PVA Study Guide

(Adapted from Chicago NATS Chapter PVA Book Discussion by Chadley Ballantyne. Answers by Ken Bozeman)

Chapter 2

How are harmonics related to pitch?

Pitch is perception of the frequency of a sound. A sound may be comprised of many frequencies. A tone with clear pitch is comprised of a set of frequencies that are all whole integer multiples of the lowest frequency, which therefore create a sound pressure pattern that repeats itself at the frequency of that lowest frequency—the fundamental frequency—and which is perceived to be the pitch of that lowest frequency. Such frequency sets are called harmonics, and are said to be harmonic.

Which harmonic do we perceive as the pitch of a musical tone?

The first harmonic. The fundamental frequency.

What is another name for this harmonic?

The fundamental frequency. In this text designated by H1. There is a movement within the science community to unify designations and henceforth to indicate harmonics as multiples of the fundamental frequency oscillation f_o, such that the first harmonic would be 1 f_o or just f_o. Higher harmonics would then be 2 f_o, 3 f_o, etc.

If the pitch G1 has a frequency of 100 Hz, what is the frequency for the following harmonics?

H1 _100_____

H2 _200_____

H3 _300_____

H4 _400_____

What would be the answer if the pitch is A3 with a frequency of 220 Hz?

H1 __220_____

H2 __440_____

H3 __660_____

H4 __880_____

Figure 1 shows the Harmonic series beginning on C3. If the frequency of C3 is 130.81 Hz, what is the difference in Hz between each harmonic in this figure? 130.81Hz

How is that different from the musical intervals between these harmonics?

Musical intervals are logarithmic, and represent frequency ratios between successive harmonics, such that $2f_o/1f_o$ is an octave or a 2/1 ratio; $3f_o/2f_o$ is a P5th or a 3/2 ratio; $4f_o/3f_o$ is a P4th, or a 4/3 ratio, etc. Even though the Hz difference between successively higher harmonics remains constant, the intervals become increasingly smaller.

In the voice, what produces harmonics?

The variations in the airflow pattern caused by the voice source or vibrating vocal folds.

What does the vocal tract filter/resonator do to these harmonics?

The vocal tract filter selectively resonates—or not—the source harmonics. Those harmonics that are near a resonance frequency peak will excite sympathetic vibration of the air within the tube and be strengthened in the radiated spectrum (output of the mouth). Those harmonic frequencies that are farther from the resonance peaks will be dampened/weakened.

Can a singer change the frequency of a harmonic without changing the pitch?

No.

Which two sets of muscles primarily control laryngeal registration?

Primarily the cricothyroids (vocal fold stretching, thinning muscles) and the thyro-arytenoids (vocal fold shortening, thickening) muscles. Other arytenoid muscles (vocal fold opening and closing muscles) participate to a lesser extent.

Where are they located?

The cricothyroids are located to the front and sides, mostly outside of the larynx. The thyroarytenoid muscles make up the body of the vocal folds.

What are the traditional names associated with vibration modes 1 and 2?

Chest and head (or in some literature, falsetto) in traditional parlance. Also modal and loft, or heavy and light mechanisms in some literature.

Of the two muscles groups responsible for laryngeal registration, which one is the dominant contraction in vibration mode 1?

Thyroarytenoid. Though the notion of TA or CT dominance has been challenged in recent studies.

Which one is dominant in mode 2?

Cridothyroid. (See above)

Chapter 3

Has the theory of vocal tract acoustics changed, or remained the same over the last 50

years?

It has evolved!

What is the primary difference between a linear and a non-linear source-filter model?

A linear model is spatially/geographically linear and cumulative.

A non-linear, interactive model postulates a feedback loop, such that a "later" factor can interact with an "earlier" factor, affecting its behavior, thus changing the input it is receiving. Thus the filter can change the behavior of the source in this model, affecting the ratio of sub/supra-glottal air pressure and the closed quotient.

What is the basic shape of a quarter-wave resonator?

And open/closed tube: i.e., a tube open at one end and closed at the other.

What are the corresponding parts in the human voice?

