

[draft] My thoughts on breathing, with an emphasis on dealing with chronic shortness of breath

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1 Introduction

maybe a better title is: overcoming chronic shortness of breath by fixing your breathing

1.1 Why this document?

there has been a lot written about breathing, both in the academic literature and in self-help/meditation/mindfulness contexts. why am i adding my own words to this vast literature? what value am i adding?

I am writing basically the document I wish someone had handed to me over a decade ago when I first started to experience shortness of breath.

There's a lot written about air hunger already. the problem is that each source only seems to have a part of the solution. there's no one-stop place to get everything i need. so in some sense i'm just synthesizing and collecting everything into one place.

but also, i've noticed a lot of sources making mistakes or not fully explaining things. so i've had to think about some stuff and work it out on my own or with friends, and also by experimenting on my own.

i will be critiquing a lot of sources as i discuss them. i don't want to sound too negative – it's only because of all these sources that i've made significant progress on overcoming my own breathing problem. but seeing how things are explained incorrectly/what can go wrong is one of the best ways to understand why something is the way it is. see [here](#) for more on this pedagogical perspective.

note to self: this document should have a tightly focused scope. it's to explain what is going on biologically in air hunger, and then explain *how to get out of that state*. all my other random thoughts about breathing should be put somewhere else. ask: will this directly help someone who is suffering from shortness of breath?

a note for breathing experts: if you're wondering what the philosophy of this document is in a few words, check out the Breathing synthesis section. In short, my philosophy is the "Buteyko method" + the "Alexander Technique" + capnometry biofeedback, with the first two terms in quotes because I'm sort of doing my own bastardized versions of them, and wouldn't want to claim I am propagating the "real thing". If you don't know what any of the three terms mean, don't worry! They will all be explained in the course of this document.

i think a lot of resources are needlessly general, to the point where the reader has to do a lot of work to figure out which parts to ignore and which parts to follow. trying to satisfy everyone by writing super generally means everyone gets a decent but not great experience. so i'm solving this problem by writing for an extremely specific audience: people like my past self. this will make the document useless or only tangentially relevant to a lot of people, but for the intended audience, it will be *exactly* what they need. i'll try to make this document a self-contained do-it-yourself guide on how to overcome shortness of breath.

1.2 Warning/disclaimer and disclosures

THIS IS A DRAFT. THIS IS NOT PERSONALIZED MEDICAL ADVICE. USE AT YOUR OWN RISK. See the section Safety below for more details. (At the same time, I *am* interested in improving this document, so if you think I am recommending something unsafe or I am making some other sort of error, I'd like to know about it. Email me at riceissa@gmail.com.)

As for disclosures, I have nothing to disclose: I am not selling anything. This document is freely available. I am not affiliated with any of the products or services I recommend in this document. I don't use affiliate links.

also, while i've made significant progress on overcoming shortness of breath, as of this writing i *still experience it daily*. so i think there's still insights i need to discover. but i think i am on the right track in a way that i was *not* before mid-2023, so i think at this point it makes sense to start writing things up and collecting it all in one place, so that as i keep learning i can edit this document. ultimate goal of this document: hopefully in a few months my breathing will be fixed forever and this document will also completely reflect my understanding of how i fixed it.

so yeah, i want to be honest that i haven't figured it all out; i won't pretend i've figured it all out while leaving readers in the dark feeling confused whether they're missing something.

1.3 Ruling out more serious medical problems

I think as a first step, it's a good idea to rule out any standard problems with the lungs or other body organs, by e.g. doing a chest x-ray, pulmonary function test, blood test, etc. I will say more about what tests I got done and why. The breathing stuff I describe later in the document *might* help with your breathing anyway, even if you have a problem with your lungs, but you definitely want to know if you do have problems and to get proper treatment for those before progressing to any breathing modification.

<https://youtu.be/G3YHBYVxxmI?t=1049> – Chris Gilbert lists a bunch of possible reasons for hyperventilation that *aren't* just anxiety/stress.

basically, get yourself checked out by one or more doctors, go through the standard protocol, and if the doctors tell you that there's nothing wrong or that your breathing problems are just due to anxiety, *then* come back to this document and try using the methods in it. the only exception i'm aware of so far is asthma. if you have asthma, then supposedly buteyko breathing is also

effective, so you can get *both* mainstream medical treatment (e.g., inhalers) and try the things in this document (though i don't have any first- or second-hand experience here so you should probably just go find a buteyko book and follow that instead).

[TODO: add more details]

2 Safety

I want to make two seemingly contradictory remarks about the safety of trying various breathing techniques.

1. Because I am *already* experiencing significant shortness of breath, just by breathing the way I already am, I have a greater appetite/tolerance for air hunger and unsafe breathing. Whether I like it or not, I am already experiencing some significant amount of risk just by existing in my current way.
2. I have the impression that a lot of breathing coaches and such don't emphasize safety enough. One of the reasons I didn't get into Buteyko breathing earlier (despite having known about it since early 2022 or so) is that I was put off by how dangerous it seemed.

When I started practicing silent nasal breathing, I got a few weird symptoms including head pressure, throat tightening (it felt as if I was being subtly choked), and possibly others. (Since I have a mysterious chronic illness, I have a daily occurrence of weird physical symptoms, so I am already quite used to dealing with random new symptoms, and it's often hard to pin down *why* a new symptom started happening, but in the case of head pressure and throat tightening, I am pretty confident it happens because of the breathing.)

The other thing I want to say about safety. It's not helpful when people just tell you a blanket "if you have health issues, don't attempt this". Part of *why* I'm interested in fixing my breathing is because I already have breathing and other health issues. I shouldn't automatically be turned away from trying to solve these issues! So, I don't want to *ignore* safety issues, but I also don't want to give useless cowardly ass-covering safety warnings. How to avoid both problems?

i also don't want to just put a big safety warning at the start, and then not mention safety at all later on. safety will be a concern throughout. but,

also, i will have a safety section here to give an overview of what you might experience.

because i have a lot of health anxiety i am pretty nervous to try new things. i think a lot of buteyko people don't have this same orientation. like, they are in it to get superpowers or something (like sleeping only 2 hours a day) and not out of a sense of desperation to breathe like a normal person. so in some sense this document is like a maximally cautious, "only in it for the health improvements" version.

