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Can a Singer's Personalized Formant Frequency Space be Helpful in Performing Multiple Styles?

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There are two acoustic profiles that every singer should obtain and update on a regular basis. The first is a Voice Range Profile (VRP), which provides the singer with his/her range of dynamics over a full range of fundamental frequencies. The VRP has been discussed at great length and will not be part of this brief discussion. The second profile is a Formant Range Profile (FRP), which is introduced here. It is designed to determine how well a singer can stretch the vocal tract into vowel configurations that are useful for various singing styles.

The key issue is: What vowel configurations can be developed consistently to allow a singer maximum flexibility in producing sound spectra that define musical styles? In particular, it is known that belting and calling are characterized by a strong second harmonic ($2f_o$), falsetto (or flute-like timbre) is characterized by a strong fundamental (f_o), and mixed registration in classical singing, or mix in popular singing, has a balance of energy between a few of the lower harmonics (f_o, $2f_o$, and $3f_o$). For a given voice, then, we ask what vowel combinations are ideally suited to support these frequency spectra over some pitch range?

Figure 1 shows an F_1—F_2 formant space produced by a female singer. She was asked to first produce five speech vowels /i/, /e/, /*a*/, /o/, /u/ in vocal fry (so that formant frequencies were easy to determine). She was then asked to produce the vowels /I/, /ɛ/, /ʌ/, /ɔ/, and /U/ with the back of the oral cavity widened, as in classical singing (mimicking an inverted megaphone shape). Vocal fry was also used for clarity in formant extraction. Lastly, she was asked to use a megaphone mouth shape (wide mouth opening) to produce the vowels /a/, /ɔ/, and /æ/, as in belting.

Let us consider the note A_4 (440 Hz) to be the center note of a pitch range (F_4—C_5) in which sound quality in singing changes dramatically. The fundamental frequency f_o of this A_4 note is shown twice with a solid line in Figure 1, once parallel to the vertical axis and once parallel to the horizontal axis. The second harmonic $2f_o$ is shown similarly with two dashed lines. Strength of f_o and $2f_o$ is judged by how close the harmonic is to a formant, and stability of a harmonic is judged by how consistently it remains *below* the formant. If the harmonic passes through the formant with rising pitch, or remains barely

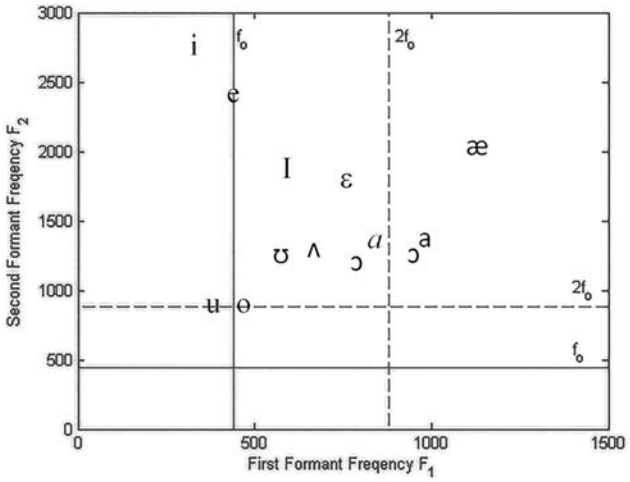

Figure 1. F_1–F_2 **vowel space as a formant range profile (FRP) of a female singer.**

above it, its energy can become weak and unstable. Thus in Figure 1, a vowel symbol slightly to the right of a vertical solid line, or slightly above a horizontal solid line, has formants that give f_o a boost. Likewise, a vowel symbol slightly to the right of a dashed vertical line, or slightly above a dashed horizontal line, has formants that give $2f_o$ a boost.

With these criteria, certain vowel clusters can be used to predict a specific timbre (sound quality) for this singer. A speech /i/ provides a stable falsetto (flute-like) quality on A_4, but speech vowels /e/, /o/, and /u/ are possibly unstable at A_4 because either f_o or 2 f_o is too close to a formant. Unless formant tuning is desirable, as in harmonic singing, some vowel modification is called for. The vowels /æ/, /a/, and /ɔ/ are stable belt vowels because $2f_o$ remains below F_1. The vowels /I/, /ɛ/, /ʌ/, /ɔ/, and /U/ are ideal for mixed registration, with f_o being well below F_1 and 2 f_o being well above F_1 (vertical lines). The speech vowel /*a*/ is borderline.

For this singer, the FRP predicts that belting becomes a problem with vowels /ɔ/ and /a/ at about 500 Hz ($2f_o$ = 1000 Hz), but with the vowel /æ/ a belt sound should be possible up to about 580 Hz (about D_5) without allowing 2 f_o to move into or through F_1.

In summary, the personalized FRP can be helpful in choosing repertoire and, within the repertoire, choosing vowels that will produce the desired timbre for a given vocal style. The FRP also helps determine the boundaries for which the timbre may become unstable on a given pitch with a given vowel.