

BRINGING BREATHING SCIENCE INTO THE VOICE STUDIO

SALLY COLLYER

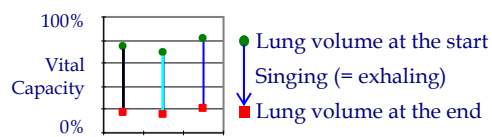
IN SEARCH OF GOOD BREATHING FOR SINGING

Good breathing is fundamental to good singing. But what *is* good breathing? And what training should a teacher give a young singer to instil healthy habits to support a lifetime of vocal excellence? Breathing science is helping to answer these questions. Unfortunately, studying breathing is not as easy as studying, say, acoustics or gesture. It requires specialist equipment and methods, so progress is relatively slow. Nevertheless, studies of singing breathing are making some fascinating discoveries which are shedding light on just how complex and magnificent the singing voice is.

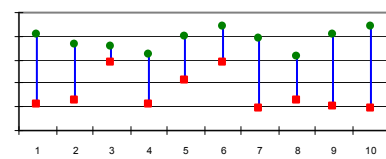
USING THE AIR - LUNG VOLUMES

An obvious place to start is with the air itself. That part of lung capacity which we can use is called the vital capacity, ranging from 0% (empty) to 100% (full). On average, singers start phrases at about 70-80%VC. Above 80%VC, recoil exhalatory force increases rapidly, the way stretching a rubber band becomes harder, so the singer has to use a lot of inhalatory muscle force to reduce subglottal pressure to match what is needed for singing. You can feel this if you completely fill your lungs, then suddenly relax: the ribcage quickly shrinks and expels air. On average, singers end phrases at about 30-50%VC, so phrases often end below resting exhalatory level, meaning that some of the singer's exhalatory muscle force at the ends of phrases is being used to counter inhalatory recoil force. Avoiding VC extremes in singing makes sense because it means less effort is expended resisting recoil forces in maintaining the subglottal pressure needed for singing. However, whilst averages give a good overall picture, singing teachers deal with individuals. And it turns out that singers are *highly* individual!

Studies have found that **an individual singer is very consistent in lung volumes but different singers use very different lung volumes even on the same task**. Consider the lung volumes used by 10 highly trained female singers singing a *messa di voce* on B4. Each vertical blue line on the graphs below represents the air exhaled from the start (green dot) to the end (red square) during the *messa di voce*. The first graph shows the lung volumes used by the first singer singing the *messa di voce* three times (black, turquoise and blue): she is very consistent, beginning at ~75%VC and ending at ~20%VC. The second graph shows the lungs volumes used by the 10 singers: they are very different. For instance, Singers 3 and 6 use a lot less air (shorter vertical lines) than Singers 9 and 10. They finish the *messa di voce* quite high at 57%VC; that's only 5% lower than where Singer 8 starts her *messa di voce* at 62%VC!



One singer, 3 times = very consistent ...



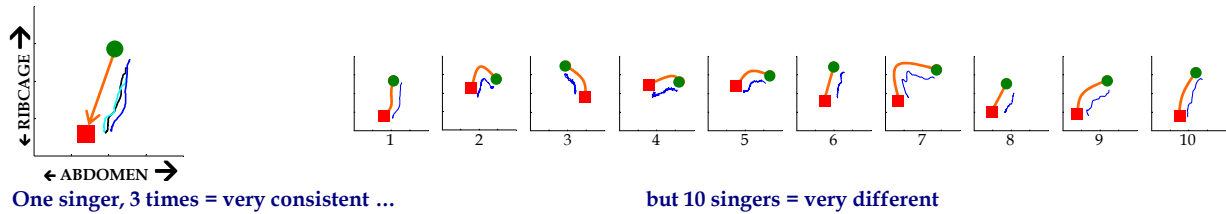
but 10 singers = very different

Consider what these start and end lung volumes say about how they sing. Four singers (1, 6, 9 and 10) start at >80%VC, which means they begin the *messa di voce* with a lot of exhalatory recoil force generating high subglottal pressure. But a *messa di voce* begins very quietly, with low subglottal pressure, implying they have to use a lot of inhalatory muscular force to reduce the pressure. Three singers (7, 9 and 10) end at very low lung volume (<20%VC), where inhalatory recoil forces are strong, suggesting they have to work even harder at the end of the phrase. Singers 1, 4, 6, and 8 have the best voices - Singer 6 is an international opera singer - but even they use very different lung volumes.

