Vrije Universiteit - Ambulatory Monitoring System (VU-AMS)

Prof dr. Eco de Geus

Dept Biological Psychology

Vrije Universiteit, Amsterdam

eco.de.geus@vu.nl

Physiological Stress Response

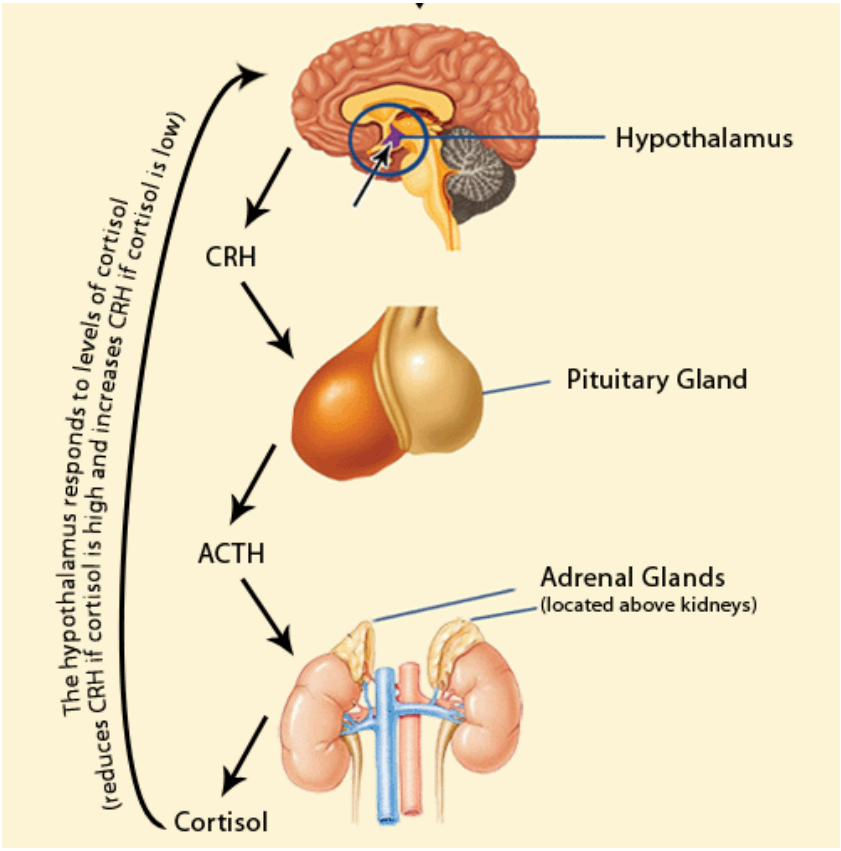
"Limbic Brain"

Hypothalamus ("head ganglion")

Brain stem & spinal cord nuclei

Sympathetic nerves (activation; 'flight & fight')

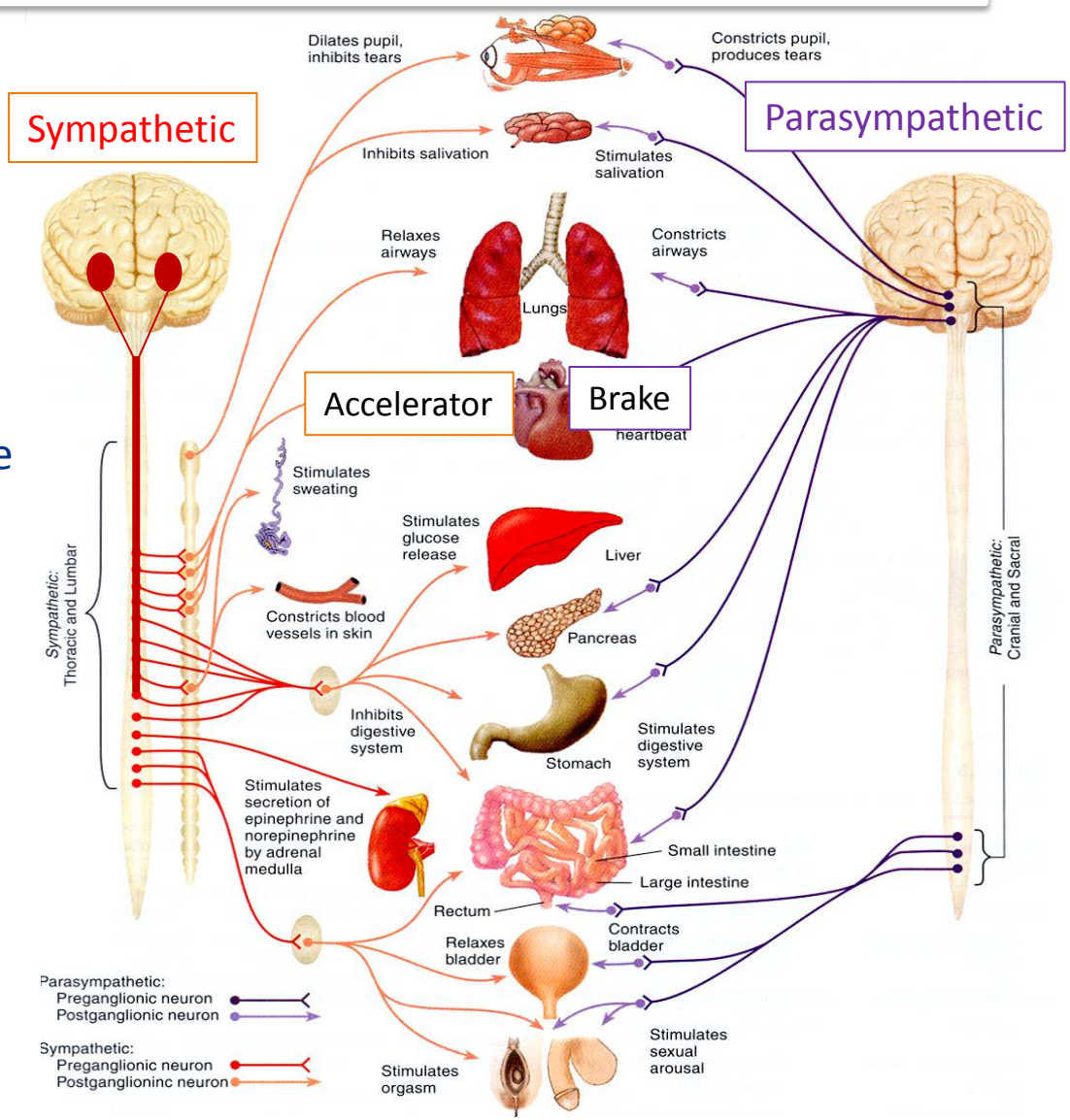
Parasympathetic nerves (restoration; 'rest & digest')



Autonomic Nervous System

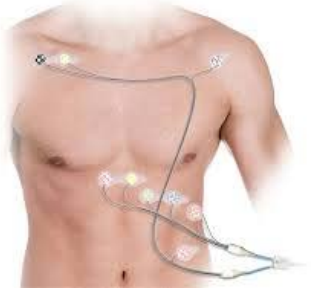
The **physiological stress response** represents an unknown mix of **sympathetic activation** and **parasympathetic de-activation**.

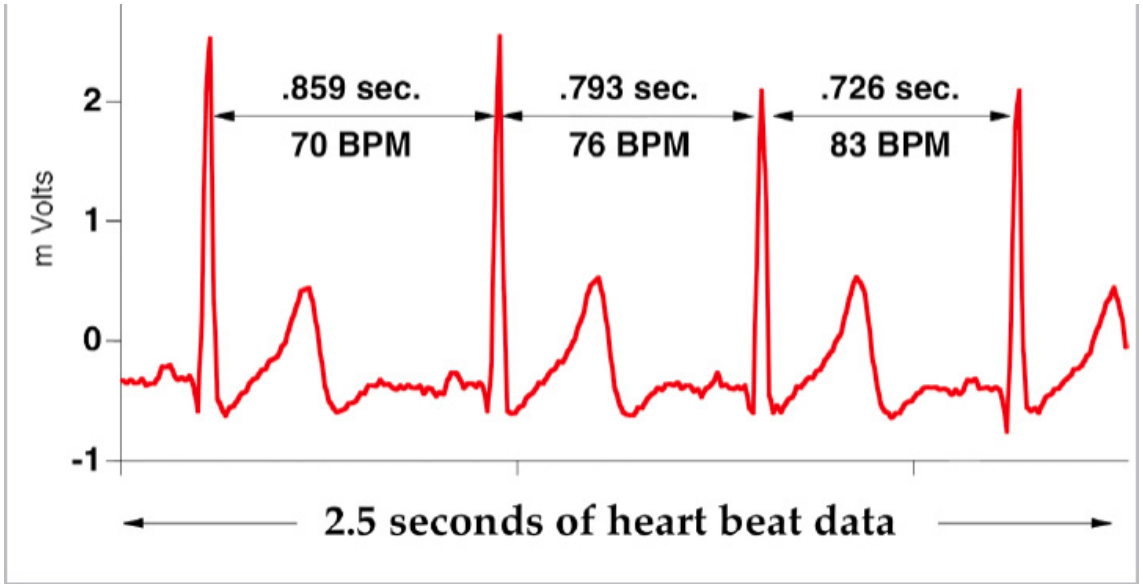
- Emotional antecedents of sympathetic reactivity need not be the same as those of parasympathetic reactivity
- Health outcomes of sympathetic hyperreactivity need not be the same as those of parasympathetic hyperreactivity
- SNS and PNS effects are opposing and their reactivity to emotion often reciprocal (but not dogmatically so).

