“Sympathovagal Balance” A Thermodynamic Perspective

Ronald Schondorf, Julie Benoit, Melvyn J. Lafitte
McGill University, SMBD Jewish General Hospital,
Montreal, Quebec, Canada

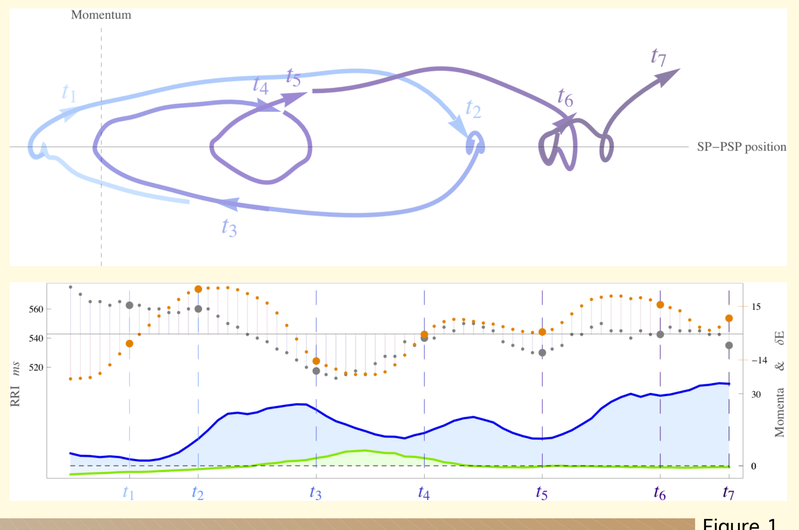


Figure 1

PREAMBLE:

We have previously applied a novel time domain method to provide kinematic descriptors of vagal and sympathetic responses of cardiac autonomic activity during well-characterized physiologic maneuvers. This method essentially considers each component in isolation and provides little insight into the overall impact of these responses. Thermodynamics considers energy changes within a system in terms of heat entering the system and macroscopic work done by the system. Usually the latter is regarded as meaningful by an outside observer. We adapted our analytic method to obtain an index of energy balance from the original phase space representation of our beat-to-beat responses in an attempt to obtain a more physiologically interpretable index of activity.

We focused on state changes to varying levels of orthostatic stress in normal subjects and in patients with POTS or neurally-mediated syncope because the physiology of the cardiomotor response is reasonably well understood. A brief synopsis of the analysis strategy is provided in *Figure 1*.

Figure 2: Response to 0.1 Hz phasic neck suction (data provided by Dr. Luciano Bernardi). In this and all other figures grey is RRI, green is the kinematic descriptor of the vagal response, blue is the kinematic descriptor of the sympathetic response and orange is the index of change in energy. In this example there is a very strong correlation between delta energy and delta RRI.

Figure 2

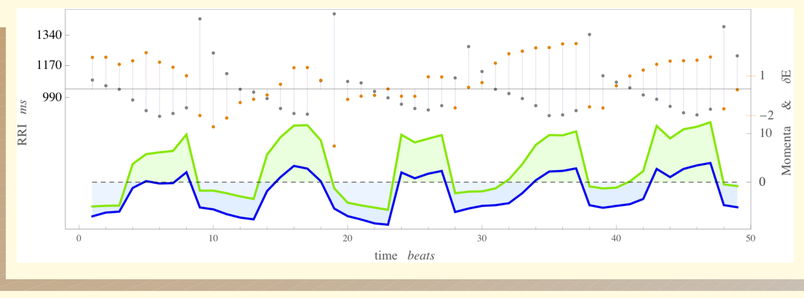


Figure 3: Response to head up tilt (HUT) in a normal subject (tilt onset beat 175). Large increases in energy fluctuations during tilt appear to drive fluctuations in RRI.