Novozhilov (2012) mentions cleansing reactions that can happen, in the section called "Cleansing reactions". Unfortunately it just lists a bunch of pretty nonspecific symptoms without any guidance on what to do about them...

Novozhilov (2012)'s main suggestion for dealing with problems seems to be "get an expert to coach you". i mean, sure, that's always one solution. but what i'm trying to do here is to write everything down so that one can do all the steps on one's own, as safely and effectively as possible.

buteyko people also mention this, but increased sensitivity to medications can be a thing. i used to (2024-01-07 was last time i took it before breathing changed) be able to take 5–10 drops of methyl factors and it would just give me a bit of energy, but now (2024-01-27) even 1 drop of it seems to send me into irritable/uncomfortable/anxious state. i haven't noticed this kind of heightened sensitivity with any of my other meds/supplements so far though. because the methyl factors thing has only happened once so far (i'm in the middle of the episode as i write this), it *could* be a one-time fluke, who knows.

i tentatively recommend going pretty slowly (need a better descriptor here...) so that you get adjusted to the changes. i'm not sure how to go slowly on some of the steps (e.g., when i switched from loud nasal to silent nasal, the loud nasal just felt very unnatural so i couldn't go back and titrate it).

if you are already ill in various ways like i am, then maybe it's not a big deal to suffer for a while and make rapid progress. the problem is if it's not *just* being uncomfortable for a while, but if it becomes permanent or if it's a sign of actually dangerous stuff happening. i don't know how to distinguish what each symptom means. hence the recommendation to go slowly.

2.1 Accidental meditation

as you try to normalize your breath, you're constantly paying attention to the way you breathe, and that's essentially the mental motion that meditators

make (at least, when they do the kind of meditation where they focus on their breath). could you be accidentally meditating by trying to fix your air hunger? is that why the intracranial pressure happens? how can we correct the breath without risking accidentally meditating? (most people might have the sense that meditation is harmless, but my current belief is that if you do more than like a few minutes a day, then meditation requires a lot of care to do correctly, and you can really risk hurting yourself/disrupting your whole life. see stuff like “dark night of the soul”. as they say about meditation, “Better not to start. Once started, better to finish.” you really don’t want to accidentally meditate.)

i don’t have any good answers yet. i’m still working through this myself. for the head pressure, it was somewhat bad for one day, but then after that it just got better on its own, and now i don’t notice it at all. i’ve also been just trying to do other stuff, so that even as i do inevitably bring my attention back to my breath to see if i’m still doing silent nasal breathing, i’m not just sitting there doing that the entire day.

Novozhilov (2012) even says “Exercise 1 is really another version of meditation using the focus on breathing and relaxation of the breathing muscles as the means for avoiding wandering thoughts.”

2.2 Coughing

Buteyko people seem too anti-coughing to me. My uninformed guess is that it’s good to cough sometimes, e.g., to clear mucus or during a viral infection. Then there are other more mysterious forms of cough (e.g., twice in my life for like a month each, I had a habit of little micro-coughs/chest itchy feeling) where I think suppressing the cough is more justified (the second time it happened, doing soft breathing to make the cough not trigger is what finally made it go away).

Novozhilov (2012) says to cough without opening your mouth, but based on personal experience I think this is a bad idea. There can be too much air coming through your nose which can damage the nose tissue. Anyway, this was never a huge issue for me but people with actual asthma might have to adopt different strategies.

3 The biological basis of shortness of breath

If you followed my advice and ruled out serious medical problems with a doctor, you may be thinking there is no biological cause of your shortness of breath, that it is just all “in your head”. Certainly this is what doctors kept telling *me*, that it was all due to anxiety or some other hard-to-verify physical cause like mast cell activation (primary care physician, two pulmonologists, allergist).

It turns out that there is a pretty well-understood cause of air hunger! But to understand it, we need to have a decent understanding of the chemistry of respiration; in particular we’ll need to correct some misconceptions about breathing. So that’s what this section is about.

The aim of this section is to give you a useful mechanistic model of how respiration works. I will skip a lot of details because while it’s helpful to know them, they aren’t essential.

The central thing we’re trying to explain here is: why is it that if you have shortness of breath, the right thing to do is to breathe *less*, even though your body is telling you to breathe *more*? What is going on at the chemical level when people have shortness of breath?

(This is sort of like Cooper (2021) on air hunger, but there are a few things I don’t like about his explanation, so I’m going to be writing my own ideal version. But if you prefer a video explanation, then you can start with the video and then come back here.)

3.1 Respiration and misconceptions about CO₂

The chemistry of respiration

What causes the urge to breathe? Humans have what are called chemoreceptors in their brain (and some other places) that tell the body to breathe. How do chemoreceptors know *when* to breathe? They watch out for signals from the body, in the form of carbon dioxide levels, oxygen levels, and blood pH. Most of the time, when people breathe, it is because the carbon dioxide level increased above some threshold. Oxygen only triggers breathing when it gets really low (so low that I don’t think most humans experience it except on very rare occasions). I think blood pH also matters, but maybe only during exercise? (but it might matter more for air hunger; see below).

i’m not very attached to “high levels of CO₂ are super healthy”. i honestly haven’t vetted the claims. but basically everyone (including mainstream

western medicine) agrees that 35–45 mmHg is the healthy range for partial pressure of CO₂.

3.2 Chronic overbreathing and the bicarbonate buffer system

acid–base balance, bicarbonate buffer model (also called “renal compensation”, e.g., see https://en.wikipedia.org/wiki/Renal_compensation and <https://youtu.be/G3YHBYVxxmI?t=1527>)

mention how people with shortness of breath might not think they are hyperventilating. For example I don’t think I’ve ever overtly hyperventilated in my life. And yet, I was constantly low-grade overbreathing. Gilbert (2014, p. 68) says “Hyperventilation tends to persist in many people, and once a pattern of overbreathing is established it can be maintained by only a 10% increase in minute volume, which could be achieved by a combination of deeper breaths, faster breathing, or an occasional sigh”.

3.3 The Henderson–Hasselbalch equation and CO₂ tolerance

[argh, this is kind of hard to explain well. curse of knowledge...]