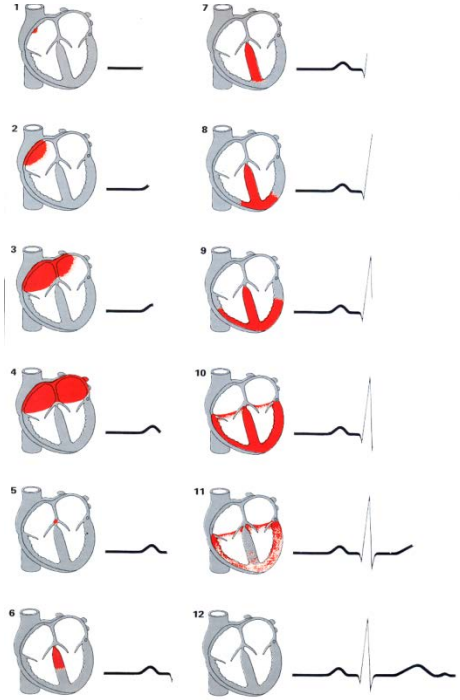


All time favorite: Heart Rate

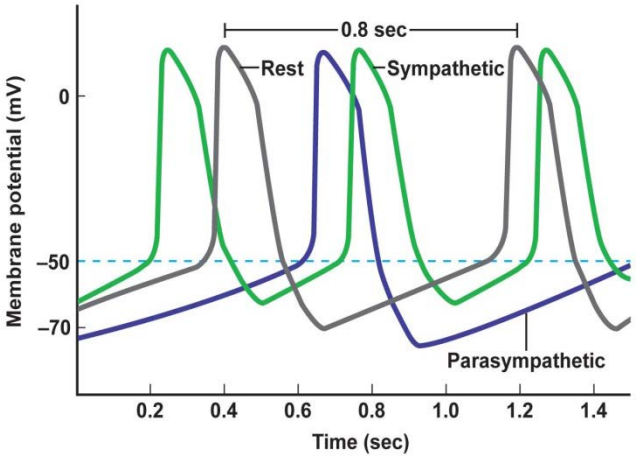
- An increase in heart rate is one of the most robust response to emotional engagement
- It can be very easily measured with minimal costs
- High trust in / familiarity with the basic signal, the ElectroCardioGram (ECG)

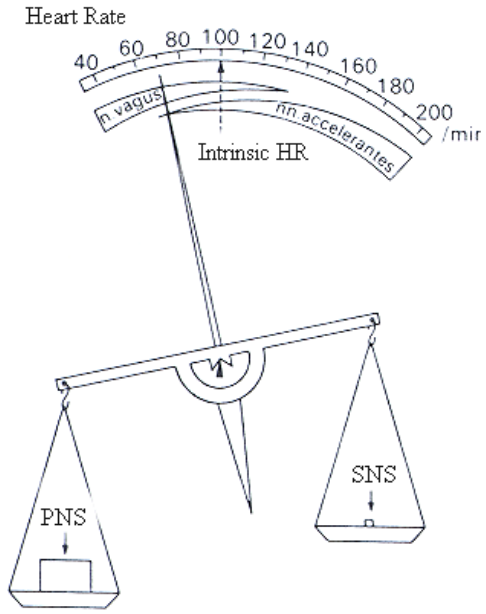






Cardiac autonomic control





Heart rate is a function of:

1 Intrinsic heart rate (HR_0)

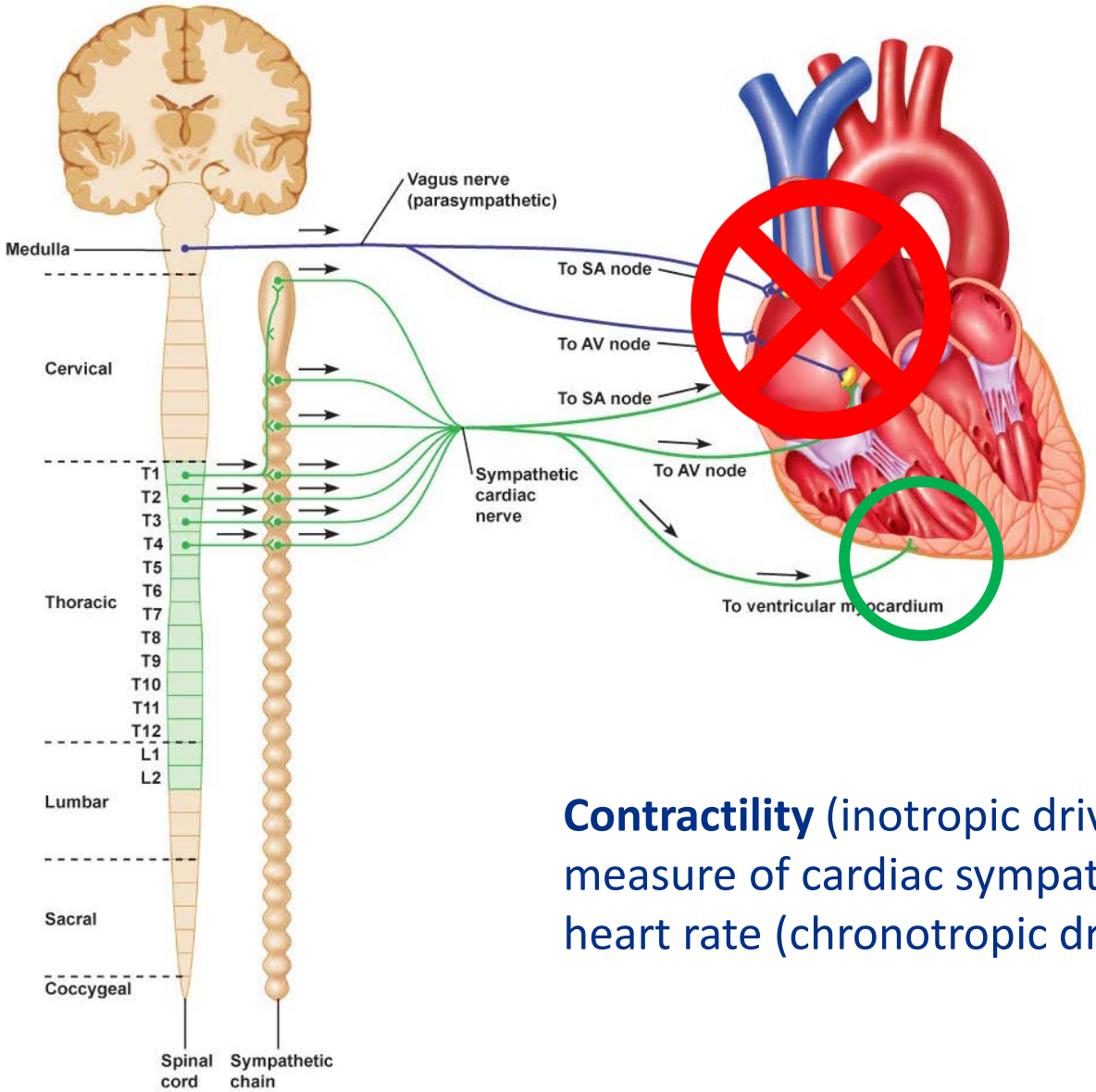
2 Extrinsic chronotropic effects that consist of a mixture of

2a sympathetic cardiac control

2b parasympathetic cardiac control

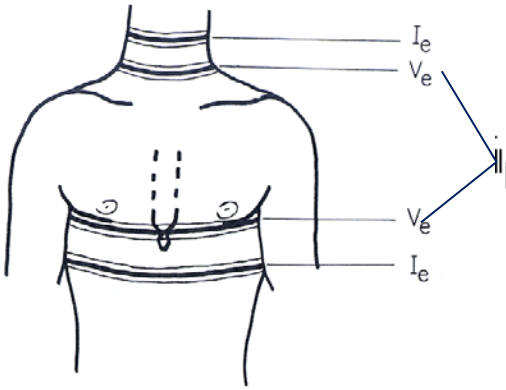
3 Interactive effects between sympathetic and parasympathetic control (accentuated antagonism)

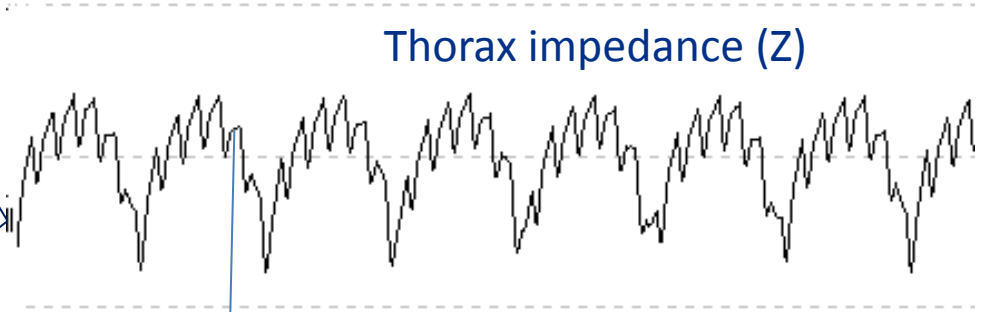
Can we selectively measure cardiac **sympathetic** activity?



Contractility (inotropic drive) is a more pure measure of cardiac sympathetic activity than heart rate (chronotropic drive)