Figure 3

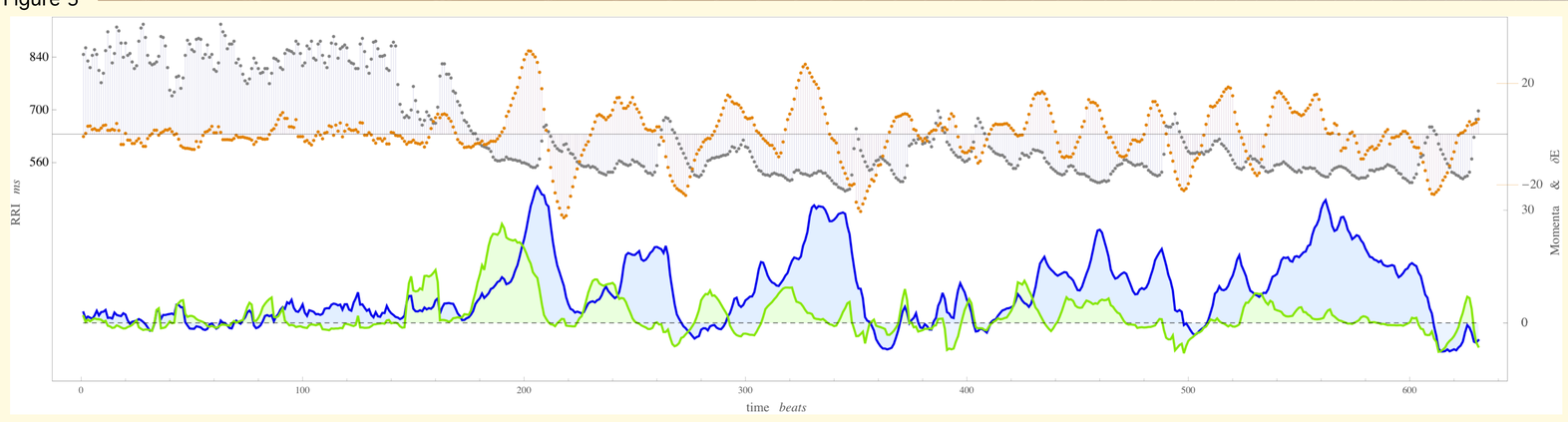


Figure 4: Response to combined HUT and heat stress. Note the more pronounced cardiomotor response and fluctuations in energy.

Figure 4

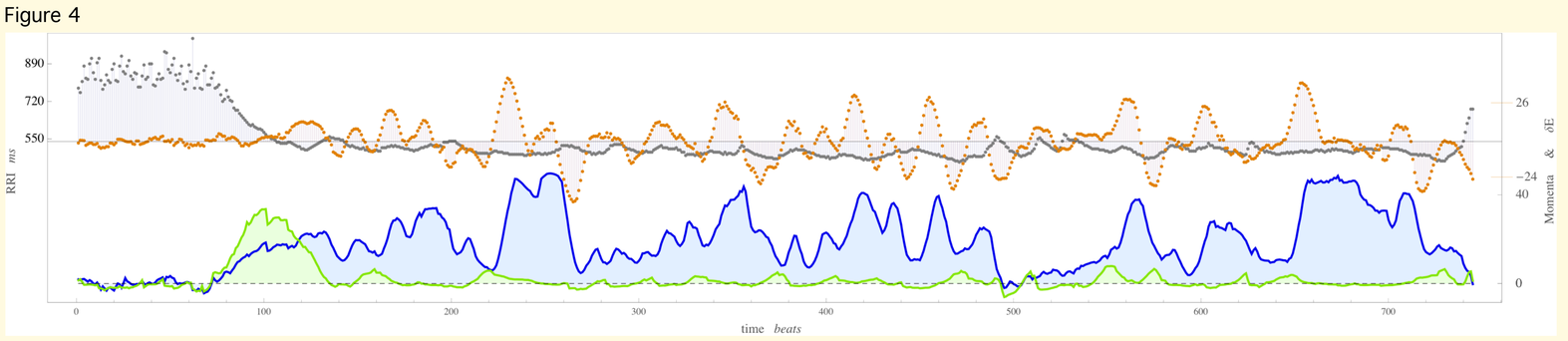


Figure 5: Response to MAST pants inflation and deflation during HUT in a patient with POTS. Note the attenuation of energy fluctuations during MAST pants inflation.

Figure 5

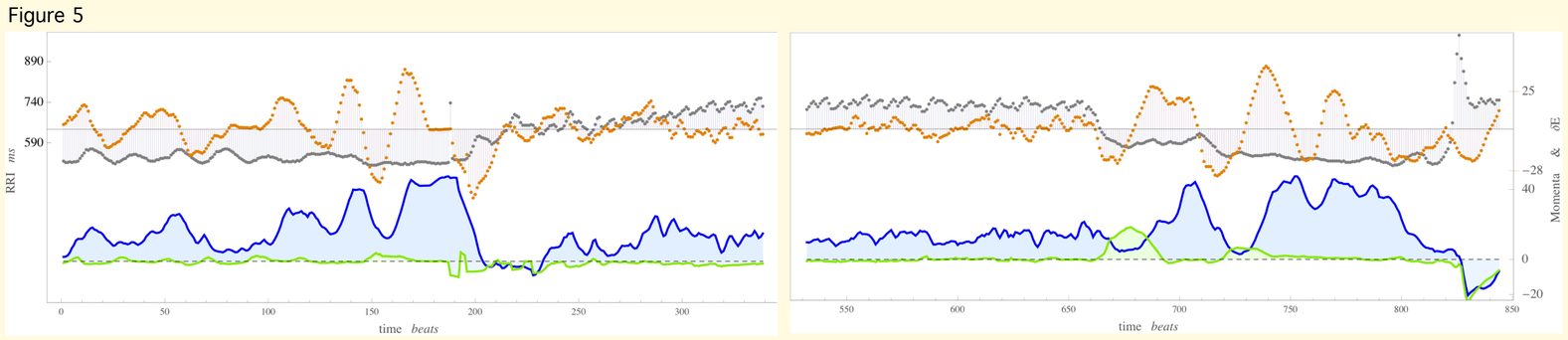


Figure 6: Later stage of HUT and tilt down in a patient with pure vasodepressor syncope. Note that the large fluctuations in energy prior to syncope seem not to translate as changes in RRI.

