%)	Fo-High (Hz)	I-Low (dB)	MPT (s)	DSI (points)	DSI%
0	2	2.8	587	56	8.5	-1.4	
3	2	1.4	587	56	11.2	0.9	59
7	2	1.0	622	56	14	2.1	71
11	2	2.1	987	60	16.2	2.3	73
15	2	0.5	1100	54	17.4	6.0	110
23	1	0.5	1046	60	19.6	5.1	101

At each follow up voice examination, the DSI percentage, as well as the percentual voice improvement were communicated to the boy, to his mother and/or father, and to the external speech pathologist providing the functional voice therapy. The improving DSI percentages were well understood, even by the child, and kept everyone concerned (the patient, his parents, and the treating speech pathologist) well motivated to go on with the therapeutic program.

### 3.3. Case three

The third case to which the DSI% was applied, was a 37-year-old female teacher of gymnastics, presenting a posttraumatic dysphonia after having become the victim of a strangulation attempt by one of her pupils. Five months after the trauma, a pseudocyst was phonosurgically removed from the right vocal fold. Eleven months after the trauma, functional voice therapy was started with a frequency of two sessions a week, and was still being continued when the patient, 23 months after the trauma, had an expert voice evaluation at the request of the physician of an insurance company. As it was felt that voice improvement was still in progress at that moment, a partial repetition of the expert voice evaluation was done 26 months after the trauma. A video-laryngostroboscopy performed during each of the two voice examinations, revealed a moderate, bilateral Reinke's edema of the vocal folds, the size of which appeared to be decreased at the second examination.

Table 3 shows the DSI related results obtained during each of those two voice examinations.

Table 3. Follow-up of case three, a 37-year-old teacher with posttraumatic dysphonia. The time indications are : (1) 23 months after the trauma, (2) 26 months after the trauma.

Time	G score	Jitter (%)	Fo-High (Hz)	I-Low (dB)	MPT (s)	DSI (points)	DSI%
1	2	2.9	466	56	8.8	-1.8	32
2	2	1.241	523	57	8.2	0.1	51

To the referring physician from the insurance company, the DSI results were reported according to the original scale, as well as to the percentual scale introduced in the present paper. The latter scale permitted to state that at the second voice evaluation, after three additional months of functional voice therapy, the patients's voice had further improved with  $51\% - 32\% = 19\%$ , and situated itself  $15\%$  underneath the lower limit of normality.

#### 4. Discussion

Previous papers (Wuyts et al., 1999, 2000a, 2000b) introducing the Dysphonia Severity Index (DSI), illustrate that this multiparameter measure, without being time-consuming, offers the possibility of determining the degree of a dysphonia objectively and mathematically, and of following up the results of all types of voice therapy in the same objective way.

The above described cases additionally illustrate, however, that, when transformed into a percentage value, the DSI results are more directly, and more concretely communicable to patients and to other laymen in the field of instrumental voice evaluation. Percentual DSI results make the patient's grasping of the information given by voice clinicians, be it phoniaticians, laryngologists or speech pathologists, faster and easier. Case two in particular also shows that gradually improving DSI percentages form a very important motivating factor for patients and voice therapists alike.

Moreover the cases illustrate that, when a percentual cutting point is added to the percentage scale, the DSI not only becomes a measuring system of vocal abnormality, but also of vocal normality. The  $0\%$  to  $100\%$  DSI percentage scale permits an accurate mathematical determination of the percentage a given voice is situated above or below an average, perceptually normal voice, and the  $66\%$  cutting point additionally provides the possibility of determining in percentual terms how much a voice is above or below the lower limit of normality. The latter possibility often involves a comforting, encouraging value for the patient. When, for instance, a patient, like the one described above as case three, is informed that his or her voice quality improved to  $51\%$  of an average, normal voice he or she may still feel quite disappointed, because this value implies that his or her voice has only about half of the qualitative capacities of a normal human voice. When, however, the clinician, can add that a DSI of  $51\%$  is situated only  $15\%$  underneath the lower limit of normality, being  $66\%$ ,

the patient will comprehend the information more adequately, and react to it in a psychologically more beneficial way.

Additionally, cases one and two illustrate that, when a DSI value enters into the area of normality, i.e. becomes equal to or higher than 66 %, this only means that the voice is perceptually and functionally normalizing, but not necessarily that the vocal fold pathology has completely subsided. When the patient presented as case one, reached a DSI of 85 % at the last voice evaluation, the vocal fold medialization had moved the left, paralyzed vocal fold over the midline of the glottis, so that glottal closure during phonation had nearly normalized, but the left vocal fold paralysis persisted nevertheless. As mentioned above already, the boy described as case two, reached DSI values above 100 %, i.e. above the average level of vocal normality, although the nodule on the right vocal fold still partly persisted. DSI results are very reliable and robust measures of functional voice quality, but only very indirectly reflect the status of the mechanism for phonation.