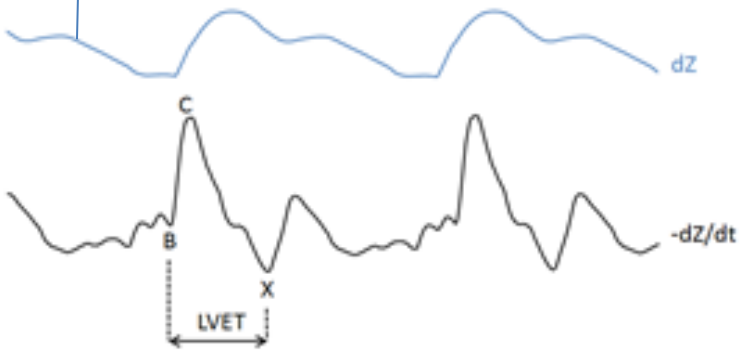
Impedance Cardiography



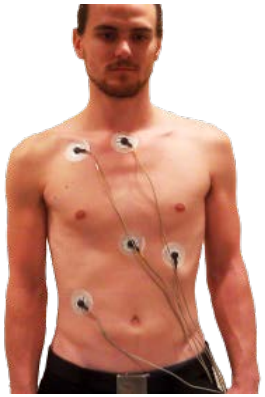


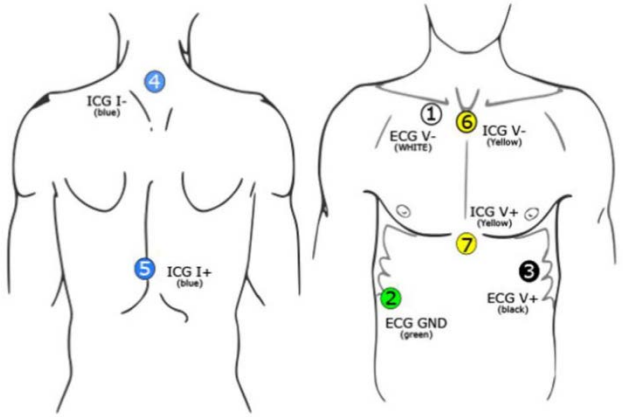
dZ = changes in Thorax Impedance

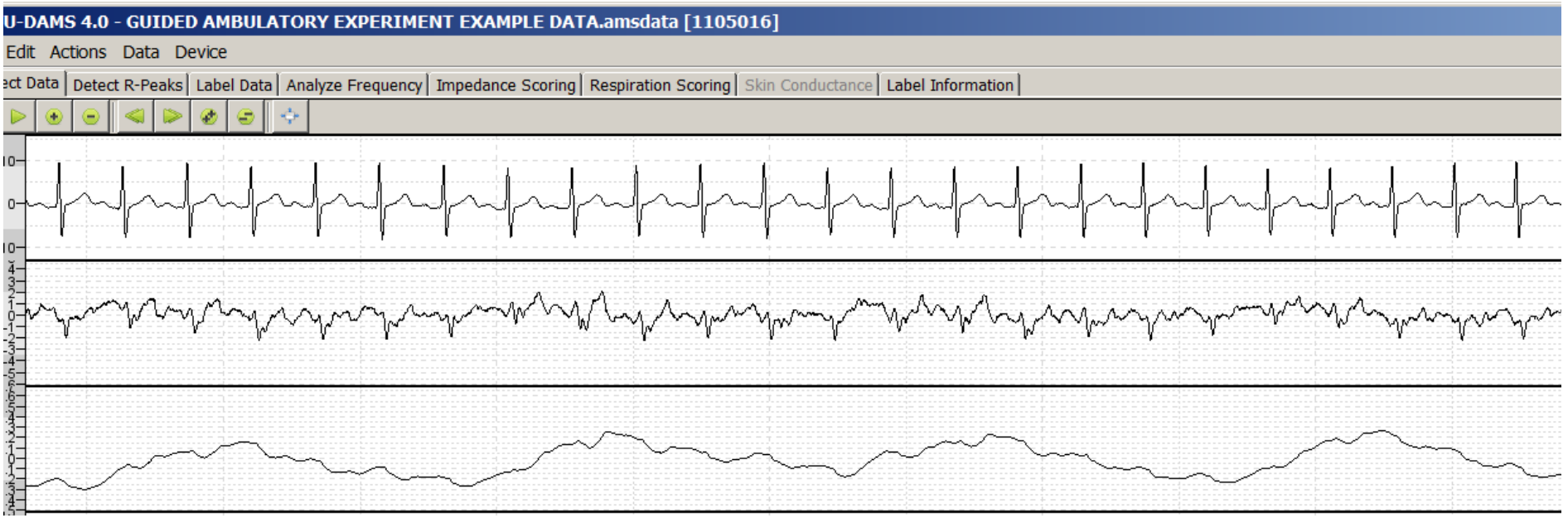
dZ/dt = Impedance Cardiogram



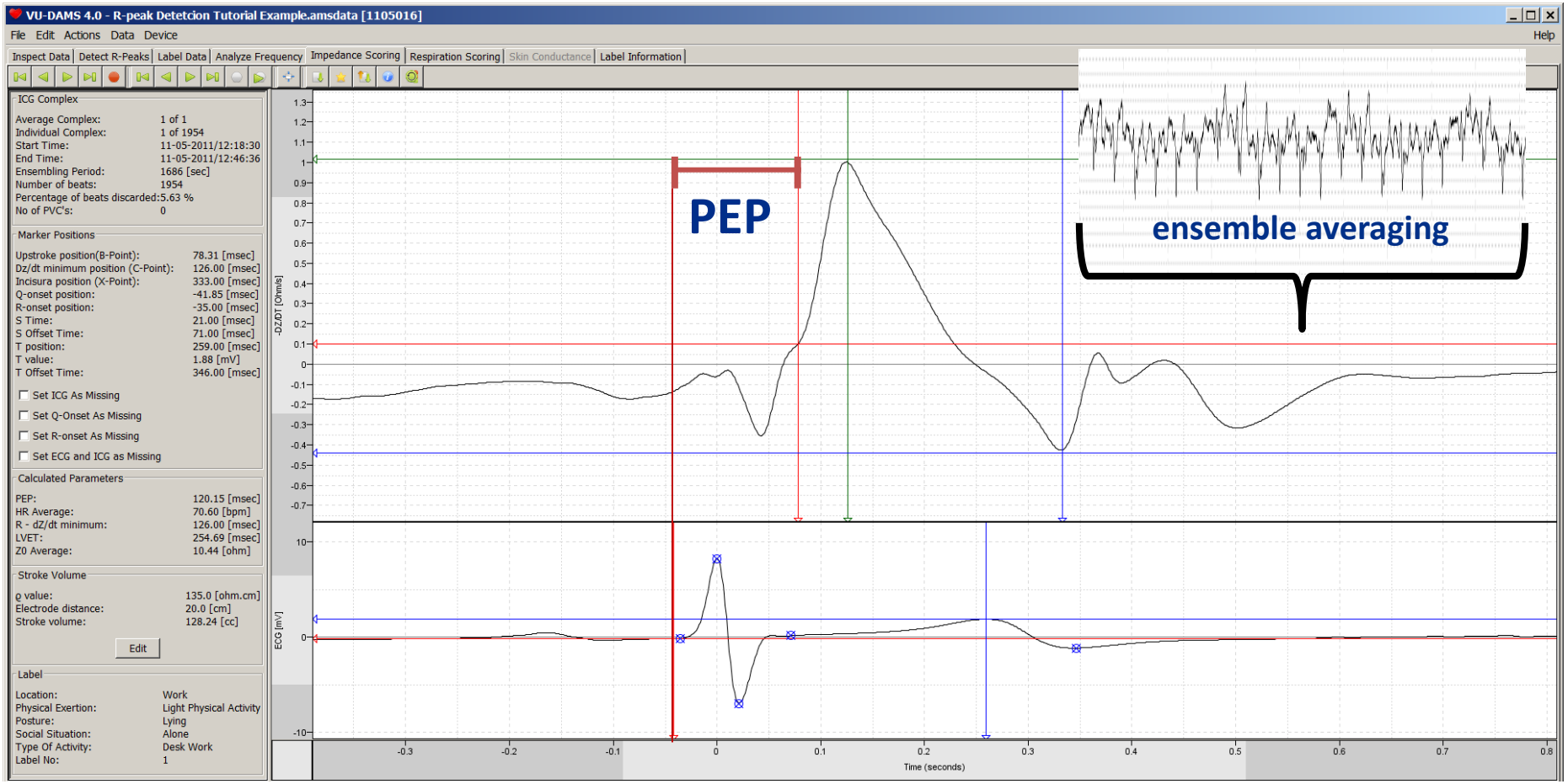
Spot electrodes







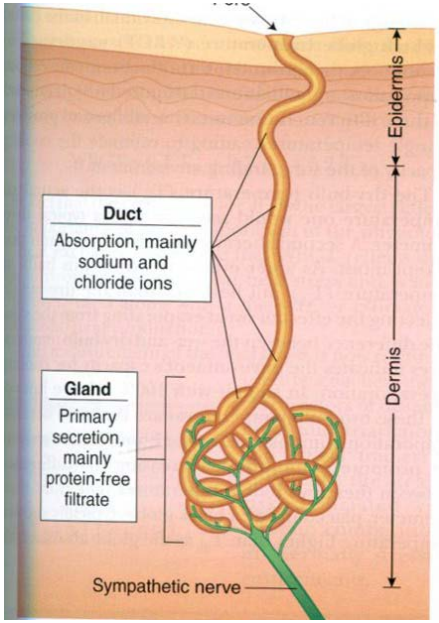
Pre-ejection Period (PEP)



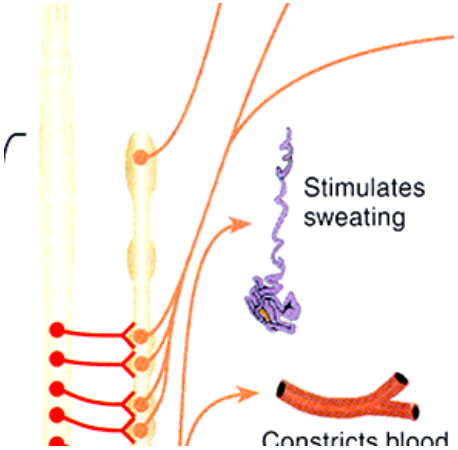
PEP is a measure of cardiac contractility
(which is influenced by SNS activity but not PNS activity)

Skin conductance

Straightforward signal origin



"Pure" Sympathetic



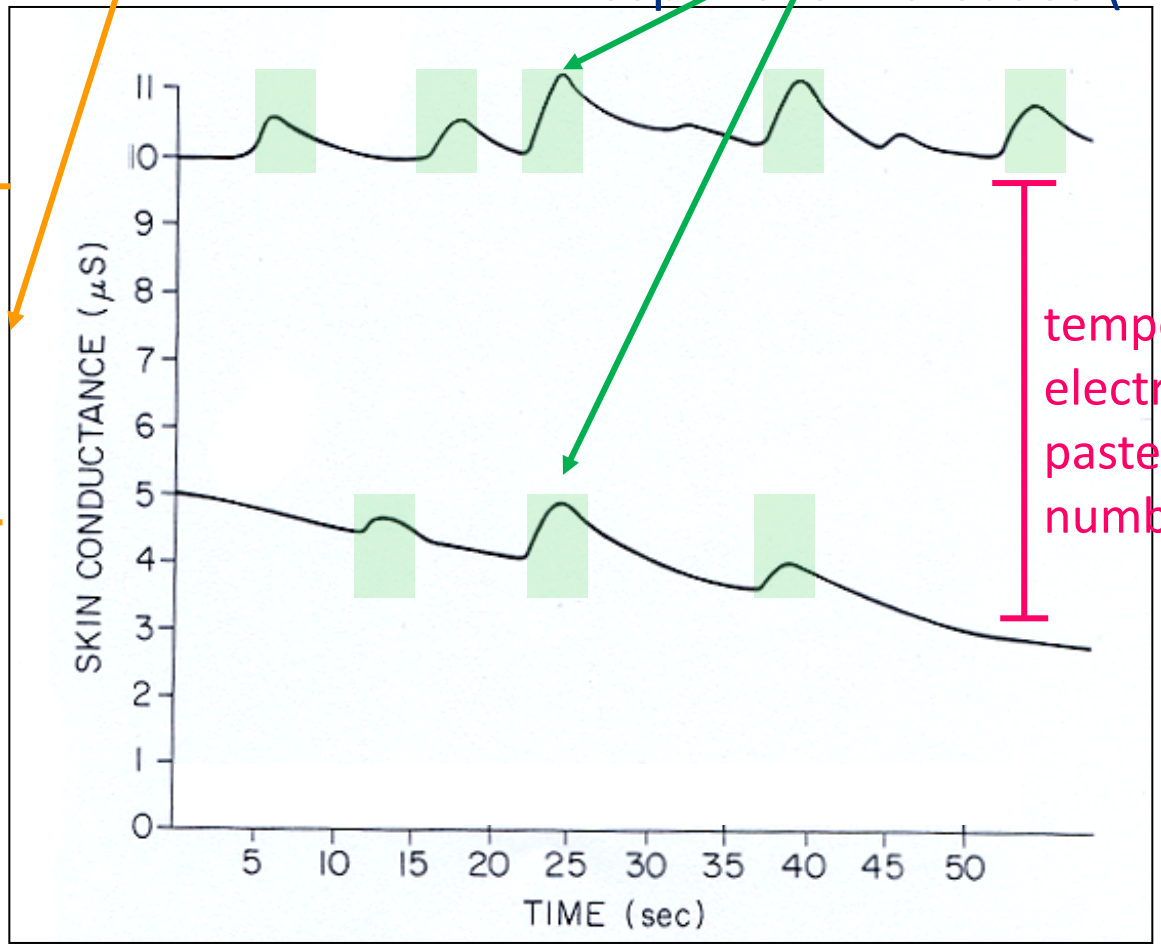
Very simple to measure

More sweat production in the ducts in a larger number of sweat glands with more sympathetic nerve activation.