Okay, so CO₂ levels (partial pressure?) in the blood regulate breathing. Now let’s imagine what happens when someone overbreathes. You might think, okay, CO₂ goes down, so then you don’t get as much of an urge to breathe. That’s true in the short term. But if someone *chronically* overbreathes, then the body tries to correct this. You see, the body tries very hard to keep the blood pH at a narrow range of 7.35–7.45. If one chronically overbreathes, then since CO₂ causes the blood to become acidic, the *lack* of CO₂ (you’re overbreathing, remember) causes your blood to become too alkaline. So the body compensates by trying to make blood more acidic. How? The kidneys dump out more bicarbonate (HCO₃[−]) into the urine. Since bicarbonate is alkaline, getting rid of it makes the blood more acidic. The kidneys don’t react immediately; all this happens over the course of hours to roughly 5 days.

[... some more stuff here ...]

The important point is that because of the form of the Henderson–Hasselbalch equation, the more CO₂ you have, the less sensitive pH is to slight increases in CO₂. So breath holding for a few seconds does not

cause air hunger/panic/suffocation. Whereas if your CO_2 is already too low (hypocapnia), then your pH is still normal (thanks to the bicarbonate levels being adjusted by your kidneys), but because of the low CO_2 , even slight changes in CO_2 can cause large shifts in pH. I think it's this decrease in pH (when CO_2 rises, blood becomes more acidic so pH goes down) that triggers a strong sense of air hunger. If you give in to this urge and breathe, then your pH will be restored, so *temporarily* you will feel better. But if you keep giving into this urge and breathing more and more, then over time you're shifting down your bicarbonate buffer even more. Your body adjusts. But that means your baseline CO_2 also keeps decreasing. So now you're *even more* sensitive to slight increases in CO_2 . It's a vicious cycle. (and this isn't even talking about the negative health effects of low CO_2 .)

Let's look at some numbers.

$$7.4 \approx 6.1 + \log_{10} \left(\frac{24}{0.0307 \cdot 40} \right)$$

above are the values for a normal person.

When I first used a capnometer, my CO_2 was around 25 mmHg. So to get the same pH, my bicarbonate level must have been around 15 (here I'm basically solving for the equation $24/40 = x/25$):

$$7.4 \approx 6.1 + \log_{10} \left(\frac{15}{0.0307 \cdot 25} \right)$$

Now let's say both individuals do a breath hold to raise their PCO_2 by 5 mmHg. In the case of the healthy person, their pH goes down to 7.34, but in the chronic overbreather's case, it goes down to 7.31.

here's the other thing vipul showed me:

suppose your equation right now is:

$$\begin{aligned} \text{pH} &\approx 6.1 + \log_{10} \left(\frac{[\text{HCO}_3^-]}{0.0307 \cdot p\text{CO}_2} \right) \\ &= 6.1 + \log_{10}([\text{HCO}_3^-]) - \log_{10}(0.0307) - \log_{10}(p\text{CO}_2) \end{aligned}$$

Now you hold your breath so that the $p\text{CO}_2$ goes up by some amount, $\Delta p\text{CO}_2$, and the pH changes by some amount, ΔpH (it's a negative quantity, since your pH goes down when the blood becomes more acidic). Your equation now looks like:

$$\begin{aligned} \text{pH} + \Delta\text{pH} &\approx 6.1 + \log_{10}\left(\frac{[\text{HCO}_3^-]}{0.0307 \cdot (\text{pCO}_2 + \Delta\text{pCO}_2)}\right) \\ &= 6.1 + \log_{10}([\text{HCO}_3^-]) - \log_{10}(0.0307) - \log_{10}(\text{pCO}_2 + \Delta\text{pCO}_2) \end{aligned}$$

Now let's subtract the first equation from the second; we get:

$$\begin{aligned} \Delta\text{pH} &= \log_{10}(\text{pCO}_2) - \log_{10}(\text{pCO}_2 + \Delta\text{pCO}_2) \\ &= \log_{10}\left(\frac{\text{pCO}_2}{\text{pCO}_2 + \Delta\text{pCO}_2}\right) \\ &= -\log_{10}\left(1 + \frac{\Delta\text{pCO}_2}{\text{pCO}_2}\right) \end{aligned}$$

What does all of this show? Well, the quantity $\frac{\Delta\text{pCO}_2}{\text{pCO}_2}$ is actually the percentage change in pCO_2 . So it shows that *the change in pH is a function of the percentage change in pCO_2* . This is one way to understand why having low CO_2 means your pH changes more easily: the same amount of absolute CO_2 change results in a greater percentage change in CO_2 .

for advanced buteyko practitioners however, my current guess is that their PCO_2 levels are normal (40–45 mmHg). so now, how do we explain how they can hold their breaths for so long? i think some other factors are at play here including:

- less sensitive chemoreceptors
- hemoglobin count or efficiency
- myoglobin count or efficiency
- reduced or more efficient cellular metabolism (slower rate of generation of CO_2)
- higher lung capacity

some of the above may also be happening in going from chronic over-breather to normal breather, but it's not obviously necessary to explain the differences in CO_2 tolerance between overbreather and normal.

3.4 Summary

So what we've established is:

- If you have shortness of breath with no clear medical cause, it is likely that your CO₂ level (and thus bicarbonate level) is too low.
- Low CO₂ means you are more sensitive to changes in CO₂, in particular to increases in it. This is why you always feel short of breath.
- The solution is *not* to “take a deep breath” and get more oxygen, but rather, to breathe *less* so that you *gradually* raise your CO₂ levels. The emphasis is on the word “gradually”. If you just hold your breath as long as possible in the hopes of raising your CO₂, you will just give yourself a panic attack. The kidneys take time to adjust the bicarbonate levels. So you want to sit with a slight-to-moderate amount of air hunger, over the course of days and weeks, so as to gradually raise your baseline CO₂. How to do this? We’ll discuss breathing techniques and breathing habits more elsewhere in this document.

3.5 Analysis of Howard Cooper videos

honestly this section might be *way* too much detail for most readers, so you can skip it on a first read (or entirely) if you want. i’m only very passionate about this topic because it took me so long to understand what was going on. i might actually move out this whole section into a separate document because i don’t think most people will care.

What does Howard Cooper’s explanation get wrong?