The closed glottis forms the closed end, the lips form the open end, the vocal tract is the tube. This assumes that the palate has shut off the nasal tract.

Chapter 4

What do we call the resonances* of the vocal tract? (*though usage is inconsistent in the literature)

Much literature refers to the resonances of the vocal tract as formants. Some researchers use the term formant only to refer to peaks in the radiated spectrum, not the resonance characteristics of the tube itself. This terminology debate has not been decisively settled. Most singing voice literature uses the terms interchangeably. This text used the designations F1, F2, etc. There is now a scientific community initiative seeking consensus in designations that is proposing the we use F_1, F_2, F_3, F_4.

Are they fixed or tunable in the human voice?

Since they result from tube length and shape (cross-sectional area), they are changeable and therefore tunable in the human vocal instrument.

What does tube length refer to in this discussion?

Tube length refers to the effective acoustic length of the vocal tract from glottis to lips. The term *effective* refers to the fact that the relative divergence or convergence of the tube changes its resonating wavelength characteristics. Divergence "shortens" the tube, and convergence effectively "lengthens" the tube.

Where does the tube begin and end?

From the glottis to the lips.

What effect does tube length have on the frequencies of the formant set?

Longer tube = lower formant set, more formants within keyboard range, and thus a deeper voice quality and category

Shorter tube = higher formant set, fewer within keyboard range, and thus a higher voice quality and category

What is the difference between a formant and a harmonic?

A formant is a resonance characteristic of the vocal tract, specifically a frequency at which the air column of a given vocal tract shape will respond with sympathetic oscillation. A formant does not create sound energy, but it can "boost" sound energy introduced into it that is at or near its frequency. A harmonic is a frequency oscillation generated by the voice source, introduced into the vocal tract, and subsequently resonated—or not—by the vocal tract filter. Harmonics are the actual energy components of the sound. The formant *structure* of the vocal tract (its resonance peaks and valleys) either causes those individual energy components (harmonics) to be strengthened or weakened in the radiated sound.

Which formants are the most tunable?

The first two formants are more responsive to tube dimension changes. All formants respond to tube length changes.

What is their collective name?

The first two formants are called the **vowel formants**. Since they are most moveable/tunable, they are available to differentiate vocal timbre into vowel qualities, or to "define" the vowels.

How are the first two formants tuned?

The first two formants are tuned primarily by the location and degree of narrowing of the tongue bulge relative to the palate or back of the throat, but also by the degree of jaw and lip opening.

What effect does lip rounding have on both vowel formants?

If independent of tongue changes (which is often not the case), it lowers both.

What effect does lip spreading have on both vowel formants?

If independent of tongue and jaw changes (which is often not the case), it raises both.

What effect does jaw dropping have on both vowel formants?

It raises F_1 and lowers F_2.

What is the difference between an acoustic register and a laryngeal register?

A laryngeal register has to do with the shaping of the vocal folds by the laryngeal muscles (TA and CT, primarily). Acoustic registers have to do with the relationship of

source harmonics to the first formant.

What causes acoustic registration events?

Acoustic registration events are caused by interactions between source harmonics—primarily the first 2 to 3 harmonics—and the first formant. Second formant interactions with higher harmonics can also play a role. Especially relevant are those pitches at which a source harmonic crosses the first formant.

What part of the vocal mechanism is primarily responsible for tuning the vowel formants?

The tongue hump location and height, plus presence and degree of lip rounding. The pharyngeal column is more influential on F_1 and the oral space on F_2.

Why do we now use the term Singer's Formant Cluster (SFC) instead of Singer's Formant?

It is caused by a clustering of formants 3-5, rather than by a single higher formant as first thought.

What role does the SFC play in perceived Fach?

Its central peak frequency location is a strong factor in perceived vocal timbre and hence, *Fach*. The higher the SFC, the higher and possibly lighter the vocal *Fach*.

What is the primary factor in stabilizing the SFC?

Stable tube length.

What are the conditions that create a strong SFC?