Skin conductance & Stress

Skin **C**onductance **L**evel (**SCL**) increases with stress

Frequency **n**on**s**pecific **S**kin **C**onduction **R**esponses increases (**nsSCRs**) with stress

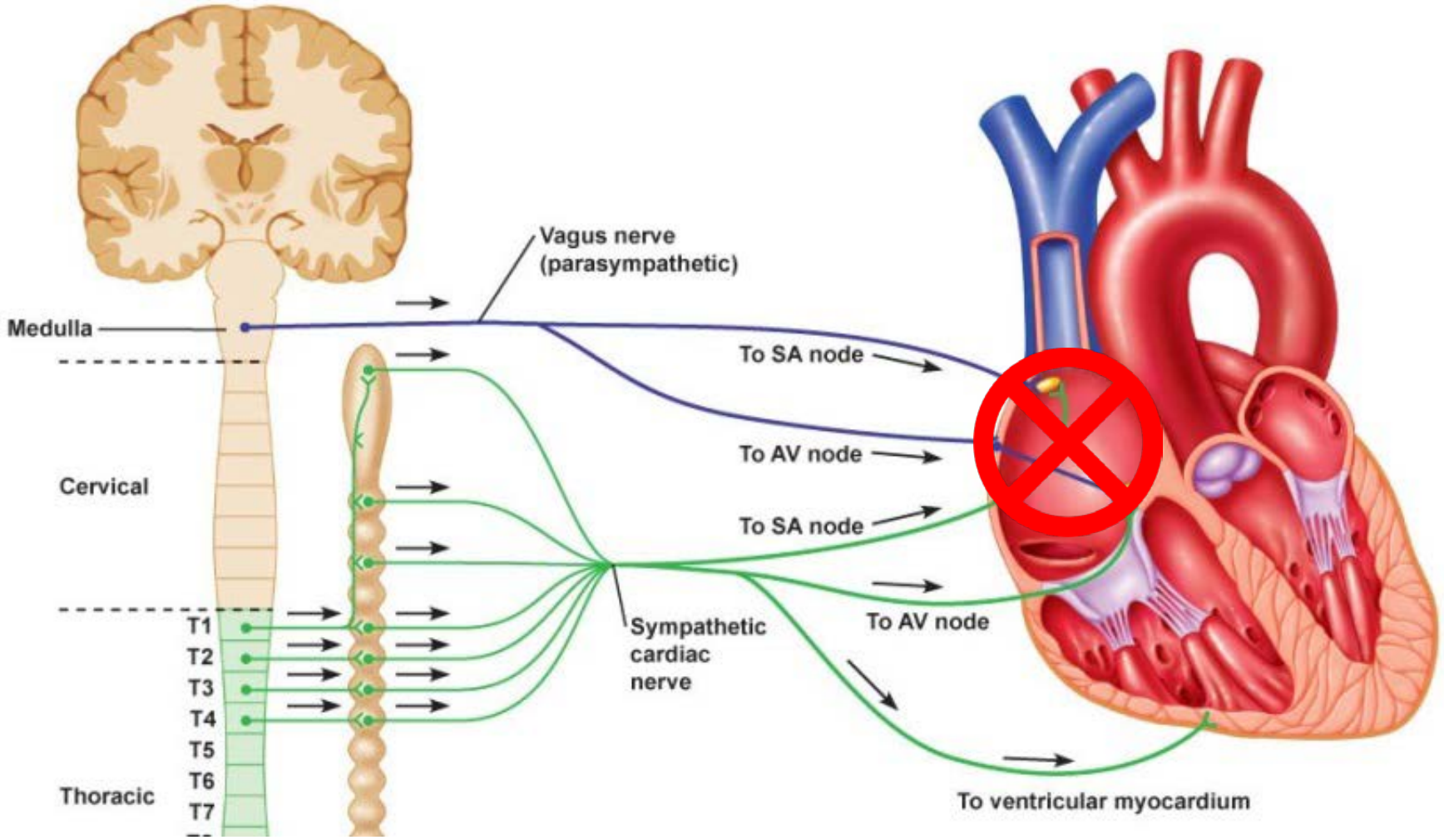


High stress

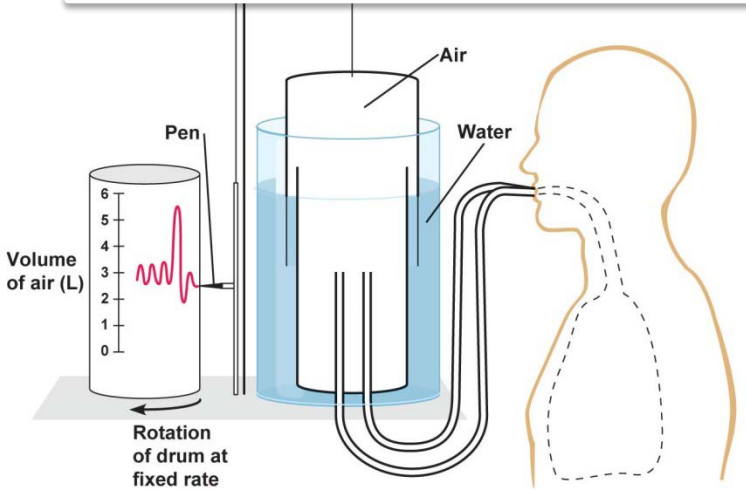
temperature,
electrode placement,
paste composition,
number of glands per mm^2

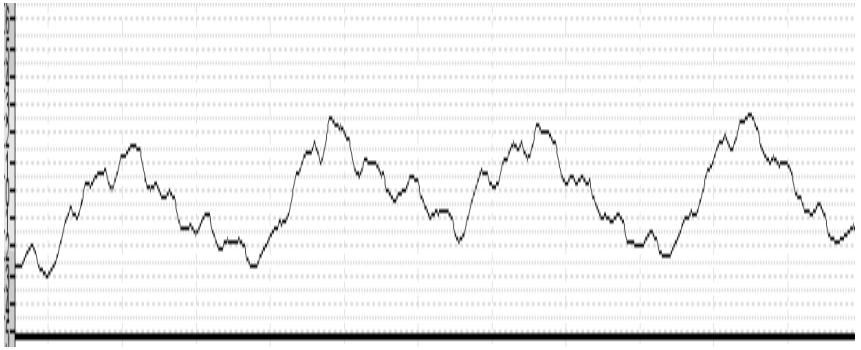
Low stress

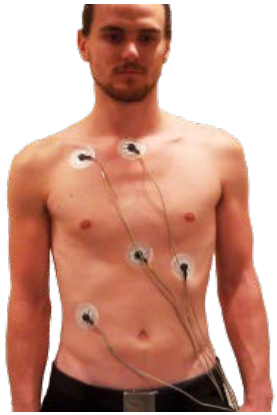
Can we selectively measure cardiac **parasympathetic** activity?

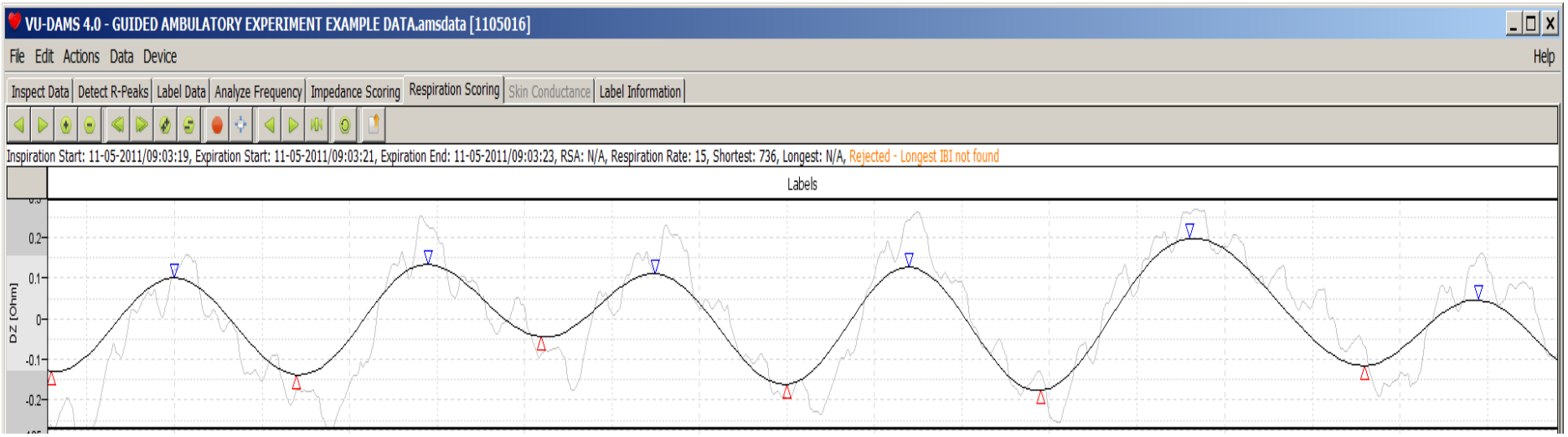


Respiration from thorax impedance



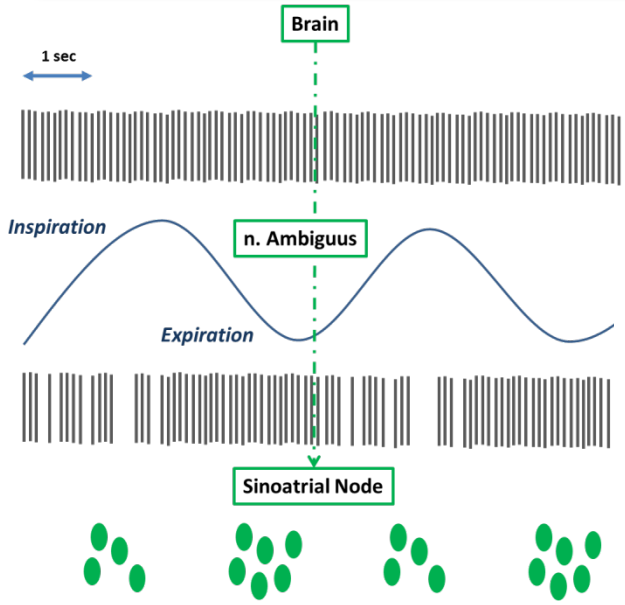






Houtveen JH, Groot PF, de Geus EJ. Validation of the thoracic impedance derived respiratory signal using multilevel analysis. Int J Psychophysiol. 2006 Feb;59(2):97-106.

