

# The Singer's Voice Range Profile: Female Professional Opera Soloists

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**Summary:** This work concerns the collection of 30 voice range profiles (VRPs) of female operatic voice. We address the questions: Is there a need for a singer's protocol in VRP acquisition? Are physiological measurements sufficient or should the measurement of performance capabilities also be included? Can we address the female singing voice in general or is there a case for categorizing voices when studying phonetographic data? Subjects performed a series of structured tasks involving both standard speech voice protocols and additional singing tasks. Singers also completed an extensive questionnaire. Physiological VRPs differ from performance VRPs. Two new VRP metrics, the voice area above a defined level threshold and the dynamic range independent from the fundamental frequency ( $F_0$ ), were found to be useful in the analysis of singer VRPs. Task design had no effect on performance VRP outcomes. Voice category differences were mainly attributable to phonation frequency-based information. Results support the clinical importance of addressing the vocal instrument as it is used in performance. Equally important is the elaboration of a protocol suitable for the singing voice. The given context and instructions can be more important than task design for performance VRPs. Yet, for physiological VRP recordings, task design remains critical. Both types of VRPs are suggested for a singer's voice evaluation.

**Key Words:** Voice range profile–Phonetogram–Singers–Opera–Physiological–Performance.

## INTRODUCTION

The voice range profile (VRP) or phonetogram, is an increasingly popular clinical tool that produces a two-dimensional image of the range of a voice in frequency and in amplitude. The appeal of such a tool lies in its capacity to depict subtleties of voice function and provide both quantitative and qualitative data. Sulter et al., in a study on differences in phonetogram features between male and female subjects with and without vocal training, commented on the scarcity of reliable VRP data studies.<sup>1</sup>

Many more VRP data have since been collected<sup>2,3–10</sup> but only a handful of studies have focused on VRP recordings of the singing voice.<sup>11–14</sup> These studies are often based on subject groups that consist mostly of students in training populations, amateurs, or a mix of choristers and soloists.

The VRP is known to be sensitive to gender, age, as well as vowels and other individual characteristics.<sup>1,4,6,15–17</sup> It would follow that the VRP could also be dependent on training and/or profession.<sup>1</sup> In the case of the singer, the VRP could ideally be sensitive enough to distinguish subtleties of the professional singer's voice.

Although a few university music programs in Europe have performed systematic VRP recordings of their students, few detailed analyses of singer VRPs have been published. Most VRP studies seem to focus on groups of speakers, and use the singer or trained group as a comparison point. The VRP seems to hold great potential for describing the singing voice, but in order for the VRP to become more clinically relevant, a frame of refer-

ence is needed to account for singer-specific issues, the possible impact of task design, and the possible need for additional or alternative VRP-derived singer-specific metrics. This study's aim was to investigate whether VRP recording practice needs to be modified to be relevant to the singing voice.

Three research questions were formulated.

Question 1. Is there a need to subclassify voices by singer category in a subject/patient VRP group?

Question 2. What tasks should be included in the protocol when the subject or patient is a singer? More specifically, should the tasks be musically designed to be as representative as possible of singing or singing exercises?

Question 3. Are there significant differences between the physiological VRP (ie, the standard VRP) and the performance VRP (a VRP entailing singing voice quality with dynamics appropriate for the stage)? In the affirmative, where do these differences lie?

## METHOD

### Data acquisition

The method for data acquisition was the same as in an earlier study.<sup>18</sup> For the reader's convenience, it is briefly restated here. Recordings were performed with a computerized, 16-bit linear acquisition, phonetograph (*Phog*, version 2.00.10, Saven Hitech AB, Sweden). This system accumulates phonation time in 2-D bins, or cells, 1 semitone (ST) wide, and 1 dB high. Cells are plotted according to the UEP standard 2/1 (dB/ST) aspect ratio.

Because *Phog* is based on a peak-picking  $F_0$  extraction, inevitably there was some degree of fundamental frequency ( $F_0$ ) tracking latching onto higher harmonics. The recorded material was inspected manually and the few instances of mis-tracking were removed.

The recordings took place in a sound-treated and isolated recording studio (volume 45 m<sup>3</sup>, ceiling height 3 m, reverberation time T30 = 0.1 s, reverberation radius >1.2 m across the spectrum, and 0.5 m deep absorbents). Singers were asked to adopt a singing stance. Head and body movements were restricted as

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much as possible without impeding the freedom of the artist. The microphone-to-mouth distance (30 cm) was measured at the beginning of each task.

A condenser microphone (Brüel & Kjaer, model 4003, Denmark) was used with a preamplifier (Brüel & Kjaer, model 2812) and a line amplifier (Nyvalla-DSP Audio Interface Box, Saven Hitech, Sweden). Singers were given a single-piece earphone (Bassonic-Champion 4939, USA) to hear prompting tones during one of the tasks. For details concerning the voicing detection thresholds, the reader is referred to Lamarche et al.<sup>18</sup>

### Subjects

Group criteria for this study were strict. The group included three voice categories: six contraltos, eight mezzo-sopranos, and 16 sopranos. Inclusion criteria included female opera soloist, nonsmoking, more than 4 years of training; no ear-nose throat medical history, no respiratory problems, and no actual voice complaints. No laryngoscopic examinations were performed. At the time of the recordings, all subjects were actively performing on classical/opera stages.