Tube convergence, an open throat, a narrowed epilarynx, a generally convergent resonator (a 6 to 1 ratio between pharyngeal space and the exit of the epilarynx).

What are the benefits of the SFC?

Clarity and carrying power (ring) of pitches below ca. D5. It is also depth dependent, so it is a major factor in Western classical *chiaroscuro* timbre.

At pitches above D5, which formant is primarily responsible for resonance?

F_1

What is *chiaroscuro* in terms of vocal acoustics?

Chiaroscuro is a balance of intensity between low and high partials (at least up to C-D5) of a tone, usually accomplished by balancing F_1 with SFC, or in some cases, with F_2.

What conditions in the vocal tract are needed to create chiaroscuro?

The same as those needed for SFC: an open throat and convergent resonator.

Chapter 5

What is meant by “coupling”?

In this text, coupling describes formant-harmonic tracking (either a formant tuned to a harmonic, or a harmonic moving into a formant peak). This is a prosaic usage of “coupling” and not its meaning/usage in scientific literature.

Which formant-harmonic tracking creates Yell coupling?

F_1 tracking $2f_o$

Which formant-harmonic tracking creates Whoop coupling?

F_1 tracking $1f_o$

What is the difference between yell coupling and yell timbre?

The cause and the timbral effect.

What is the difference between whoop coupling and full whoop timbre?

The cause and the timbral effect.

Why is formant tuning more important on higher pitches than on lower ones?

With higher pitches, there are fewer, more widely spaced harmonics available to formants to be resonated by them. If none of those more widely spaced harmonics land near a formant peak, a formant will need to be retuned to move closer to a harmonic or the voice will be weak or less resonant.

What acoustic events cause opening and closing of timbre?

The crossing of $2f_o$ above (closing) or below (opening) F_1.

How is the use of yell coupling different in classical singing and musical theatre belt timbre?

It is rarely used in classical timbre. It (or a sufficiently similar sounding acoustic strategy) is the basis of musical theater belt timbre.

What is the difference between a convergent and a divergent resonator?

A convergent resonator has some narrowing toward the open end of the tube; a divergent one widens toward the open end of the tube.

Which vowels are naturally convergent?

Primarily /i u/ but more exhaustively, /i ɪ e o u ø y/

Which vowels are naturally divergent?

/ ɛ æ a ɑ ɔ /

What are the two primary ways to raise the first formant?

Vowel opening (divergence) and tube shortening

Which is preferable and why?

Vowel opening (divergence) is preferable, since it doesn't compromise vocal *Fach*.

What is meant by the term "pitch of turning?"

The pitch at which a vowel closes or the voice "turns over" or, acoustically, the pitch at which $2f_o$ will surpass F_1. Such pitches are ca. one octave below a vowel's first formant.

Is the pitch of turning different or the same for the different vowels?

Different, by as much as an octave from the closest to the most open vowel.

What determines the pitch of turning?

The frequency of the F_1 of the vowel being sung. The pitch of turning is ca. one octave below the first formant peak frequency.

What is the difference between "turning over" and "full whoop timbre?"

Turning over occurs when $2f_o$ surpasses F_1.

Full whoop timbre occurs when $1f_o$ reaches F_1, above which F_1 tracks $1f_o$.

What are the strategies to delay arrival at full whoop timbre?

Raising F_1 by means of vowel opening so that the sung pitch does not reach F_1.

Considering the characteristics of yell and whoop timbre, what are the primary differences in resonance profiles between male and female (treble) voices in classical singing?

Males are primarily either in open or close timbre, and utilize SFC throughout their range; treble voices are usually either in close or whoop timbre, and do not need SFC above D5, where $1f_o$ and F_1 dominate the timbre.

Why would a treble singer want to raise the first formant through tube shortening?

To enable F_1 tracking of $1f_o$ above the normal maximum elevation of F_1 through vowel opening alone, i.e., for extreme high range (from ca. B5 up). When F_1 cannot be raised further via vowel opening, it becomes necessary to shorten the tube somewhat in order to continue tracking $1f_o$. Eventually $1f_o$ surpasses the singer's ability to raise F_1 and it must be resonated by some other means (such as clustering F_1 and F_2 to boost $1f_o$ in between them).