Vagal gating

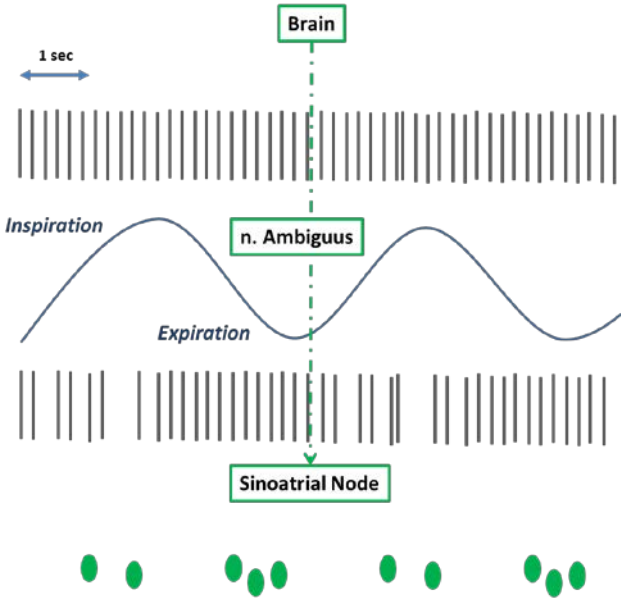


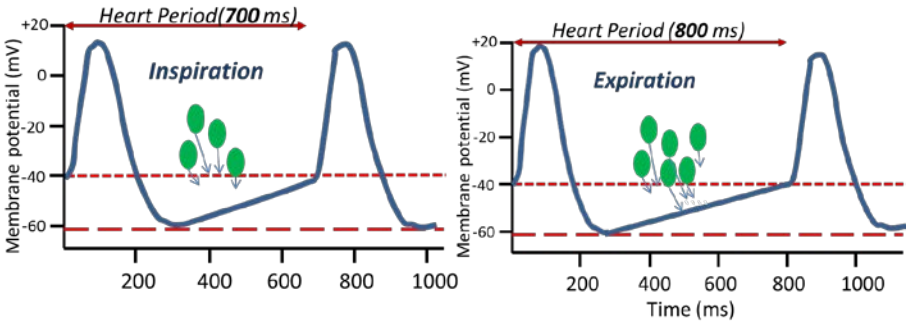
Higher neural influences and brain stem nuclei

Phasic modulation of vagal activity at the level of the brain stem

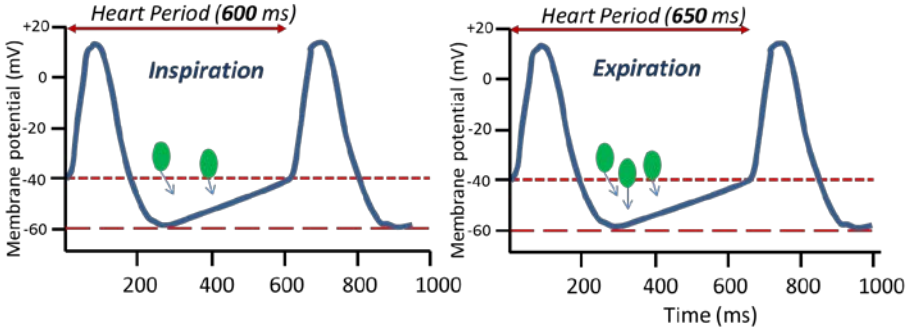
Phasic vagal activity in vagal nerve to the SA-node

Phasic release of amounts of Acetylcholine (ACh) to pacemaker cells



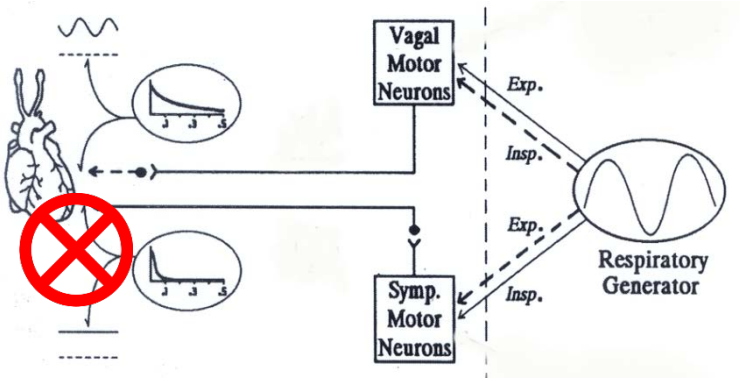


Heart period variability
800-700 = 100 ms

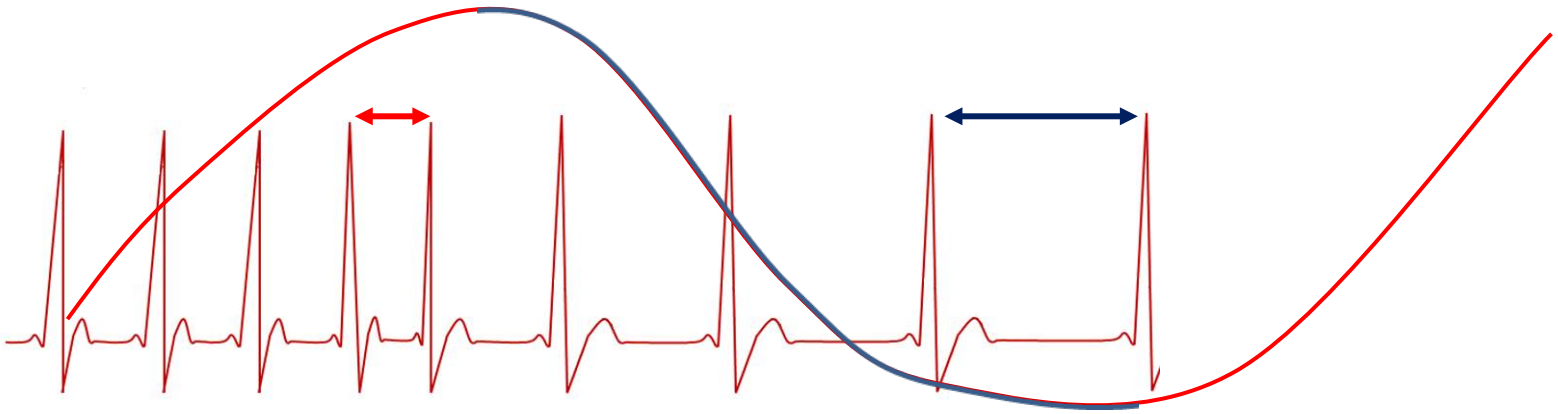


Heart period variability
650-600 = 50 ms

Respiratory Sinus Arrythmia (RSA)



longest heart period during exhalation -
shortest heart period during inhalation



Inhalation **Exhalation**

RSA is a measure of vagal heart period variability
(which is influenced by PNS activity but not SNS activity)

Heart Period* Variability measures

Heart Period	871	971	901	931	991	1101

Standard Deviation of the HP a.k.a. as the Standard Deviation of the Normal-to-Normal intervals (SDNN): 81,4 msec

Heart period	871	971	901	931	991	1101
Successive Differences (SD)		100	-70	30	60	110
Sum of SD (SSD)		10000	4900	900	3600	12100
Mean of SSD (MSSD)					6300	

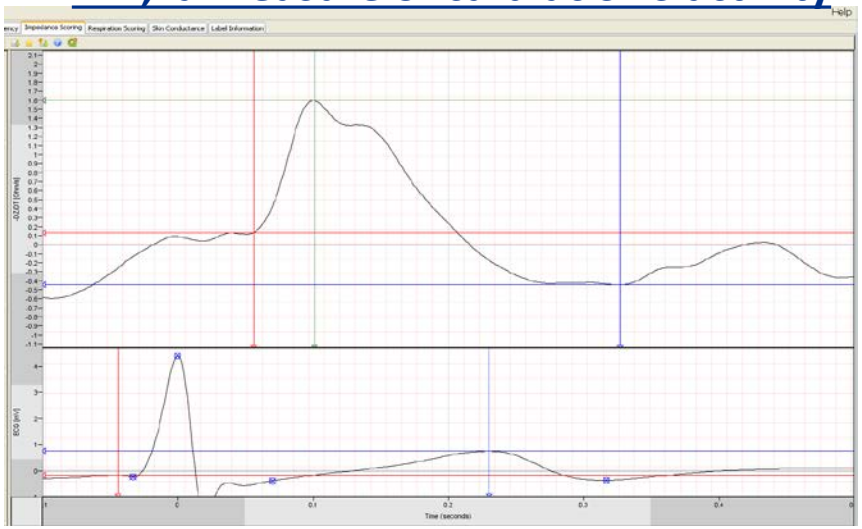
rMSSD 79,3 msec

** The more often used, but incorrect, term is Heart Rate Variability a.k.a HRV – see de Geus et al., Psychophysiology, 2018*

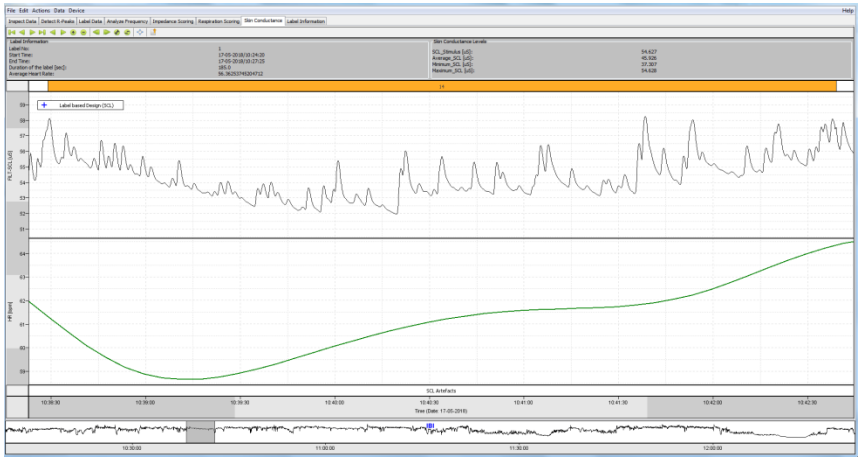
VU-AMS
Ambulatory Monitoring System

vrije Universiteit amsterdam

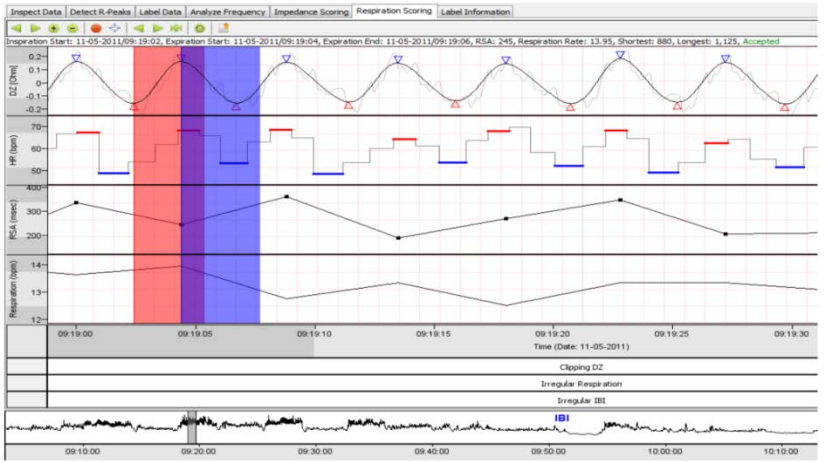
PEP, a measure of cardiac SNS activity



nsSCR, a measure of skin SNS activity



RSA, a measure of cardiac PNS activity



Outline Workshop

PART 1: How to attach the VU-AMS?