MOVING THE AIR - CHEST-WALL KINEMATICS

The differences between singers go deeper. Change in lung volume is primarily a function of change in ribcage and abdominal dimension, what we call 'chest-wall kinematics'. Kinematic plots trace the increase and decrease in ribcage and abdominal dimension underlying inhalation and exhalation. They are also called 'volume contribution plots' because the axis scales are adjusted to take into consideration that singers usually need to move the abdomen more than the ribcage to move the same amount of air.

Let's look at how our 10 singers move air: their chest-wall kinematic patterns. We saw that the amount of air used by a trained singer repeating a task is very consistent: the black, turquoise and blue lines in the first graph are of very similar length. The ribcage and abdominal changes that gave rise to each of those lines can be seen in the first kinematic plot, below. During the *messa di voce*, both ribcage and abdomen decrease; the trace moves down the vertical axis (ribcage) and left along the horizontal axis (abdomen). There is more change vertically than horizontally, meaning Singer 1 uses the ribcage more than the abdomen to change lung volume. We can see how consistently one singer behaves - the lines are very alike - but comparing the ten plots shows **there are clear differences between singers**.



Singers 1, 4, 6, 8, 9, and 10 use a generally steady decrease in both ribcage and abdomen, but the relative contributions vary: Singer 1 uses mostly ribcage, Singer 4 uses mostly abdomen. Singers 2, 5 and 7 start with something counter-intuitive: ribcage paradoxing. The paradox is when the ribcage *expands* during singing, when air is exhaling, so the kinematic trace actually rises. Air is still being exhaled because the ribcage increase is outweighed by the abdominal decrease. Ribcage paradoxing has been associated with phrases that start quietly. And Singer 3 shows abdominal paradoxing: the abdomen is actually *larger* at the end of the *messa di voce* than at the start. Breathing is clearly a lot more complex than we thought!

FRAMING THE BIG QUESTIONS

All of these findings, and lots of others which couldn't be squeezed into this short review, raise big questions. Why do singers breathe so differently? What determines a singer's behaviour? How do we tailor training to the individual singer? Just how much is nature and how much is nurture? At least part of a singer's breathing behaviour does not seem to be under conscious control. As you'd expect, the same instruction has different effects on singers with different kinematic patterns. And musical and non-musical factors influence breathing. Singers asked to change their abdominal behaviour unconsciously adjust their ribcage, too, to keep lung volumes steady, but singers asked to project their voices use less air and singers asked to sing with emotional connection use more air. These are just some of the challenges facing breathing science, and we haven't even mentioned posture or the diaphragm yet!

THE FUTURE

It was noted earlier that measuring breathing requires specialist equipment. Unfortunately, few teachers have access to this, so a key ingredient of learning - the chance to play - is missing. But new sensor technologies, like Wii and 3D tracking systems, mean that kinematic measurement in the studio could be just around the corner. Stay tuned!

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DR SALLY COLLYER holds an MMus from the Queensland Conservatorium of Music and a PhD from The University of Sydney. She maintains a private studio in Melbourne specialising in theatre-based singing: classical (opera and recital), music theatre and cabaret. She also conducts professional development workshops for singers and teachers on breathing, vocal-fold function, acoustic analysis, and perceptual assessment, and acts as a research and technical consultant for singing teachers who want to keep their practice at the cutting edge. Her research has been presented at international conferences and published in journals such as the *Journal of the Acoustical Society of America* and *Journal of Speech, Language and Hearing Research*.
PO Box 156, Box Hill Vic 3128, Australia phone: +61 (0)412 546 580 email: sallycollyer@yahoo.com.au