What are the effects of tube shortening through raising the larynx in the male *passaggio*?

It encourages pressed (more effortful) phonation, shallower "spreading" of timbre (loss

of depth), and therefore a lack of true SFC.

Chapter 6

Why do women (treble) singers have roughly half as many harmonics within the keyboard range as men?

Treble voices sing an octave higher, hence their fundamental frequencies ($1f_o$) are twice as high, raising the entire harmonic set relative to the filter formants.

What are the implications of this for vowel/resonance?

The higher the $1f_o$ the more necessary formant tuning or tracking becomes in order to be resonant, since there are fewer harmonics available to the formants for resonation by them.

Why do women typically have fewer formants within keyboard range than men?

Treble voices tend to have shorter vocal tracts. The shorter the vocal tract (tube), the higher the formant set, the fewer that fall within keyboard range.

In Western classical singing, which formant-harmonic coupling should primarily be tracked by female (treble) voices?

F_1:$1f_o$

Why is this formant-harmonic coupling important for classical singing?

It is the characteristic "head dominant" timbre of classical singing, avoiding yell timbre. It also enables timbral depth and fullness at high pitches, as well as ease of phonation, flexibility, and endurance.

Why are open vowels problematic in the middle voice for female singers?

Western classical treble timbre favors M2 laryngeal function, which is best supported by whoop acoustic strategy. Since the F_1s of open vowels are near the top of the treble clef, those vowels make whoop timbre (F_1 tracking of $1f_o$) difficult in the middle voice.

Why are they helpful in the upper middle and high voice?

The higher F_1s of open vowels support whoop timbre in the upper middle and upper voice.

Why are close vowels most helpful in the middle voice?

The lower F_1s of close vowels support whoop timbre in the middle voice.

Why must close vowels be opened/modified in the upper middle and high range of treble voices?

Their lower F_1s need to be raised with ascending pitch to maintain whoop timbre. Otherwise the voice will lose fullness.

In the Leontyne Price examples, why must the vowels /e/ and /y/ be opened/modified in the melismatic passages?

Same as previous answer—to raise F_1 in order to track whoop timbre.

Are the vowels still intelligible even though she is actively modifying them?

Probably not—but the tonal beauty is worth the trade off for most listeners. Leontyne's modifications in these examples are perhaps larger than necessary, but nonetheless very beautiful.

What would be the result if she attempted to sing these passages without modifying or opening the vowels?

The timbre would thin and lose fullness and beauty.

What would happen in terms of formant-harmonic relations?

F_1 would have no harmonics to resonate. F_2 on a higher harmonic would dominate, creating a shrill timbre.

What would be the result vocally or in the sound?

Shrill, thin timbre and possible increase in vocal effort.

Chapter 7

Describe the yell instinct:What is the action of the vocal tract and the laryngeal register?

Humans like to track rising harmonics with F_1. They do this by raising the larynx, narrowing the pharynx, and opening (widening) the vowel, increasing overall divergence. This is epitomized in yell coupling: F_1:$2f_o$, which encourages M1 laryngeal register and pressing.

How does this affect the formant set, timbre and perceived $Fach$?

This raises all formants, encourages pressed phonation, and "spreads" the timbre, resulting in what sounds like a poorly executed higher vocal *Fach*.

What is the primary thing that young male singers must learn in order to overcome the yell instinct?

Not to raise the larynx or open the vowel too early. Rather, to maintain shape, let the vowel migrate and the voice turn over.

Acoustically, how is the yell avoided?

By maintaining F_1 (vocal tract length and shape) until $2f_o$ has surpassed it and the timbre has closed/the voice has turned over.

What are two common terms for this shift?

Cover, turning over, closing. ("hooking" if overdone)

When a vowel does not turn over, what is the resulting timbre?

Blatant, yell-like, spread, shallower, and probably pressed.

What are the two (or three) likely causes?

Larynx raising, pharynx narrowing, vowel opening, pressure increase.