- ❑ We work in 5 groups ;
  Per group we
  - need two volunteers to be wearing the VU-AMS
  - need two leading ‘ research assistants’

- ❑ Follow instructions of
  - Mandy Tjew-A-Sin
  - Martin Gevonden
  - Denise van der Mee
  - Matthijs van der Zee



VU-DAMS

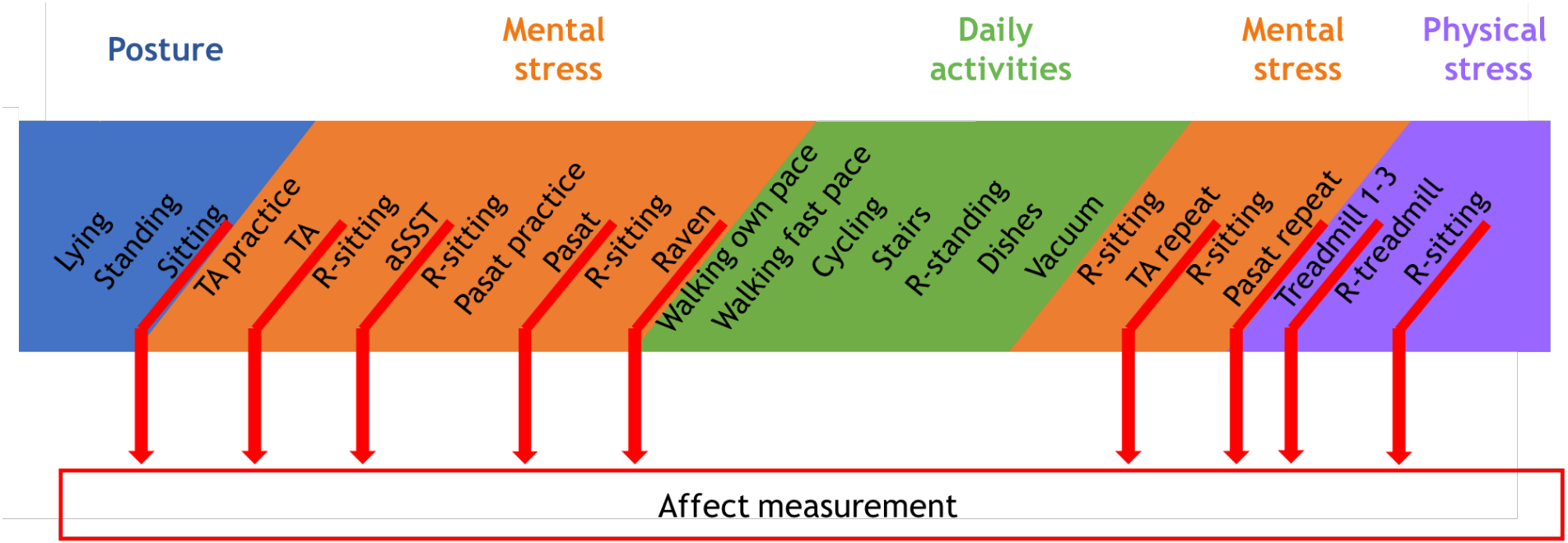
PART 2: How to obtain Heart Period (and HR), RMSSD, and RSA from a VU-AMS recording?

(using own computer – internet via eduroam)

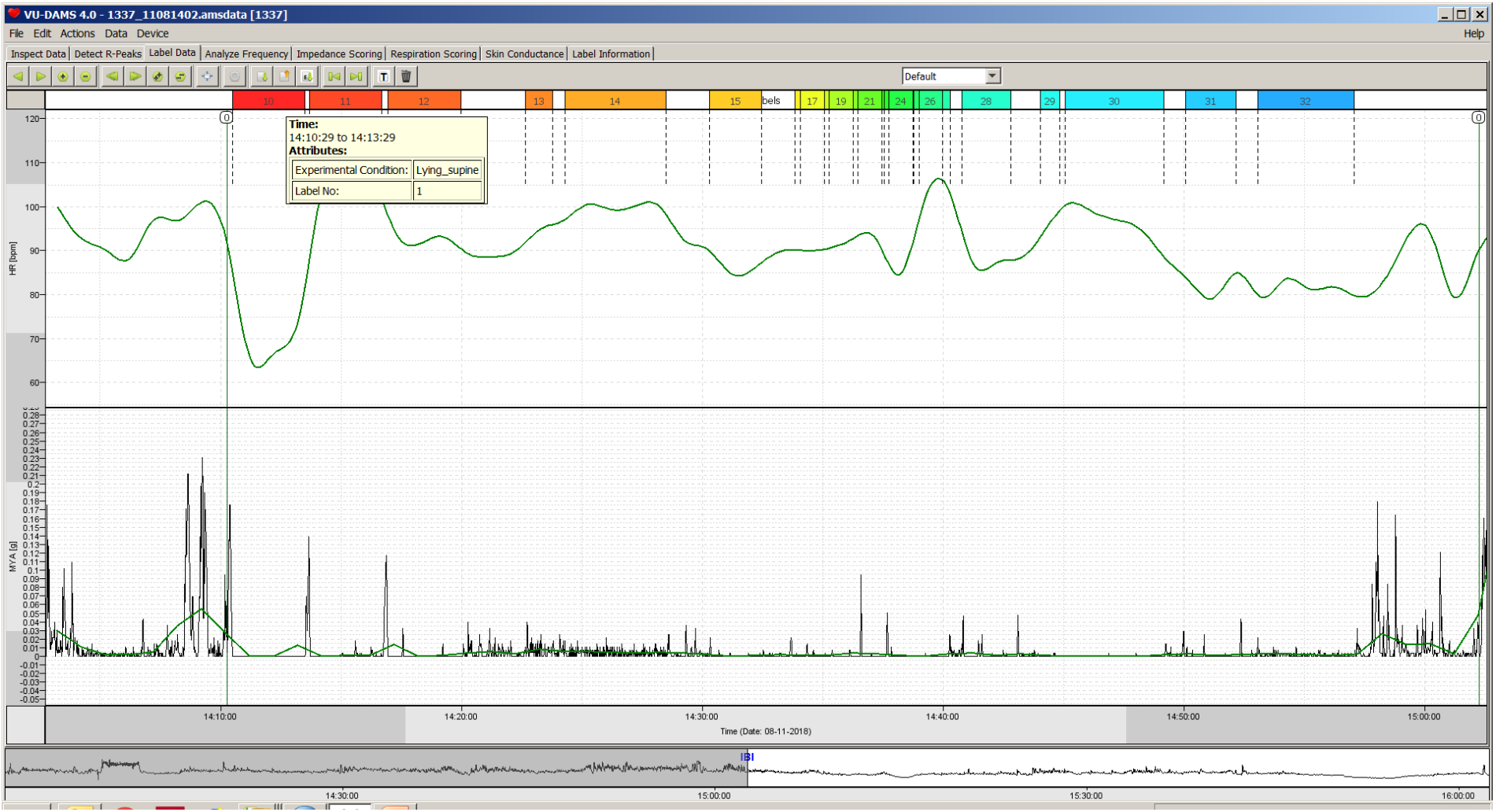
- Download from
  http://www.vu-ams.nl/support/downloads/software/
  or copy from the USB sticks:
  - VU-DAMS 4.0
  - Example file LABORATORY

- Install VU-DAMS 4.0 (needs Java)