- In the initial video, he doesn’t give any mechanism for why people with air hunger are more sensitive to CO₂ buildup. He just says that it’s like people who are sensitive to alcohol. But why does your level of CO₂ affect how sensitive you are to buildup of CO₂? It’s completely mysterious.
- In the second video, he tries to give an explanation in terms of the bicarbonate buffer model. The problem is, in his analogy with the water levels, *everything is on an additive scale*. The inferred version of the Henderson-Hasselbalch equation becomes $-\text{pH} = -\text{CO}_2 + \text{HCO}_3^-$ (water level = $-\text{water leaving} + \text{water entering}$). A healthy person and a chronic overbreather will *both* have the same buildup of CO₂ when they hold their breath. So why does the chronic overbreather have a lower Control Pause? His model can’t explain this. You need to look at the real Henderson-Hasselbalch equation, with the log and fraction, to understand this.

more notes on howard cooper videos:

video 1: (Cooper 2021)

(why am i making such a big deal out of his videos? it's because it's the first resource that really made things click for me. it's what got me to start doing breath pauses and nasal breathing. but it wasn't sufficient because it got the theory a bit wrong and also didn't have a good solution other than "do some breath pauses" which i now think are not the most effective way to cure air hunger. so, i want to take the good stuff from this video while also correcting the stuff it got wrong.)

sequence/flow of the video:

- this video is about air hunger and anxiety
- cooper personally had air hunger, and it was real bad
- but people told cooper to do breathing exercises: this just made it worse! being conscious of his breathing made it worse.
- there is a physical cause of air hunger; it's not in your head.
- caveat: but make sure you get checked out by a doctor. the rest of this video assumes you have nothing obviously wrong.
- carbon dioxide: cells take in oxygen and release CO₂. when CO₂ builds up, you get an urge to breathe.
- anxiety -> overbreathing. "take deep breaths".
- if you have overbreathing for a long time, your CO₂ levels go down. your body makes adjustments to the low levels of CO₂, and one of these is to become very sensitive to any increase in CO₂ [this is WRONG. it's the low level itself that makes you sensitive, not due to any adjustment, as far as i know.]
- alcohol tolerance analogy.
- so what's the cure? gradually expose yourself to more and more CO₂, so your body gets used to it.
- "take a deep breath": the worst advice you can give.
- strategies for dealing with air hunger:
 1. sit with the feeling of air hunger, and do shallow breathing.
 2. breathe through your nose. you can even tape your mouth. shoutout to buteyko method.
 3. control pause test introduced. [unfortunately, he doesn't explain it very well. in particular, he doesn't mention that you shouldn't breathe any differently AFTER the test is completed. lol and he

even *does it wrong* in the video by doing an audible inhale after the test!!!] control pause as a marker of your CO₂ tolerance.

4. reduced breathing exercise: you want a manageable amount of air hunger for “a period of time”. halve your CP, then do a breath hold for that many seconds, take in some normal breaths, repeat. [i think buteyko people distinguish between reduced breathing and breath holds, and this is a breath hold exercise.] 20 second CP as a marker of normal. exercise while reduced breathing is mentioned. anxiety also improves as CP increases.
5. avoid ruminating. tell yourself that mild air hunger is ok.

video 2: <https://invidious.slipfox.xyz/watch?v=RLMjvDYJL6Q>
sequence/flow of the video:

- this video is about air hunger.
- check with doctor first.
- CO₂ isn't all bad – but doesn't elaborate.
- urge to breathe comes from increase in CO₂.
- The “sciencey bit”:
 - pH of blood is very important. so important that body will prioritize keeping pH in a certain range over keeping you comfortable with your breathing.
 - CO₂ causes blood to become acidic -> carbonic acid. the big reason your body breathes is to regulate pH.
 - water tank is analogy for pH level (it's actually the “strength of acid” or -pH). water flowing out is CO₂ being breathed out; 1 tap means normal breathing; 2 taps means you're overbreathing. he then says a confusing thing. he says the water coming from the sink is “a bunch of systems the body has in place to maintain equilibrium”. i think this is wrong. what's going on instead is that your body produces more CO₂ as part of normal metabolic functioning. so that should be what the sink water represents. if you overbreathe, the second tap in the tank opens. water level (acidity) starts to go down. water pitcher = bicarbonate buffer (makes blood more acidic). actually this is the other confusing thing in this analogy. it's not that more bicarbonate is being dumped into the body to make it more acidic – that would be the opposite, since bicarbonate is alkaline. instead, the body is getting *rid* of more bicarbonate in the

urine, so as to make it *less* alkaline, aka more acidic. the water level analogy is just too primitive to be able to get all the signs right and i haven't even begun to critique the additive nature of it. . . But then he shows that if you turn the second tap off, then water level goes up (because the pitcher water is still coming in, as kidneys take time to adjust) = your blood gets more acidic, aka you get air hunger.

- and THEN he says, after all that, “in other words, your body becomes hypersensitive to any increase in CO_2 ”. this is the part that is most wrong about this video, although i'm still a bit confused about this. it's true that if the overbreather holds their breath, their water level increases faster than the normal breather's because the pitcher is pouring in extra water. but i think this is not what's happening. the other incorrect interpretation i had was that the inflow and outflow are the same, it's just the bicarbonate levels being different, so both the overbreather and normal breather should have equivalent buildup of CO_2 in the same amount of time, which wouldn't explain why the overbreather is more sensitive to that same amount of CO_2 buildup. hmm so actually the water analogy may be more correct than i thought – the chronic overbreather has to overbreathe to maintain the pH, which means more bicarbonate has to be leaving; the bicarbonate isn't just a static thing, it's also the rate that matters. BUT the bicarbonate levels are essentially static wrt a single breath. so i'm confused. the water analogy is wrong because it shows everything on a similar timescale and on the same additive scale. chronic overbreathing seems to change the bicarbonate levels to a certain extent, but then the bicarb level settles after a while. why? ok maybe what's going on is that each style of breathing has an “equilibrium CO_2 ” level that it goes to. so my old breathing style would go to 25–30mmHg, but breathing in this style forever wouldn't actually lower CO_2 more and more, it just asymptotes for some reason. if that's the case, then if you breathe like a normal person or you hold your breath, then it's still not because of the bicarbonate level that you get air hunger more easily; it's still because of the CO_2 levels. so the howard cooper video is still wrong.