Thirty female opera singers with a mean age of  $33.7 \pm 8.8$  years were recorded. The project was ethically vetted by the "Regional etikprövningsnämnden i Stockholm" (certificate 1358-31). Subjects were remunerated for their participation. Subjects had on average a training experience of  $13.4 \pm 5.9$  years. Table 1 lists information and taxonomy pertinent to the subject group.

### Procedure and tasks

The data collection took place from December 2006 to May 2008. To document the subject group thoroughly, each singer filled in a questionnaire addressing general health and vocal practice. They also participated in five different types of recordings: one habitual speech range profile (SRP) one physiological VRP ( $VRP_{phys}$ ), and three versions of a performance VRP ( $VRP_{perf}$ ). Tone duration for the sustained tone tasks was roughly 2 seconds on the vowel [a]. The completion of all tasks took approximately 50–55 minutes. No specific instructions related to mode of phonation and/or vocal strategies were given. Rather, subjects were asked to sing in a way representative of their performance voice use.

For the  $VRP_{phys}$ , the objective was the recording of minimum and maximum productions regardless of phonation mode, whereas for the  $VRP_{perf}$  we wanted to capture the voice as it is used on stage. All five tasks were recorded in one session. The subjects could communicate with the investigator by intercom and visual contact through a window was possible. They could however not see the phonetogram display to avoid interference with a parallel task studied in Lamarche et al.<sup>18</sup>

Task 1a: A thematic spontaneous speech task was performed. Subjects were asked to make a 1-minute description of their warm-up routine.

Task 1b: A counting exercise in which the subject used soft (but no whisper), regular, and loud public speaking voice.

Separate SRPs were saved for each task. Subjects spoke in their native tongue (Swedish, French, or German). Henceforth, the SRPs will be referred to as SRPs (1a and 1b).

**TABLE 1.**  
Participants' Age, Self-Reported Voice Type, Years of Singing Training, and Taxonomy<sup>37</sup>

Subjects	Age (y)	Self-Reported Voice Classification	Years of Training	Taxonomy
1	28	Lyric soprano	6	4.1b R/T: m
2	37	Coloratura soprano	9	3.1a N: M
3	43	Lyric soprano	6	2.1 I: P
4	26	Lyric mezzo	11	4.1b R/T: m
5	55	Dramatic mezzo	25	3.1a N: M
6	43	Lyric soprano	22	3.1a N: M
7	28	Coloratura mezzo	8	4.1b R/T: m
8	26	Lyric soprano	11	4.1b R/T: m
9	25	Lyric soprano	9	4.1b R/T: m
10	26	Lyric mezzo	8½	4.1b R/T: m
11	29	Lyric soprano	13	4.1b R/T: m
12	41	Lyric mezzo	17	3.1b N: m
13	39	Lyric-dramatic mezzo	15	2.1 I: P
14	25	Lyric soprano	8	4.1b R/T: m
15	32	Lyric soprano	17	4.1b R/T: m
16	20	Lyric coloratura soprano	9	4.1b R/T: m
17	25	Lyric contralto	8	4.1b R/T: m
18	28	Lyric soprano	9	4.1b R/T: m
19	20	Lyric soprano	6	4.1b R/T: m
20	46	Light lyric soprano	20	2.1 I: P
21	33	Dramatic mezzo	11	2.1 I: P
22	31	Lyric soprano	12	4.1b R/T: m
23	33	Lyric soprano	13	3.1a N: M
24	33	Coloratura contralto	11	4.1a R/T: M
25	33	Dramatic soprano	16	3.1a N: M
26	40	Contralto	10	2.1 I: P
27	33	Contralto lyric	23	4.1b R/T: m
28	48	Contralto	20	4.1b R/T: m
29	35	Contralto	17	3.1a N: M
30	49	Mezzo lyric dramatic	27	4.1b R/T: m

The following abbreviations are used: Regional/Touring (R/T), National (N), International (I), and Major principal (M) and minor principal (m).

Task 2: The  $VRP_{phys}$ . The aim was to register explicitly the subject's vocal extremes in pitch and in level. This was done with a descending *glissando* (a slow frequency sweep) and ascending *glissando* exercise on the vowel [a]. The *glissandi* were repeated and modified to acquire the best possible achievement (as deemed by the subject and the investigator).

For the  $VRP_{perf}$ , singers were instructed to sing as they deemed *musically acceptable for the stage*. Singing voice quality and vibrato were *obligatory* and the aim was to adhere to one's stage singing ideals at all times, *both* in pitch and in vocal dynamics.

At the start of each  $VRP_{perf}$  task, subjects were asked to sing a *messa di voce* on a comfortable tone to exercise and explore their full performance-mode dynamic range.

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