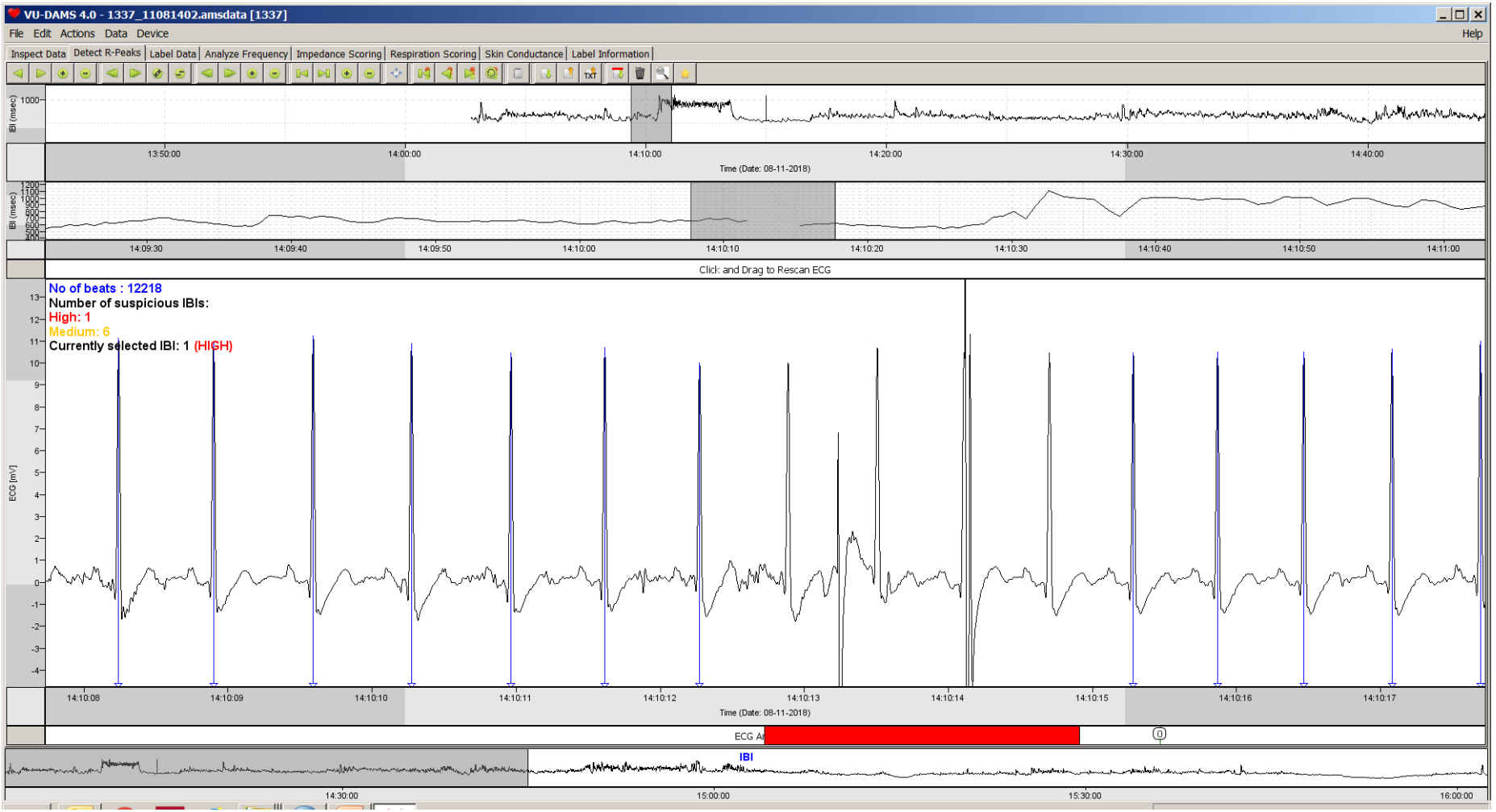
Timeline of the experiment



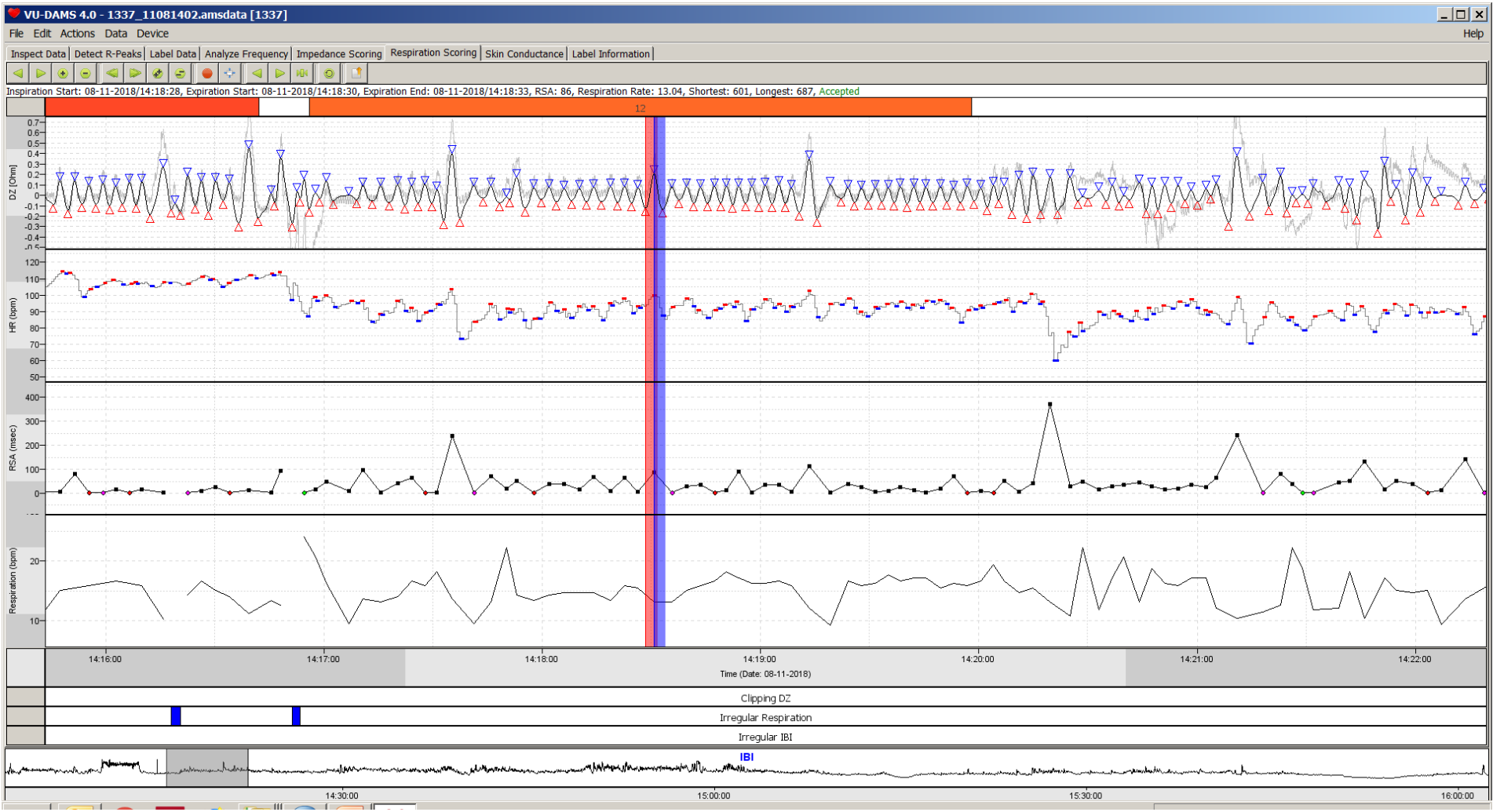
Check the labeling - Go to the Label Data Tab



Check the R-peak detection - Go to the R-peak Detection Tab



Check the automated RSA scoring - Go to the Respiration Scoring Tab



Systolic Events

International Journal of Psychophysiology 120 (2017) 136–147

Contents lists available at ScienceDirect

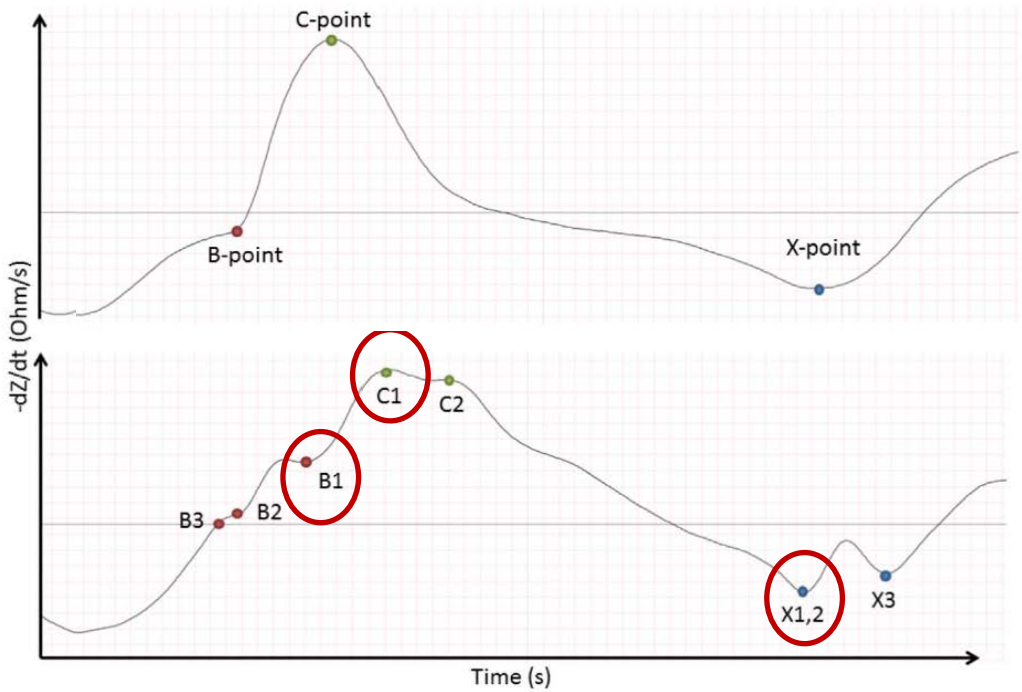
International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

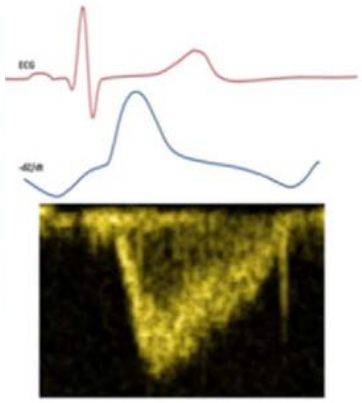
Impedance cardiography in healthy children and children with congenital heart disease: Improving stroke volume assessment

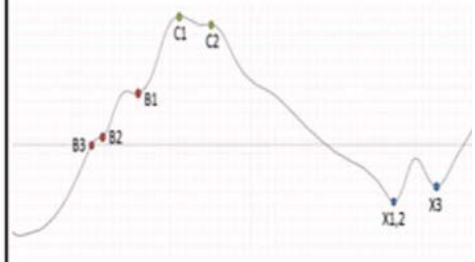
Ineke Nederend[a,b,*], Arend D.J. ten Harkel[b], Nico A. Blom[b], Gary G. Berntson[c], Eco J.C. de Geus[a]