- need to gradually increase CO_2 levels.
- anxiety cycle – being hyperfixated on breathing. anxiety causes you to overbreathe, and you maintain your air hunger, and the air hunger makes

you more worried about breathing. so there's a vicious cycle. so need to treat both breathing and anxiety.

4 Is healthy breathing the same for everyone?/Is normal breathing universal?

One of the weird things I discovered while using the CapnoTrainer is that the breathing style that brought CO₂ levels up to normal in the most effortless way turned out to be what the Buteyko people have been saying all along: silent nasal breathing. This raises the question of whether there is some universally “optimal” breathing style that everyone should have, or if it's more of a preference (different people can have different breathing styles, but what matters is that your CO₂ levels are normal and you don't have air hunger or other breathing issues).

Peter Litchfield on the other hand says that it doesn't matter how you breathe – you could even mouth breathe – as long as your breathing habits are “functional” (by which I think he means your CO₂ levels are at like 40 mmHg).

5 Can you overshoot your CO₂ levels by doing too much reduced breathing?

so you combat air hunger by breathing less, which raises CO₂. what if you just keep going? could you be overshooting and getting *hypercapnia* instead?

Here's a heuristic argument for why this shouldn't happen: even people who overbreathe don't overbreathe so much that their CO₂ just keeps dropping indefinitely. Each style of breathing seems to asymptote at a certain point. So I think Buteyko-style reduced breathing also asymptotes in terms of CO₂ levels.

But also, I think there must be some other effect going on, because I don't think the Buteyko people have abnormally high CO₂ (that's just my current guess).

the main lesson here is that having a capnometer is quite useful, to give the assurance that your CO₂ levels are normal.

6 A short timeline of my improvements

i don't know how representative the speed of my improvements is, but it's the only case i am deeply familiar with, and it might give people an idea of what to expect.

[TODO: add this]

7 Sequence of cumulative constraints of breathing practice

I think it may be helpful to conceptualize breathing practice¹ not as a set of “breathing techniques” that you practice over time to help calm you down or whatever (such as: “when you’re feeling anxious, do square breathing; once you feel comfortable with that, you can move onto different patterns like 4-7-8”), but instead as a *sequence of cumulative constraints*. The reason for having a *sequence* is that it’s too hard to pay attention to the more subtle stuff and get it right all on the first try before you get the basics down; each stage might take a month or more. (The other reason for this particular sequence: if you follow the sequence, then by doing the previous steps, you automatically almost do the next stage, so that at each stage you only need to put in a *little* bit of effort, not invent a whole new thing.) The reason for having *constraints* rather than practices is that it mostly doesn’t matter *how* you achieve good breathing, you just want the outcome.

This page used to use the phrase “sequence of moving targets” rather than “sequence of cumulative constraints”, but I renamed this page because I thought the new version is a more accurate phrasing. Like the Gram–Schmidt process in linear algebra the constraints are cumulative (at each step n , you want to make sure that the new vector you create is orthogonal not just to the $(n - 1)$ th vector, but to *all* the vectors $1, \dots, n - 1$. This kind of mechanic also happens a lot in puzzle games where if you get one thing in a “good” state, and then try to get another thing in a “good” state, the first one will turn back into a “bad” state, and the difficulty of the puzzle is to make sure you can get all the good states cumulatively). Also “constraint” feels more accurate than “target” because you’re not trying to hit some new breathing pattern some of

¹By “breathing practice”, here I specifically mean breathing practice to cure shortness of breath from over-breathing, but it may also apply to meditative practices as well, I don’t know.

the time, but rather you're trying to *only* do the “good” kind of breathing *all* of the time.

7.1 The sequence

Here is the sequence I am thinking of:

1. Initially, because I was still mouth-breathing a significant percentage of the time (20%?), my constraint was to do nasal breathing. *Any* nasal breathing. The goal was simply to get away from the habit of mouth breathing. Nasal breathing is a good first target because (a) it's extremely obvious whether any particular breath happens through the nose or mouth; and (b) on its own it already has pretty dramatic effects (see Nestor (2020) for a lot more detail on this). Achieving nose breathing itself occurs in two stages:
 - Consciously do nasal breathing. You use any and all tools you have to try to nose breathe: just anxiously paying attention all the time, nasal strips, nose cones, azelastine, NeilMed, allergy sheets, etc. (Flonase is another option that *might* help people but it didn't work for me because of side-effects and there's a chance it builds up a dependence even though it's not supposed to?) You want to get to a point where the only times you mouth breathe are when you have to blow your nose, when you swim, when you take a shower, or things like that. I nose breathe even with a mask on, even when I'm brushing my teeth, and as much as possible even in my sleep (mouth taping might help with this). (This step took around 1 month for me.)
 - Eventually, it becomes automatic, and you won't even need the training wheels. (After a month, my nasal breathing became habitual/automatic. I remained at this stage for the next 4 months or so, not because I wanted to but because I wasn't sure what to do next.)
2. Next stage: silence your breath.
 - Same two stages here (conscious/manual techniques, then unconscious/automatic habit). Silent breath is the next constraint because it's also easy to detect: it means you can't hear your own

breath at all (neither inhale nor exhale). Silent breath. At least when you're just sitting or standing. I'm not sure how feasible it is yet to have a silent breath while exercising. (This stage took about a week once I got the CapnoTrainer, though arguably it's still ongoing. In particular, there was a 24 hour period where I had a kind of epiphany and figured out how to do this right.)

- As with the nose breathing stage, you don't have to get it to be perfect. Sometimes, breathing in a silent way can make your diaphragm or your throat hurt. I think this happens because you're manually trying to control those muscles too hard by tensing them up in the wrong ways. If that's the case, you can try for a while to just make a bit of noise when breathing, just like you might still have "rescue breaths" through your mouth sometimes.