## 5. Conclusion

Without making any basic change to the original DSI rating scale, the Dysphonia Severity Index (DSI) percentage scale equipped with a 66 % cutting point between vocal normality and vocal abnormality, enhances the communicability of the DSI results to patients and to other laymen in the field of instrumental voice evaluation, and permits, besides mathematically measuring dysphonia, also to mathematically determine degrees of vocal normality.

## Note

An Excell spreadsheet, making the original DSI (in points), as well as the renewed DSI% immediately available, can be obtained free of charge from the second author (Floris.Wuyts@ua.ac.be).

## Samenvatting

De Dysphonia Severity Index (DSI), ontwikkeld door Wuyts et al. (2000a, 2000b) kwantificeert op objectieve en numerieke wijze de gepercipieerde stemkwaliteit. Zoals oorspronkelijk ontworpen, bedraagt de gemiddelde DSI voor erg hese stemmen -5, en voor normale stemmen +5. Mathematisch kan deze schaal gemakkelijk worden gemodificeerd tot een percentuele schaal, waarbij 0 % overeenkomt met de gemiddelde DSI voor erg hese stemmen, en 100 % met de gemiddelde DSI voor normale stemmen. Deze DSI uitgedrukt als een percentage, wordt genoteerd als DSI%. Zowel voor de originele als voor de percentuele schaal geldt dat, hoe lager de index

van een patiënt is, des te slechter zijn of haar stemkwaliteit is. Overigens wordt een "cutting point", dat de grens tussen normale en abnormale stemmen vormt, aan de DSI-schaal toegevoegd. De praktische voordelen van de vernieuwde DSI%-schaal worden geïllustreerd met de presentatie van drie stempatiënten die ermee werden bestudeerd.

## References

- Hirano, M. (1981). *Clinical Examination of Voice*. New York: Springer-Verlag.
- Van de Heyning, P.H., Remacle, M., Van Cauwenberge, P., De Bodt, M., Wuyts, F.L., Moerman, M., Van Lierde, K., Raes, J., Heylen, L., Sasserath, M., Henri de Hassonville, A., Clement, P.A.R., Qiu, J., Molenberghs, G., Bruckers, L., Mertens, F., Pattyn, J., & Millet, B. (1996). Research work of the Belgian Study Group on Voice Disorders 1996. *Acta Oto-Rhino-Laryngologica Belgica*, 50, 321-386.
- Van de Heyning, P., Remacle, M., Van Cauwenberge, P., De Bodt, M., Heylen, L., Raes, J., Van Lierde, K., Wuyts, F.L., Mertens, F., Millet, B., Pattyn, J., Clement, P., Moerman, M., Morsomme, D., & Henri de Hassonville, A. (1999). Voice assessment: what and why : results of a multicenter study concerning 1100 Belgian subjects. In Dejonckere Ph., & Peters H.F.M. (Eds.), *Communication and its disorders: A science in progress. Proceedings 24th Congress International Association of Logopedics and Phoniatrics* (pp. 263-266). Nijmegen: Nijmegen University Press.
- Wuyts, F.L., De Bodt, M.S., Molenberghs, G., Remacle, M., Heylen, L., Millet, B., Van Lierde, K., Raes, J., & Van de Heyning, P.H. (2000a). The Dysphonia Severity Index : An Objective Measure of Vocal Quality Based on a Multiparameter Approach. *Journal of Speech, Language, and Hearing Research*, 43, 796-809.
- Wuyts, F.L., De Bodt, M., Molenberghs, G., Remacle, M., Heylen, L., Raes, J., Van Lierde, K., Morsomme, D., Millet, B., Clement, P., & Van de Heyning, P.H. (1999). Dysphonia severity index : a multiparameter approach for voice assessment. In Dejonckere Ph., & Peters H.F.M. (Eds.), *Communication and its disorders: A science in progress. Proceedings 24th Congress International Association of Logopedics and Phoniatrics* (pp. 271-274). Nijmegen: Nijmegen University Press.
- Wuyts, F.L., De Bodt, M.S., & Van de Heyning P.H. (2000b). De Dysphonia Severity Index: een objectieve maat voor de stemkwaliteit. *Stem-, Spraak- en Taalpathologie*, 9, 38-54.