I. Nederend et al.



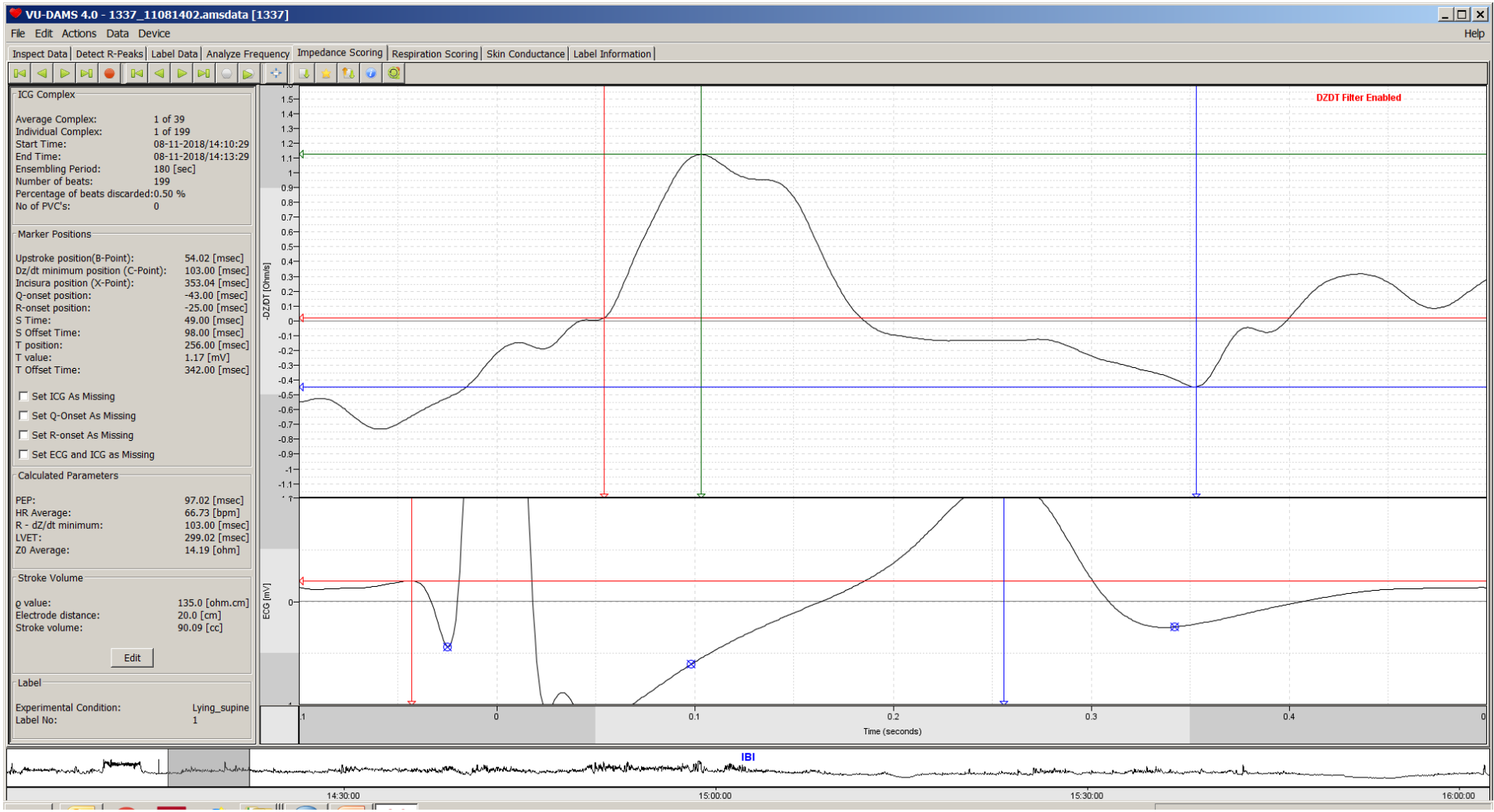
STUDY 1
Comparison of RB and RX intervals using different B/X points in simultaneously measured TTE & ICG





Optimal Scoring Method ICG (highest ICC)

Interactive B-, C- and X-point scoring - Go to the Impedance Scoring Tab



NB complex 2, 13, 16?

Labeled output

VU-DAMS 4.0 - 1337_11081402.amsdata [1337]

File Edit Actions Data Device

Inspect Data | Detect R-Peaks | Label Data | Analyze Frequency | Impedance Scoring | Respiration Scoring | Skin Conductance | Label Information

Subject ID	Start Date	Start Time	End Time	Average IBI [msec]	SDNN [msec]	RMSSD [msec]	Average HR [bpm]	Average Mot [mg]	PEP [msec]	LVET [msec]	RSA-0 [msec]	Respiration Rate [bpm]	Total Motility [mg]	Artefact Free Length	Experimental Condition	Experimental Condition Code
1337	08-11-2018	14:02:43	16:02:28	587.33	107.96	23.72	105.70	70.63	-9999	-9999	30.81	19.43	165.14	7176.55	Total Registration	-9999
1337	08-11-2018	14:10:29	14:13:29	904.40	67.82	68.13	66.73	0.12	97.02	299.02	115.98	14.95	5.99	180.00	Lying_supine	10
1337	08-11-2018	14:13:42	14:16:42	560.32	38.19	43.82	107.43	0.84	90.00	230.01	10.17	14.56	9.48	180.00	Standing	11
1337	08-11-2018	14:16:56	14:19:58	653.56	36.29	20.02	92.07	0.69	114.00	238.75	34.98	15.11	7.51	182.00	Sitting	12
1337	08-11-2018	14:22:40	14:23:46	636.75	24.90	18.53	94.37	7.27	115.00	231.00	29.80	16.78	30.03	66.00	TA_practice	13
1337	08-11-2018	14:24:18	14:28:30	602.32	24.91	16.56	99.78	3.95	113.87	218.13	23.78	22.32	17.90	252.00	TA	14
1337	08-11-2018	14:30:18	14:32:28	703.36	42.66	22.65	85.62	0.33	113.00	253.47	37.88	16.73	8.11	130.00	Recov1	15
1337	08-11-2018	14:33:51	14:34:03	690.50	14.66	15.81	86.93	0.24	118.57	241.43	37.50	17.18	8.94	12.00	SSST_Read1	16
1337	08-11-2018	14:34:03	14:35:03	671.98	41.09	23.22	89.62	0.93	121.00	238.00	42.58	14.10	10.22	60.00	SSST_Countdown1	17
1337	08-11-2018	14:35:03	14:35:15	665.65	18.73	16.73	90.21	0.24	119.00	244.00	23.00	18.48	8.73	12.00	SSST_Read2	18
1337	08-11-2018	14:35:15	14:36:15	655.24	37.92	23.64	91.87	0.58	121.00	235.00	44.67	13.46	8.73	60.00	SSST_Countdown2	19
1337	08-11-2018	14:36:15	14:36:27	671.94	26.38	22.40	89.43	0.00	124.00	233.00	21.00	16.68	8.56	12.00	SSST_Read-Speak	20
1337	08-11-2018	14:36:27	14:37:27	654.07	46.04	29.61	92.18	2.56	124.00	228.00	53.08	13.70	14.08	60.00	SSST_Speak_countdown	21
1337	08-11-2018	14:37:28	14:37:32	622.50	22.69	16.38	96.49	0.00	116.00	230.00	-9999	17.14	8.12	4.00	SSST_Speak	22
1337	08-11-2018	14:37:32	14:37:44	632.00	42.07	24.51	95.33	8.30	120.75	228.25	13.00	19.18	36.02	12.00	SSST_Read3	23
1337	08-11-2018	14:37:44	14:38:44	715.94	64.90	42.82	84.50	0.23	113.00	239.00	90.23	14.06	6.47	60.00	SSST_Countdown3	24
1337	08-11-2018	14:38:47	14:38:59	680.76	34.50	26.14	88.35	0.00	112.00	258.39	35.50	17.68	6.37	12.00	SSST_Read-sing	25
1337	08-11-2018	14:38:59	14:39:58	573.38	45.82	17.05	105.29	0.06	106.00	203.00	28.00	18.91	6.51	59.00	SSST_Sing_countdown	26
1337	08-11-2018	14:39:58	14:40:17	520.56	25.82	9.66	115.54	3.33	100.94	201.06	28.67	14.74	14.61	19.00	SSST_Sing	27
1337	08-11-2018	14:40:47	14:42:48	690.82	61.62	37.69	87.52	1.71	112.00	241.00	72.44	14.56	11.51	121.00	Recov2	28
1337	08-11-2018	14:44:02	14:44:51	626.82	33.25	24.60	95.99	0.21	109.00	234.00	44.92	17.71	7.36	49.00	Pasat_practice	29
1337	08-11-2018	14:45:04	14:49:10	617.71	37.19	19.54	97.49	0.04	101.00	211.56	26.65	20.80	7.47	246.00	Pasat	30
1337	08-11-2018	14:50:03	14:52:09	752.39	93.76	51.26	81.05	0.48	112.00	263.87	108.92	14.37	7.78	126.00	Recov3	31
1337	08-11-2018	14:53:03	14:57:04	735.67	48.21	41.02	81.91	1.56	119.00	260.58	66.13	18.15	12.20	241.00	Raven	32
1337	08-11-2018	15:02:42	15:04:42	635.13	26.08	21.20	94.63	189.40	96.00	252.05	45.12	18.37	466.13	120.00	Walking_own_pace	33
1337	08-11-2018	15:04:48	15:06:48	581.92	19.02	14.04	103.21	303.82	-9999	-9999	27.03	20.40	749.22	120.00	Walking_fast_pace	34
1337	08-11-2018	15:08:29	15:12:45	508.74	23.34	8.26	118.17	110.40	75.07	210.84	17.04	21.15	250.75	256.00	Cycling	35
1337	08-11-2018	15:13:43	15:17:15	454.75	50.38	5.37	133.54	182.89	72.54	159.50	9.48	22.97	440.21	212.00	stairs_up_and_down	36
1337	08-11-2018	15:17:52	15:19:55	525.09	19.57	7.13	114.42	3.37	111.17	162.64	12.12	17.63	17.12	123.00	Recov_standing	37
1337	08-11-2018	15:20:39	15:22:39	530.14	22.07	6.69	113.37	13.82	109.38	203.00	6.81	20.55	54.70	120.00	Dishes	38
1337	08-11-2018	15:22:55	15:24:55	542.95	35.93	16.11	110.97	66.35	90.00	201.75	28.09	18.39	169.68	120.00	Vacuum	39
1337	08-11-2018	15:25:59	15:27:59	616.34	38.55	23.11	97.71	2.35	113.00	223.08	38.43	16.41	14.31	120.00	Recov4	40
1337	08-11-2018	15:28:44	15:32:56	556.65	28.77	11.54	108.07	2.14	108.99	195.56	16.16	22.33	14.11	252.00	TA_repeat	41
1337	08-11-2018	15:33:34	15:35:36	620.12	52.42	27.06	97.39	2.64	120.36	223.64	54.84	14.25	12.59	122.00	Recov5	42
1337	08-11-2018	15:37:01	15:41:01	584.94	32.07	13.05	102.87	2.32	111.34	217.66	17.92	22.19	13.35	240.00	Pasat_repeat	43
1337	08-11-2018	15:42:30	15:46:30	557.96	38.50	12.41	107.95	192.16	95.06	218.68	17.84	21.76	474.24	240.00	Treadmill1	44
1337	08-11-2018	15:46:31	15:50:31	495.79	17.76	5.44	121.17	287.75	71.54	171.65	10.10	23.67	702.97	240.00	Treadmill2	45
1337	08-11-2018	15:50:32	15:54:31	387.55	24.22	2.78	155.36	726.17	-9999	-9999	4.47	27.15	1299.89	239.00	Treadmill3	46
1337	08-11-2018	15:54:32	15:57:33	431.87	35.31	2.65	139.91	153.81	76.00	132.00	4.74	26.08	394.00	181.00	Treadmill4	47
1337	08-11-2018	15:57:58	16:00:58	524.83	22.08	8.62	114.52	1.78	109.95	198.69	15.53	16.62	12.08	180.00	Recov6	48