3. Next stage: smooth your breath.

- Even when your breath is through the nose and silent, it can be "jagged" on the CapnoTrainer. It can even *feel* jagged to you, like you're manually forcing air out in little bursts, instead of it just flowing out like it should. I don't know how to fix this one yet, but it seems harder to notice and harder to fix, so that's why it comes later. But the idea, at least for the exhale, is to just try to let go of the breath and naturally let your diaphragm relax. It should feel like your body is just relaxing, instead of exhaling (even though of course you are also exhaling). As I said, I'm still experimenting with this one.
- This one is tricky because I notice that as I try to do it my diaphragm can get sore if I do it wrong. In particular, it can sometimes help to break the "silent" rule in order to get the breath smoother. There's a distinction between breathing in a way so that you aren't hypocapnic, and breathing in a way that is comfortable and not painful to your body. Every combination is possible.

4. Next stage: slow down your breath.

- Your breath should already be slower if it's more quiet and smooth. But when you're trying to make it quiet or smooth, you don't want to focus on slowing it down ... that just makes you uncomfortable because you're not used to that much air hunger. But once your breath is silent and smooth, it's time to focus on slowing it down. I

still haven't gotten to this stage so I don't know how slow is optimal. I suspect this is the point where an HRV monitor or such would be handy: there might be individual variation in the optimal rate. Notice how it's much harder to say what "slow breath" is compared to "nasal breath" or "silent breath" or "smooth breath", and it is much harder to track without an instrument like a capnometer (counting in your head all the time seems annoying!).

- UPDATE (2024-01-26): i am thinking more and more that slowing your breath is unnecessary; it's like the diaphragm thing and it automatically happens. i think some of the buteyko people also say the same thing. e.g. see Novozhilov (2012); in the section "Approach 3 – Just hint at reduction of airflow" there is an illustration of a snake where slowing down the breath is a sign of doing the exercise wrong. Under mistakes, he lists "Increasing the frequency of your breathing or changing the length of inhalation or exhalation."

Note that the above is essentially (some of the particular techniques taught in) Buteyko breathing. The differences are: (1) pedagogical, in that I think focusing on each step in sequence works a lot better, and (2) whether to use a CapnoTrainer to help with some of the steps.

7.2 Any more stages?

upper chest (intercostals) vs diaphragm? i feel like this one happens automatically by doing the ones above. But for some reason this is like the focus of many breathing gurus/meditation experts. but it's not necessary! in fact, i think it can be harmful to focus on your diaphragm too much – it leads to exaggerated/forceful movement of it which can cause overbreathing/sore muscles. like, sure, it's fine to check your abdomen to see that you are generally breathing with your diaphragm more than upper chest, but it shouldn't be a target.

8 Clearing your nose

In my view, nasal breathing is essential for overcoming shortness of breath. It's also the very first step. There's a lot of strategies here so I'll list a bunch along with what I think of them. My guess is that different ones will work for

different people, so you kind of want to try a bunch and see what works (most of these are quite cheap).

I won't say much about *why* it's better to breathe through your nose, as I think this is already covered pretty well in other sources, in particular Nestor (2020), which gives a pretty vivid description of the author's own experiment of breathing solely through his mouth (it's scattered throughout the book, so unfortunately I can't cite a specific chapter).

I think there are two broad ways you can react to "you need to clear your nose". One of them will be to say "Yeah, I hardly ever breathe through my nose; I know I need to work on it but I don't know how". The other is to say "I already breathe through my nose; I don't think I need any advice". For this second type of person I want to mention my own anecdote. Before I started really focusing on my breath, I used to think I was already a nasal breather, but when I started paying attention I realized that I was actually taking quite a few mouth breaths throughout the day. A sure way to find out is to tape your mouth during the day (even for just 15 minutes or so) and see how easy it is for you. I think I probably went from around 80% nose breaths to 99.9% nose breaths by following the strategies listed below (just a wild guess unfortunately because I didn't keep good records); during breathing attacks, I probably went from 10–50% nose breaths to 95% nose breaths. So if you already think you are a nasal breather, I would still try paying attention.

Now, here are the main strategies I recommend for clearing your nose so you can nose breathe more:

- Saline spray: works less well than the saline wash, but it's a lot less unpleasant. it doesn't go "deep" enough, which is why it is both less painful and doesn't work as well. i went through about 1.5 bottles of the NeilMed one (lime green color bottle) before my nose improved enough that I didn't need to use it anymore.
- Saline wash/netipot: tried this once. it works really well for clearing your nose, but it was also quite unpleasant. make sure to never use tap water for this.
- Nose strips: these were quite helpful. at first i used the RiteAid brand ones and they worked well enough, and then i got cheaper ones from Amazon and those also worked fine. so my guess is that there isn't much of a quality difference between different brands, and you can just go with whatever. the main thing to watch for is that your skin should not get irritated from using them. also, you should *immediately* notice an

improvement. if you don't immediately breathe better, then you're either not putting them on right or the thing isn't working. There is also a magnetic strip made by a company called Intake Breathing. I never used it so I don't know how well it works, but if you can't get regular nose strips to work, you can look into this.

- Nose cones: these didn't work for me (i got them because i was encouraged by how useful the nose strips were, and cones seemed like reusable strips). they don't go deep enough in the nose, so they really only help i think if you have a deviated septum or something. . .
- Patrick McKeown's nose unblocking exercise: this is one where you pinch your nose while holding your breath, and swaying or walking around as you do that. I tried this back when my nose was stuffier, and it didn't work very well for me, but i also didn't try very hard to get it working (i just followed one of his videos).
- Antihistamine spray (e.g., azelastine): my guess is azelastine did nothing for me. but maybe it helped a bit with reducing mucus producing during the night. i never tried olopatadine (the more famous antihistamine nasal spray) because my insurance doesn't cover it.
- Steroid spray (e.g. Flonase): i would stay away from these, unless you already know they work well for you. definitely try all the other ones in the list first. note that there are different kinds of steroid sprays and some of them are *very* bad to keep using long-term. Flonase is supposed to be one of the safer kinds, but i only used it once so i can't speak to any longer-term effects.

Important note: as you start breathing through your nose more, you should find that your nose becomes less blocked even without doing these things. I used to need the nose strips *a lot* when I first started nasal breathing. But now I hardly need them. So these techniques should be thought of as temporary crutches – or like training wheels on a bicycle. They are there to help jump start your nasal breathing until your nose is strong enough, but you shouldn't need them forever. I had a clear shift when I first switched to nasal breathing, and then a second shift when I switched to *silent* nasal breathing. It seems odd that my nose would clear up with *less* air moving through the nose. My hypothesis is that either my health in general got better, or maybe less air means less irritation.

