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The features marked with a star (*) are based entirely on material taken straight from standard research (and other Official and Therefore Always Correct) literature. Many of the other articles are genuine, too, but we don't know which ones.

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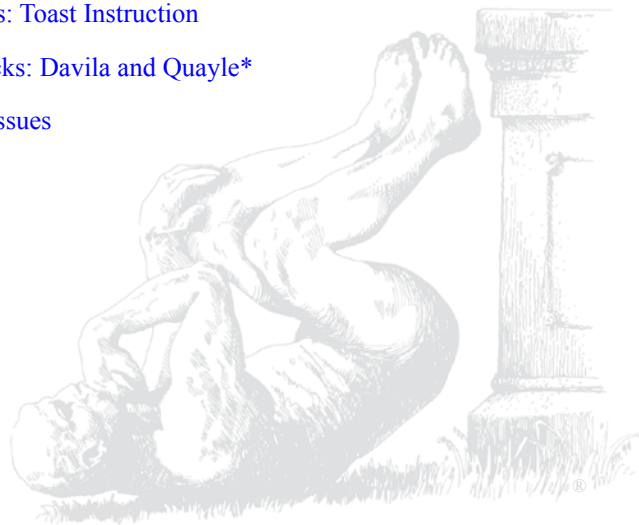
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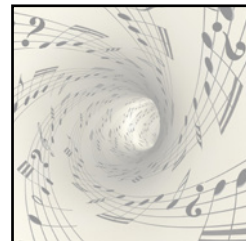
ANNALS OF

IMPROBABLE RESEARCH



On the Front Cover

Music is a source of confusion and thus inspiration, for some scholars.



On the Back Cover

Chocolates that resemble tools and hardware, on sale in a train station in Manchester, UK. Photo: Alice Shirrell Kaswell.



Some Coming Events

See IMPROBABLE.COM for details of these and other events:

March–April 2018

Ig Nobel EuroTour

July 2018

Ig Nobel Ceremony Tickets go on sale

September 13, 2018

Ig Nobel Prize Ceremony, Harvard U

September 15, 2018

Ig Informal Lectures, MIT

September 2018

Japan

October 10, 2018

Hartford, CT, USA

Autumn 2018

Ig Nobel Fall EuroTour

Where There's More

There's always new improbable — it's not what you expect! — stuff on the **Improbable Research** blog at IMPROBABLE.COM

CAN SOPRANOS BE UNDERSTOOD?

Are high-voiced good singers necessarily hard to understand?

by Alice Shirrell Kaswell, *Improbable Research staff*

Intelligibility of Sopranos (2000)

“Perceptual Confusions of High-Pitched Sung Vowels,” Harry Hollien, Ana P. Mendes-Schwartz, and Kenneth Nielsen, *Journal of Voice*, vol. 14, no. 2, June 2000, pp. 287-298. The authors, at the University of Florida, report:

Questions exist as to the intelligibility of vowels sung at extremely high fundamental frequencies and, especially, when the fundamental frequency (F_0) produced is above the region where the first vowel formant (F_1) [the lowest resonance of the sound] would normally occur.... 18 professional singers (5 males and 13 females) were recorded when singing 3 isolated vowels at high and low pitches at both loud and soft levels. Aural-perceptual studies employing four types of auditors were carried out to determine the identity of these vowels, and the nature of the confusions with other vowels.... It was found that F_0 change had a profound effect on vowel perception...

[We conclude that] only very few correct identifications of isolated vowels can be expected when fundamental frequency reaches or exceeds the usual first formant of a vowel.... Such patterns were noted especially for high-pitched productions by female singers.

Intelligibility of Sopranos (2004)

“Acoustics: Tuning of Vocal Tract Resonance by Sopranos,” Elodie Joliveau, John Smith, and Joe Wolfe, *Nature*, vol. 421, no. 3, January 8, 2004, p. 116. (Thanks to Jaleh Vittam for bringing this to our attention.) The authors, at the University of New South Wales, Sydney, Australia, explain that:

We have directly measured the resonance frequencies of the vocal tract of sopranos during singing, and find that, towards the top of their range, they consistently increase the frequency of the lowest resonance to match that of their singing. This significantly increases the loudness and the uniformity of tone, albeit at the expense of comprehensibility....

This helps to explain the well-known difficulty in identifying words sung in the high range by sopranos, and may be one of the reasons why opera houses often use surtitles even for operas sung in the native language of their audience.