Why do different vowels turn over on different pitches?

F_1 locations of vowels vary by as much as an octave.

What implications does this have on traditional theories about the *passaggio* or *zona di passaggio*?

The traditional location of the *zona di passaggio* can be explained by various closures/turnings of vowels rather than primarily as a result of laryngeal factors. Most significant formant-harmonic intersections occur within the historic *zona di passaggio.* Understanding them enables a more detailed approach to training the *passaggio*.

What is the difference between passive and active vowel modification?

Passive modification or vowel migration is a change in vowel quality that accompanies /results from a pitch change with no shape change. It is caused by changing relationships between moving harmonics and stable formants. Active vowel modification results from active shape changing, resulting in a retuning of the first two formants.

What is the goal of passive vowel modification in the male *zona di passaggio*?

To maintain F_1 in order to allow $2f_o$ to surpass it, closing the timbre and turning over.

While the author advocates passive vowel modification for most vowels in the *zona di passaggio*, when is active shape change necessary:

within the *zona di passaggio*?

For the close vowels /i u/ to avoid whoop timbre: they should be opened.

above the *zona di passaggio*?

For other vowels to achieve an F_2—*3* or $4f_o$ tuning for a more powerful top.

What is meant by closed quotient?

The proportion of time that the glottis is closed in each vibration cycle, designated as closed phase over open phase. The longer the closed phase (the higher the closed quotient), the more efficient the resonator, and the stronger the higher harmonics.

What are the conditions that increase inertive reactance?

Resonator convergence. (open throat, narrowed epilaryngeal exit, fronted tongue,

convergent vowel shape).

Which vowels are naturally convergent?

Generally, the close vowels: /i ɪ e o u ø y/

What must be done to maintain convergence in vowels that are not naturally convergent?

They should be articulated as closely as pitch and vowel allow, with as high and fronted a tongue as will still give an acceptable vowel. Care should also be taken to maintain an actually settled larynx and uncompressed thyrohyoid space. In other words, avoid using compression of the laryngopharyx in defining vowels.

What are some other factors that might affect students as they try to create and maintain a convergent resonator in singing?

They might unduly inhibit or hold the jaw, collapse internal openness (palatal height), or use inappropriate tongue tension.

What acoustic events are responsible for the sensation of "narrowing" or the "hourglass perception" of the *passaggio*?

Timbral closings as harmonics rise through the first formant subjectively give a sensation of collecting, concentrating the sound. Thus closing the vowel and acoustic sensation—but not actually compressing the physical boundaries (certainly not of the throat)—creates the perception of narrowing.

What is a formant-harmonic explanation for the location and actions of the *primo* and *secondo passaggio*?

Primo passaggio: $3f_o$ closing of the open vowels; $2f_o$ closing of the mid-close vowels

Secondo passaggio: $2f_o$ closing of the open vowels; arrival in whoop timbre of the closest vowels.

Chapter 8

Why is "turning over" primarily a phenomenon in male voices rather than in female or treble voices?

All first formants lie in contact with the treble clef, an octave above much of the male range. Therefore, male voices are frequently facing F_1:$2f_o$ intersections but rarely facing F_1:$1f_o$ intersections. Treble voices on the other hand are mostly facing F_1:$1f_o$ intersections, i.e., whoop timbre.

From the perspective of the singer, describe the difference in perception of "turning over" vs yell timbre.

Yell timbre is wide and mouthy, divergent or "spread" in feel, and accompanied by an

increase in pressure and force. It feels as if one is approaching the voice from underneath and reaching up, narrowing the body and widening the sound. Tuning over is concentrated, collected, singular in sensation, and can facility a lightening of pressure/force. It feels taller inside, with some sense of coming from above the sound. It feels as if the body is open but the sound narrowed.

Why must /i/ and /u/ be actively opened or modified through the *zona di passaggio*? (implied in an earlier question)

In order to avoid whoop timbre and stay in a ringier, virile timbre.

What acoustic (or formant) factors could assist in maintaining a clear, ringing sound through the turn as H2 ($2f_o$) passes above F_1?

