NEWSLETTER
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Homeostatic fluctuations indexes the parasympathetic tone

The homeostasis of the human body is not a static equilibrium but a dynamical one. In this dynamics, the cardiovascular system, hormone systems, afferent and efferent nerves coordinate with the brain, to maintain balance. In this balancing act there are often small but characteristic variations at different time scales that indirectly encode information about different parts and states of the body. In some cases you can use variability patterns as markers for different regulatory parts of the body that are otherwise very hard to measure directly.

One example of this is the influence of the parasympathetic nervous system on heart variability (HRV) and it's role in cardiovascular and hemodynamical regulations.

It's known that the parasympathetic nervous system, via the vagus nerve slows the heart down, while the sympathetic nervous increase the average heart rate, but this basic fact just by itself does not explain the variability in beat to beat heart rate.

If we via an ECG measures the RR intervals over 5 minutes, it looks something like this:

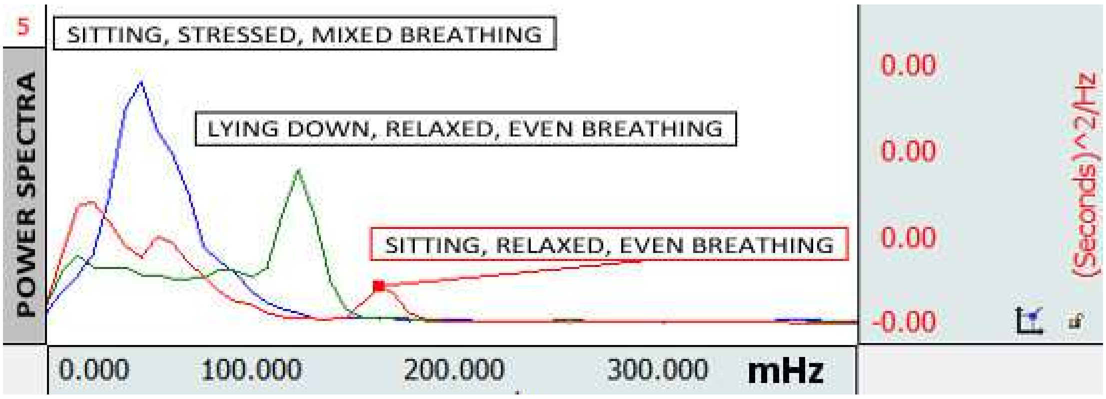
A first spontaneous reaction to this might be to suspect that something is unstable and wrong as the heart rate is jumping up and down. But this is not the case! On the contrary these small variations indicate an important functioning ongoing dynamical regulation. Total abscence of variability here would actually be a larger cause for concern.

You can see in the example above that there are a farily large amplitude component around 0.12Hz, which correlates with a slow breathing of the subject. The question is: How come the respiration influence the heart rate?

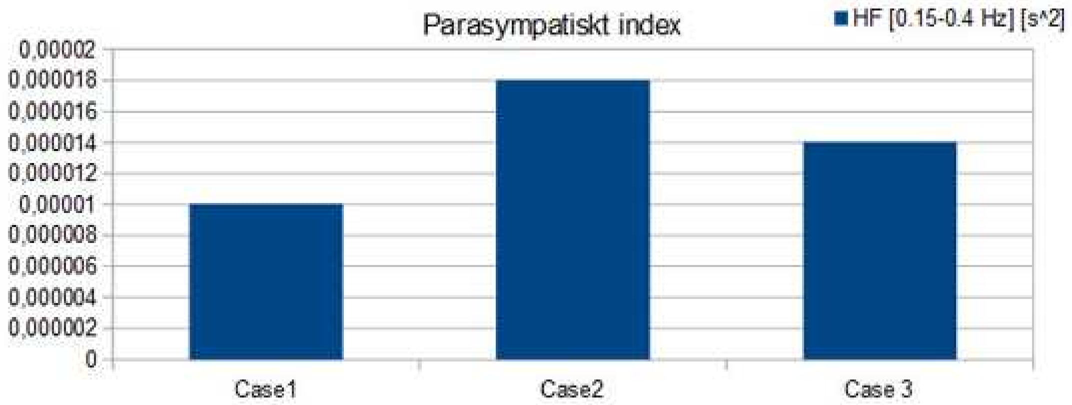
There is a respiratory driven modulation of both the efferent parasympathetic and sympathetic signaling of the pacemakercells of the heart. But it happens so that the parasympathetic receptors have the order of 5 times faster response than the sympathetic ones, which means that the modulations effectively only influence the heart from the parasympathetic inputs at typical breathing rates. This has the effect that the heart beats a little faster at inhalation when the damping of vagus decreases, and then it slows down on exhalation. And the amplitude of this ”effect” depends mainly on the parasympathetic level.

This means that the **heart rate variability modulated by respiration can be used as a useful index of the parasympathetic tone**, something that is otherwise very difficult to measure on a human. Ie. The variability of the RR intervals increase around the respiration frequency when the parasympathetic tone increases – however as with all experiments one must control wether other parameters also changes during the experiment, that can also influence this variability. This can be body posture, respiration pattern (unless using paced breathing), medications etc. A good idea is for control is thus to always also measure the respiration when doing HRV, otherwise the mere change of respiration pattern alone can change the index.

If you now do this a little more systematically, and make a spectralanalysis of the RR signal, you will see in which frequency ranges the variability occurs, and often there is some kind of peak around the respiration frequency, but the more irregular the respiration is, the less distinct will the RR variability also be. An example of a HRV power density spectrum from 3 simple 5-min tests we see here:



Often you integrate the power density spectrum in various frequency bands, and when you do this for the HF band (0.15-0.4Hz) this covers the typical respiration frequencies then this number that you get can be used as a parasympathetic index which can then be seen to vary during different exepprimental conditions. But caution is needed here, especially if the respiration frequency is outside this band. All the mathematical tools you need for this is included in Acq*Knowledge*. It has the standard implementations already, but also all the required tools to define custom measures.



The variability in the lower frequency bands are at least as interesting, but they are unfortunately also more complex to interpret. Historically the LF band was often used as a sympathetic index, and thus the LF/HF was an index for sympatho-vagal balance as this under certain circumstances has been shown to make sense, but nowadays it's known that this is not generically true and the actual situation is much more complex. The LF band first of all depends on both the parasympathetic and the sympathetic tones, as well as some other parameters, which makes it far less trivial to interpret this frequency band. So extra care is required when interpreting and using this indexes.

One can also look at even lower frequencies and there are ongoing research here and suggestions that certain frequency bands might serve as candidate risk markers for various medical conditions, but this gets far more complex than LF and HF as it involves not only ANS, but also hormonal regulatory systems and direct afferent feedback between heart-brain. All this is interesting to anyone wanting to explore this field and look for potential new markers would also need the same setup to get ECG, maybe respiration and the software to work with and customised measures.

Follow link below. You will find more details and:

- Video demonstrations on how to use HRV tools

- BIOPAC scripting tools and scientific reference papers

You are welcome to E-mail **biopac@jor.se** or contact Fredrik Rådebjörk, **fredrik@jor.se**, if you have further questions and tell us about your projects so we can get back to you with more specific proposals for your research.

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