*Detail from the study
“Acoustics: Tuning of
Vocal Tract Resonance
by Sopranos.”*

Perceptual Confusions of High-pitched Sung Vowels

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Summary: Questions exist as to the intelligibility of vowels sung at extremely high fundamental frequencies and, especially, when the fundamental frequency (F_0) produced is above the region where the first vowel formant (F_1) would normally occur. Can such vowels be correctly identified and, if so,

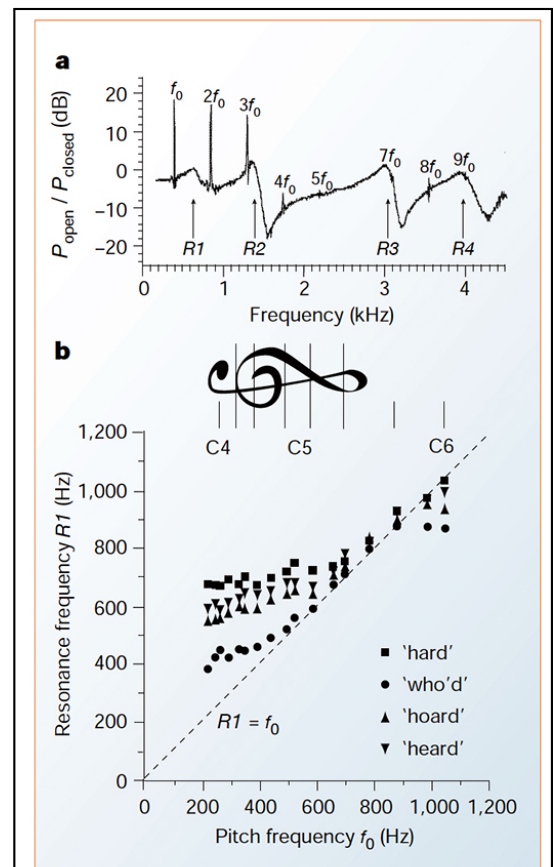


Figure 1 Simultaneous measurements of the resonance frequencies of the vocal tract and the harmonics present in the voice signal. **a**, The ratio of the spectrum measured with the mouth open, to that with the mouth closed (P_{open}/P_{closed}) when the vowel in the word ‘hard’ is sung at A4. Several harmonics of the voice signal with

continued >

CAN SOPRANOS BE UNDERSTOOD? [CONTINUED]

Intelligibility of Sopranos (2006)

“Vowel Intelligibility in Classical Singing,” Jean Westerman Gregg and Ronald C. Scherer, *Journal of Voice*, vol. 20, no. 2, June 2006, pp. 198-210. The authors, from Woodbridge, Connecticut, and at Bowling Green State University, Bowling Green, Ohio, report:

Many people attending concerts sung in English readily state that they cannot understand the words being sung....

Eleven words—“beat, bait, Bob, boat, boot,” representing the most frequently occurring vowels in practice, and “bit, bet, bat, bought, but, book,” representing the other six vowels that occur less frequently—were arranged in six random orders....

In this study, there were 21 subjects (15 women, 6 men), all Western classically trained performers as well as teachers of classical singing. They sang 11 words containing 11 different American English vowels, singing on two pitches a musical fifth apart....

[In] general, vowel intelligibility was lower with the higher pitch, and vowels sung by the women were less intelligible than those sung by the men. Identification accuracy was about the same for the singing teacher listeners and the speech-language pathologist listeners except for the lower pitch, where the singing teachers were more accurate.