Strategies that facilitate an F_2 tuning to a higher harmonic, or that maintain a strong SFC. Subjectively, maintaining some sense of ring along the hard palate, rather than collapsing/softening/drooping the soft palate.

In terms of formants and tube length, how would you describe the technique of "hooking" or heavy covering?

Deliberate vowel modification to lower the first formant: tube lengthening, via laryngeal depression or lip trumpeting and active modification (shape changing) toward a closer vowel. The perceived vowel and timbral change is usually more obvious and attention drawing, but may in some cases be distorted, dulled, or perceptually "too far back."

How does it differ from passive vowel modification at the point of turning?

Passive modification is subtler, more elegant, and can avoid vowel distortion or drawing such strong attention to the event. It also better facilitates lightening of vocal effort and pressure.

Why would early $F_1{:}1f_o$ coupling be beneficial for soft dynamic effects?

The resultant whoop timbre is sweeter and softer in effect.

Chapter 9

How are resonance and vowels related?

Both vowels and fullness of timbre are formed by having harmonics resonated by F_1 and F_2. If vowel formants are not well tuned, the resultant voice will be less resonant.

Concerning the "General Principles," are there any that are unclear?

Which ones do you find most helpful in your own singing and teaching?

If tube length and vowel opening or closing control F_1, what controls F_2?

Oral cavity size and size of mouth exit.

How is whoop timbre postponed above the F_1:$2f_o$ crossing (turning)?

By vowel opening, keeping F_1 above $1f_o$ (the pitch being sung).

How are tones in whistle register resonated?

Probably by having $1f_o$ resonated by either a clustering of F_1 and F_2 or by F_2 alone.

What happens when F_1 can be raised no further?

When F_1 can be raised no further, higher pitches will be in whistle register, being resonated by a clustering of F_1 and F_2.

Is whoop timbre the same thing as mode 2 vibration?

Whoop timbre is the result of the resonance strategy of F_1 tracking $1f_o$. It will tend to stimulate a Mode 2 laryngeal adjustment, but doesn't require it.

If it is different, how is it different?

One is resonance (whoop timbre), one is laryngeal muscle adjustment (mode 2).

Chapter 10

Why is /i/ the most open throated vowel and not /ɑ/?

The tongue is the highest and most fronted in an /i/ and the lowest in an /ɑ/, bulging toward the back throat wall.

Bozeman describes the association of the open throat and yawny /ɑ/ as a "false kinesthesia." What are some examples of false kinesthesia that you have encountered in your own singing or teaching?

Why is excessive orality a problem for Western classical singing?

It discourages SFC, *chiaroscuro*, and interactivity of resonance.

Bozeman says the concept of subjective tonal placement sensations is "risky." Specifically for this discussion, how could a student's misconceptions of tonal placement affect tube length stability?

A mouthy, yell orientation seems brighter and possibly more forward to the student, but induces a raised larynx, for example. A false feeling of open throatedness –which is actually narrow in the throat—can result in a dull, excessively yawny sound.

Why is /u/, a back vowel, often felt in the front of the oral cavity?

We hypothesize that it has something to do with F_2 and pressure nodes.

Which formant is perceptually associated with the oral cavity?

F_2

Chapter 11

Why is a divergent resonator useful for belting?

It makes yell coupling (F_1 tracking $2f_o$) easier.

Why are /a/ and /e/ particularly useful vowels for belting?

They are sufficiently open and "bright" to facilitate yell coupling (F_1 tracking $2f_o$).

What are three physical aspects of a divergent resonator/vocal tract?

Wide mouth, narrow pharynx, raised larynx.

If belt only commences above the normal F_1-$2f_o$ intersection of the mid to open vowels, at approximately what pitch does belting begin?

D4-E4 or higher, depending on the vowel and voice type.

How does that relate to the natural break between mode 1 (chest) and mode 2 (head) vibration?

Very similar in location.

Bozeman coins the term *chiarochiaro* to describe belt timbre as opposed to *chiaroscuro* of classical singing. In belt timbre, how is F_1 used to achieve *chiarochiaro*?