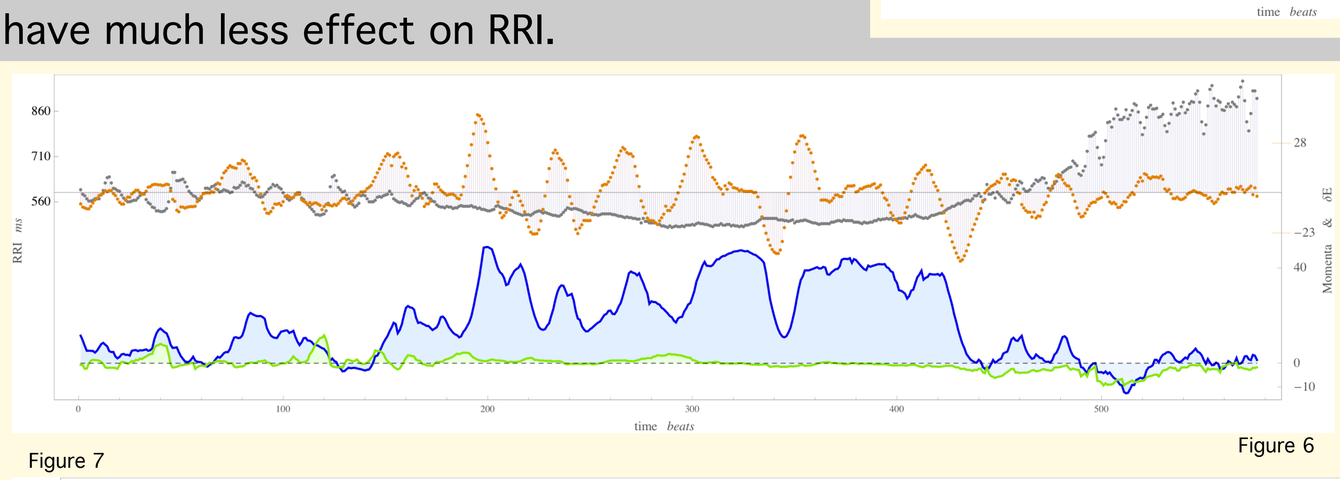
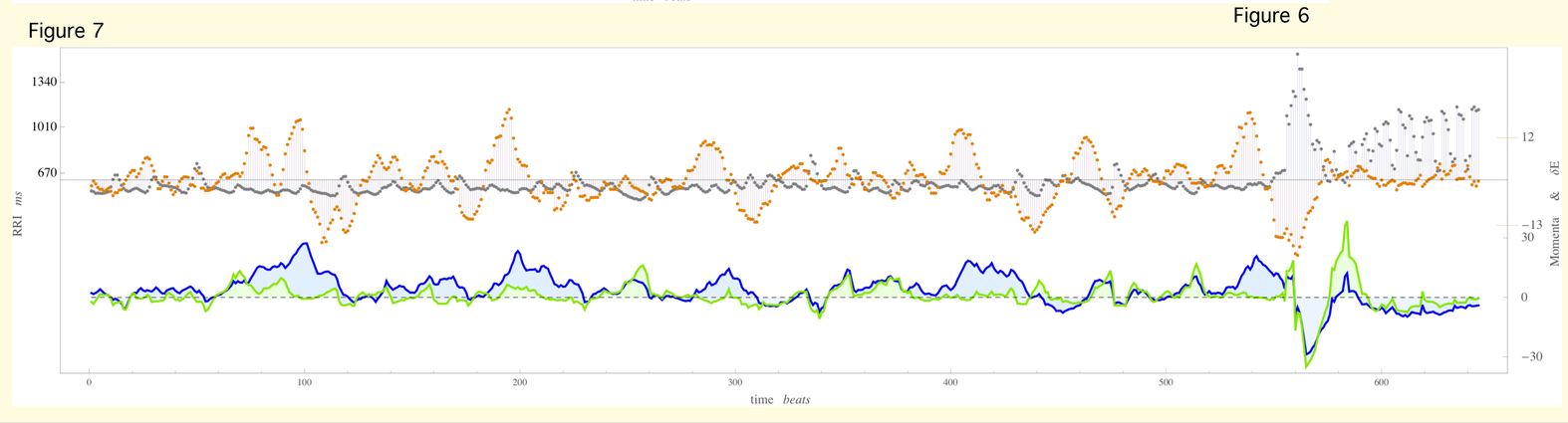


Figure 6

Figure 7: Later stage of HUT and tilt down in a patient with cardioinhibitory syncope. Note the strong correlation between energy fluctuation and RRI at syncope whereas earlier in HUT similar fluctuations seem to have much less effect on RRI.

Figure 7



INTERPRETATION:

It would appear that analogous to other thermodynamic systems not all energy transfers cause changes in RRI. In some instances *heat* production that does not result in meaningful work appears to dominate.

Changes in RRI cannot be predicted or derived solely from isolated descriptors of cardiac autonomic activity without simultaneously considering overall effective energy transfer.

Hôpital général juif
Jewish General Hospital

DyAnsys