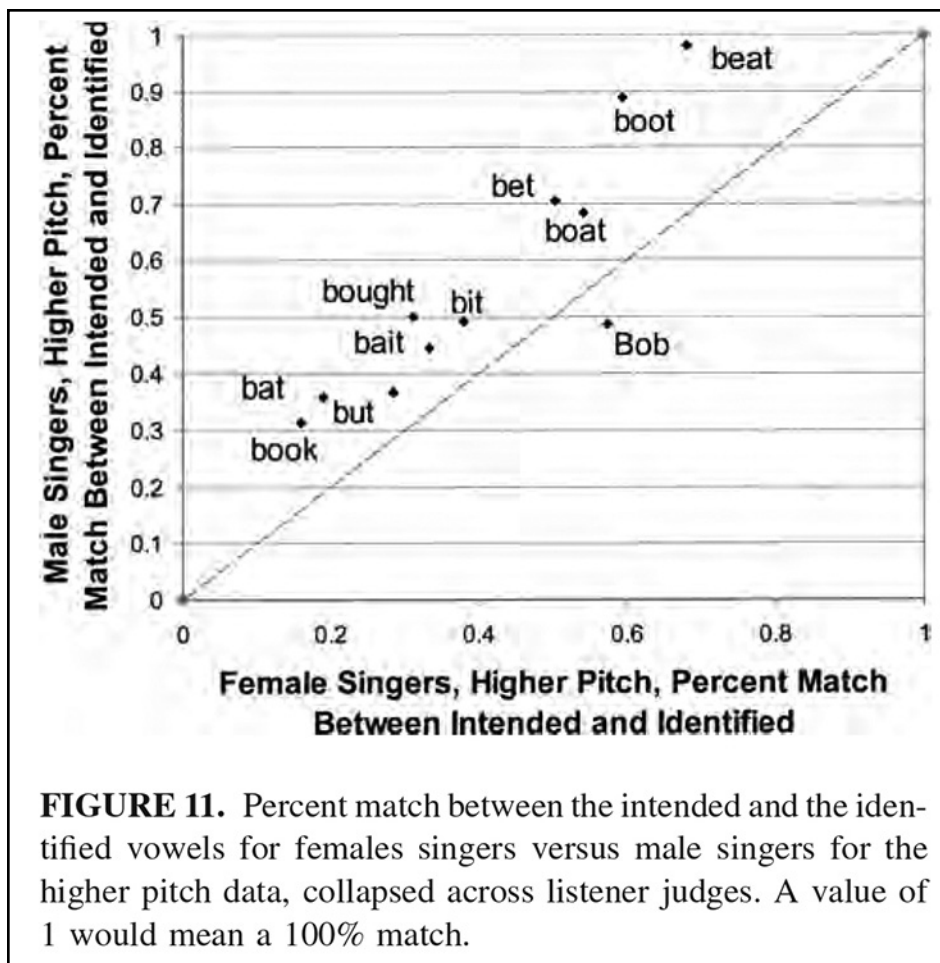


FIGURE 11. Percent match between the intended and the identified vowels for females singers versus male singers for the higher pitch data, collapsed across listener judges. A value of 1 would mean a 100% match.

Detail from the study “Vowel Intelligibility in Classical Singing.”

[continued >](#)

CAN SOPRANOS BE UNDERSTOOD? [CONTINUED]

Gibbons and the Techniques of Sopranos

“Soprano Singing in Gibbons,” Hiroki Koda, Takeshi Nishimura, Isao T. Tokuda, Chisako Oyakawa, Toshikuni Nihonmatsu, and Nobuo Masataka, *American Journal of Physical Anthropology*, vol. 149, no. 3, 2012, pp. 347-355. (Thanks to Tom Sheldon for bringing this to our attention.) The authors, at Kyoto University, Ritsumeikan University, Tohoku University, and Fukuchiyama City Zoo, Japan, report:

Gibbon song is acoustically unique, comprising loud, melodious, penetrating pure tone-like calls....

We were successful in analyzing the vocal sounds of one female juvenile white-handed gibbon, *Hylobates lar*, in normal air and helium-enriched atmospheres....

The subject was put in a cubical customized chamber with 1.5 m sides together with the caretaker. After becoming habituated to the chamber, the subject occasionally produced song calls, provoked by the song calls that the caretaker mimicked in a face-to-face position within the chamber....

Soprano Singing in Gibbons

Hiroki Koda,¹ Takeshi Nishimura,^{1*} Isao T. Tokuda,² Chisako Oyakawa,³ Toshikuni Nihonmatsu,⁴ and Nobuo Masataka¹

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KEY WORDS gibbon song; heliox vocalization; acoustic simulation; source-filter theory; speech

ABSTRACT Diversifications in primate vocalization, including human speech, are believed to reflect evolutionary modifications in vocal anatomy and physiology. Gibbon song is acoustically unique, comprising loud, melodious, penetrating pure tone-like calls. In a white-handed gibbon, *Hylobates lar*, the fundamental frequency (f_0) of song sounds is amplified distinctively from the higher harmonics. Acoustic simulation further supported that this amplification is produced analogously to professional soprano singing, in which a precise tuning of the first formant (F_1) of the source to f_0 amplifies the fundamental component of the source. Thus, in gibbons, dynamic control over the vocal tract configuration, rather than anatomical modifications, has been

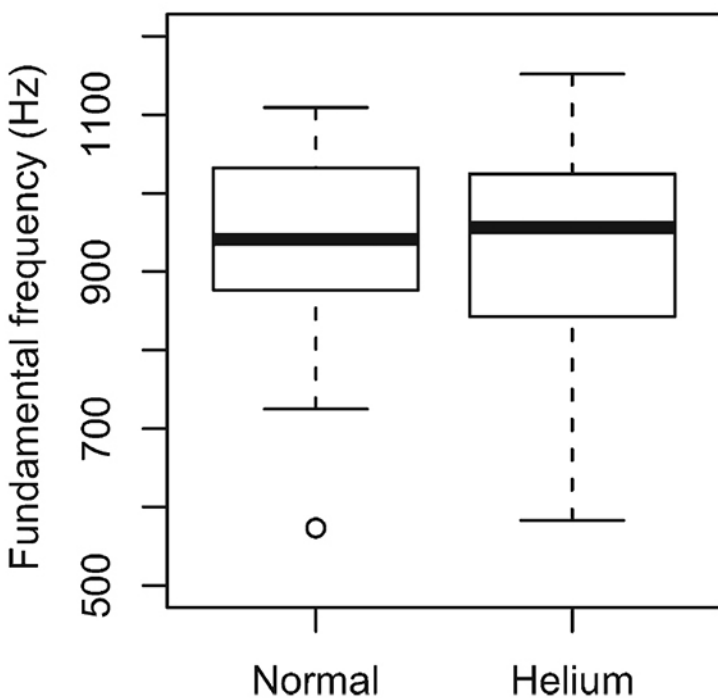


Fig. 7. Boxplot of the fundamental frequencies (f_0 s) of vocalizations elicited in helium and normal air conditions. There were no significant differences for f_0 between the helium and normal air conditions ($F_{1,55} = 0.30$, $P = 0.59$, n.s.), suggesting that the experimental procedure did not influence f_0 .

*Detail from the study
“Soprano Singing in
Gibbons.”*