It is raised a bit and tracks $2f_o$.

Under strategies employed by belt specialists, point 4 mentions perceived pressed phonation or a timbral emphasis on upper partials (harmonics) in the tonal ideal. What are some implications of this on belt technique?

Belt needs to achieve the upper partial-rich timbre of the yell with minimal actual pressing, via as long of a closed phase as possible without pressing. Belt uses vowel opening, probably some degree of tube shortening, and breath retention (as opposed to breath compression) strategies in order to achieve the acoustic profile of a yell without the level of pressure and force of actual yelling, allowing the inherent expressiveness of the yell to be extended much higher in the range, yet more safely than raw yelling.

If Broadway singers are expected to belt to D, what are some possible resonance strategies to assist this requirement?

Clustering of F_1 and F_2 can resonate $2f_o$ in between them. Relinquishing $2f_o$ dominance for some higher harmonics to create timbral brightness is an alternative strategy.

Bozeman references clustering F_1 and F_2 to extend yell timbre in belting. Since F_1 and F_2 are the vowel formants, what vowels would most easily facilitate clustering of these formants?

Those whose F_1 and F_2s are already fairly clustered: / æ a ɑ ɔ /

Once clustered, how could these formants be raised or lowered?

Lowered by rounding: / æ a ɑ ɔ /; raised by spreading: / ɔ ɑ a æ / and larynx raising.

Under Vocal Tract Factors, point 3 deals with false fold compression. What is meant by a possible "noise element?"

Non-harmonic frequencies from asymmetric vibrations or random contributions of the false folds.

Would there ever be moments in pop-belt singing when this noise element would be beneficial?

Yes, there are styles that call for it.

Chapter 12

What is "cover?" (What is the acoustic action that produces cover?)

Acoustically, cover is when $2f_o$ surpasses F_1. It is more associated with this occurrence on the open vowels near the *secondo passaggio*.

How would you describe the acoustic effect of cover in the youtube examples of Pavarotti?

Rounder, warmer, fuller, richer, more noble, more vertical, with more depth; less spread, less yell-like, less blatant.

What does Bozeman mean by "heavy cover?"

Deliberate, active vowel modification (lengthening the tube and closing the vowel) to precipitate the $2f_o$ passing of F_1 with a more dramatic timbral shift.

Bozeman suggests teaching "turning over" by a sequence of / ɛ e ɪ i/ on the pitch D4 in a tenor voice. In terms of F_1, why would this vowel chain be effective in teaching turning over?

F_1 in that vowel sequence in a tenor voice would move from about Eb5 to C#5 to B4 to F#4, precipitating a turn (dropping below the $2f_o$ of a D4).

How are the terms "open" and "close" vowels related to the physical location of the tongue hump?

Open vowels have a lower tongue that bulges more to the back of the palate or back wall, and close vowels have a higher, more fronted tongue, that bulges nearer the front hard palate.

What are the implications of this when working to maintain a convergent resonator?

Open vowels need to be kept in a closer position, with as high and fronted a tongue as possible (which paradoxically is more like rapid speech articulation in which vowels are

closer together in articulation).

What is meant by a “fronted tongue?”

A tongue that is not being pulled toward the back wall by the styloglossus muscles, rather is relaxed toward its origin in the back of the chin and close to its resting position on the hard palate.

What could “destabilizing acoustic factors” be, based on the formant-harmonic discussion of this book?

Some destructive inertance or non-linearity that challenges the stability of vocal fold vibration, especially near challenging range areas of laryngeal registration. The stronger and greater the focal vocal fold contact (as in mode 1) and the stronger/more stable the vocal tract posture, the less acoustic factors destabilize the outcome.

If H2 ($2f_o$) prominence is the primary characteristic of belt, how is this different from whoop timbre?

H1 ($1f_o$) is prominent in whoop.

Why is belting equated with skillful yelling?

Both belt and yell involve F_1 tracking of $2f_o$. Belting—if skillfully done—avoids the degree of high pressure or force typical in raw yelling.