Definitely don't get surgery, unless you've tried all the safe options and nothing works. I think the mainstream medical world understates the risks

here, e.g., you should read about empty nose syndrome. Nestor (2020) has a bit about this. See also Sager (2024) for a random encouraging anecdote that I came across on Twitter.

i should say something about mouth taping as well. i don't have any *strong* argument again it, but i have personally not done it. as you improve your breathing, your mouth should automatically close. so mouth taping is, in my view, unnecessary in the long-term. what about the short term? after all, all the other nose-unblocking stuff i'm recommending are short-term crutches as well. i think in the short term maybe it's completely fine? i was just personally scared of using it, and never needed it.

my nose still sometimes feels unblocked in the morning. not sure what's going on there.

9 The unreasonable effectiveness of capnometers

One might naively expect that capnometers would be useless, since they don't actually *do* anything to your breathing. All of the breathing changes you make are ones you make yourself, and the capnometer just tells you what your CO₂ levels are without affecting them. One might thus conclude that capnometers are useless. I don't have a great reply to this – in fact, some people seem to get better just by doing Buteyko breathing “blind” (i.e., without seeing their breathing curve using a capnometer). So clearly it *is* possible to do the same things without a capnometer. (Even Peter Litchfield admits this to some extent.²) But in my case, it was only after I got a capnometer that I saw rapid progress. Here I will try to build a model of *why* having a capnometer is so useful.

²From Litchfield and Reamer (2024):

You may be wondering, “can I benefit from the course without using technology?” The answer, of course, is a resounding YES. The ultimate objective of breathing behavior analysis work is NOT about learning to use technology for manipulating breathing with physical techniques, i.e., an outside-in paradigm, but rather it is about learning new breathing habits that automatically optimize respiration, that is, aligning breathing with respiration based on the principles of self-regulation, an inside-out paradigm. The CapnoTrainer GO technology is a powerful tool for making this transition from an outside-in to an inside-out paradigm, that is, for identifying existing habits and learning new ones.

My model of why capnometers are so “unreasonably effective” is basically that with Buteyko breathing, part of the problem is that even if you make progress, you can never know if you’re pushing so hard that you’ve overshot your CO₂ and are now having too much CO₂. You can’t really avoid this problem because both too low CO₂ and too high CO₂ feel pretty much exactly the same – air hunger. So a capnometer is what actually lets you know for sure whether you are undershooting, just right, or overshooting.

It’s just super helpful to *see* what your breath looks like. Buteyko breathing can feel *scary* because you don’t know if you’re going too hard and might be harming yourself. Hooking yourself up to a capnometer tells you whether your CO₂ levels are normal.

one of the things i’m still trying to figure out is, supposedly Konstantin Buteyko originally had various machines to measure CO₂ or whatever, but then they were destroyed, so then he was forced to come up with the Control Pause as the sort of replacement metric. but what i’m wondering is, what did his machines measure? was it just end-tidal CO₂? and if so, then what did he do after people reached a normal 40 mmHg of pCO₂? was that the end of treatment? or did he try to push the CO₂ even higher?

10 Capnometry biofeedback

[TODO: fill out this section. It should be about how to use the capnometer well. maybe include my list of “things to try on the capnometer”. talk about what the ideal breathing curve should look like.]

11 Posture

I’m appreciating posture more now – it really makes silent relaxed breathing easier when you have better posture. But “good posture” is maybe not what society thinks is good posture, but whatever feels comfortable to you and allows for good breathing.

The Buteyko people also emphasize posture, but I have not read much about what they say.

i still have a lot to learn here. apparently some posture techniques can be quite dangerous (can even cause die-off reactions??)

12 Breathing synthesis

My synthesis = “Buteyko method” + “Alexander Technique” + Capnometry biofeedback

or maybe:

My synthesis = Nasal breathing + Silent relaxed breathing + Posture + Habits + Capnometry biofeedback

- Buteyko provides nasal breathing, silent breathing and a theory of air hunger via CO₂ levels. I put it in quotes because this is probably a vast oversimplification of the Buteyko method – but I only needed this much of the theory.
- “Alexander Technique” is what I mean by just allowing the breath to happen: smooth, not jerky. “Allowing the breath to happen” rather than doing the breath. And also making the good breathing a *habit* rather than “executing techniques” when you need them. Make it automatic/autonomic/subconscious/unconscious, rather than conscious/manual – this one might be two separate things actually (the smooth part, and the unconscious/habit part). Some of the Buteyko people also *mention* this, but it tends to be much more buried and not *emphasized*. I think it really needs to be thought of as one of the main components.
- Capnometry biofeedback is discussed elsewhere in this document, e.g., see the section The unreasonable effectiveness of capnometers.

13 Techniques vs habits

One of the disagreements I’ve seen in the breathing world is the emphasis between techniques vs habits. Those on the techniques side (such as anxiety specialists and Buteyko practitioners) present various techniques you can use when you are stressed, anxious, or have breathing difficulty. Those on the habits side (such as Peter Litchfield) say that techniques are mere bandage covering up a dysfunctional breathing habit, and that the solution is to unlearn the old habits and introduce new habits.

(actually i think *some* buteyko people have basically the same views as me.)

I find myself somewhere in between these two views. In a sense, I think both sides are right, and it’s actually quite important to understand what’s

going on here. Techniques are a way of *learning* a thing. Once you’ve learned it, you don’t need to “follow a technique” anymore, it’s just a part of you. But having it verbally, explicitly, legibly, outlined is a useful step in actually learning the thing initially. You follow the technique, you get anxious about whether you’re doing it right, you get obsessed about it, you get good at it, and then finally you get bored of it. It’s all part of the *overlearning* process. Once your bodymind digests it, it poops out the scaffolding of the technique and you can just Do The Thing. See also the four stages of competence (*Four stages of competence* 2023).

So yes, do the techniques. Learn them so well that you get bored of them and forget about them.

14 Breathing techniques

Reminder that none of these techniques will work if you can’t breathe through your nose comfortably. See the section Clearing your nose for how to unblock your nose.

14.1 Relaxed silent breathing

This one is most similar to Rakhimov (2013, section 4.6, “Relaxing the diaphragm (Buteyko relaxed breathing exercise)”), but Neil Tranter also has a similar video (Tranter 2023). Novozhilov (2012) has similar exercises too (e.g., Exercise 1).

Exercise instructions: sit upright in a comfortable way. Breathe silently through your nose. Then just try to make sure the exhale is done in a completely relaxed way, where your whole body (but esp diaphragm) relaxes. You are *not* pushing the air out. Just a whole-body relaxation on every exhale. On each exhale scan *one* body part for tenseness: shoulders? torso? legs? etc. Just focus on one body part at a time, and try to relax it on the exhale, and keep it relaxed. The idea of this exercise is that just by relaxing the exhale, your breathing should slow down (but don’t try to artificially slow down your breathing) and so it actually is a (mild) reduced breathing exercise even though it just seems like a relaxation one. Do this for 15 minutes or so.

Attention drifting during the exercise is a *good* thing because you want to make sure this style of breathing becomes a *habit* (rather than only occurring when you are consciously executing the instructions). You want your mind to

drift away from your breath, as a way of giving yourself small opportunities to see if you can maintain the same breathing pattern even when you are not paying attention. The important point is that whenever you realize you have drifted and you're aware of your breathing again, you want to gently check to make sure you're still doing the completely relaxed exhale, and that your body isn't tense. You can even try to intentionally pay attention to something else, to distract yourself, so that you can check back on your breath to see what it has been doing.

The whole exercise is basically juggling your attention in this way: Is my inhale silent or as quiet as I can manage without tensing up? Is my exhale completely relaxed? Are all of my body parts relaxed (except spine, to keep an upright posture)?

If you have trouble relaxing your exhale or knowing whether you are relaxing your exhale, try the Double inhale technique or try artificially slowing down just the first part of your exhale. These two techniques should give you an easier time relaxing the exhale so you will know what relaxation feels like.

Your hands may warm up a bit, and this seems like evidence that the exercise is working.

note that i use the word “silent” rather than “quiet” because for a long time i thought my breathing was quiet, but it turned out my breathing was still making quite a bit of noise compared to what i *could* do. i don't want others to make the same mistake i did. if your hearing is normal, you should not be able to hear your breathing. if you are hard of hearing, then maybe get someone else to check for you.

the goal is to eventually be breathing in this way all the time. so it's a “technique” but also it is going to become a habit.

an open question for me currently is: after you do this conscious relaxed silent breathing, you will build up some mild air hunger. now, *after* you complete the exercise, how long should you “keep” that air hunger going? should you feel free to just take a slightly deeper breath and “clear” the air hunger, or should you keep it going for some time (if so, how long?), or should you just try to keep it going as long as possible? i think trying to keep up the silent breathing with slight air hunger for long enough periods tends to cause a sudden burst of anxiety for me, like a sense of panic at not being able to breathe. so i think that's probably not the right thing to do. but it's confusing because i go from feeling totally comfortable with the slight air hunger to suddenly feeling panicky. Lippmann (2015) says “This process [raising CO₂ tolerance over time] is long and finicky and can cause very unpleasant symptoms. Less

is more; barely knowing whether you're doing anything is best. You can also trigger panic attacks or asthma attacks if you're susceptible." Another thought is to, whenever possible when taking deeper breaths, to do so in more Buteyko-aligned ways, e.g., through the nose and as gently as possible. So don't satisfy the urge for a deeper breath by inhaling with your mouth or yawning or being super forceful about it, just try to gently incline towards a deeper breath, a slight force with your nose. NOTE: this may not be possible at first, e.g., i had to get to silent nasal breathing in order to take "good" breaths with little force through my nose. when i was still mouth breathing some of the time, i always had to take a good breath through my mouth. then when i started nose breathing (but loudly), i could take good breaths occasionally through my nose, but only by loudly sniffing in. so there's a gradual "handoff" where the old normal becomes the new "rescue breath" method.

Try slouching too as you do this exercise, and in general experiment with your posture. Your diaphragm will give you feedback on which postures work best. For example, when I slouch as I do this exercise, I notice my diaphragm can't move as well (both for inhale and exhale). Being too upright also makes it seem like my whole torso is too "stiff". So some intermediate posture seems to work best for me, but idk yet if this is optimal.

I think this exercise might be "breathing-complete" in the sense that it's the only thing you need to cure shortness of breath – but I am still actively testing out this hypothesis.

14.2 Many small breath holds

Tranter (2022) – the actual exercise starts around 7:46.

i think the main value of this exercise is at the start, to get used to very small amounts of air hunger, to be like "ok, yeah, this is uncomfortable but it won't kill me".

14.3 Double inhale technique

you take two relatively quick inhales, then exhale in a relaxed way.

This one was shown to me by my breathing coach. I've found this quite useful for getting my body to relax the exhale. i have no idea why it works, but somehow it's just easier to exhale in a relaxed way from a more full inhale.

14.4 Misconceptions

this section is mostly an index to stuff discussed elsewhere in the document.
(might remove this section if it doesn't seem useful)

- CO₂ is bad – see Respiration and misconceptions about CO₂
- deep breaths are good

15 Acknowledgments

i've benefited from interacting with a lot of people, in the course of figuring out my breathing. (people who i haven't checked with to see if they want to be mentioned are listed as initials, unless i'm only relying on public sources and no private interactions, which applies to Howard Cooper.)

- ML: kept mentioning buteyko breathing to me saying i should try it.
- Howard Cooper: While I've benefitted from all the sources I'm citing in the References, I want to call out especially Cooper (2021) as the thing that finally made the CO₂ stuff click for me (though my understanding was still very incomplete) and got me to actually start playing around with buteyko techniques.
- CM: told me about the capnotrainer and got me excited about capnometry biofeedback.
- Vipul Naik helped me understand some key things about the biology of respiration. In particular, he was the one who figured out that having a low CO₂ means pH is more sensitive to slight fluctuations in CO₂ levels.
- DD: introduced me to JA. he was also a catalyst for me figuring out my circadian rhythm, but that's a whole separate topic.
- JA: my breathing coach; helped me
- PL: was generous enough to spend an hour talking to me about capnometer stuff.

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