Biofeedback

Applications and past decade advances

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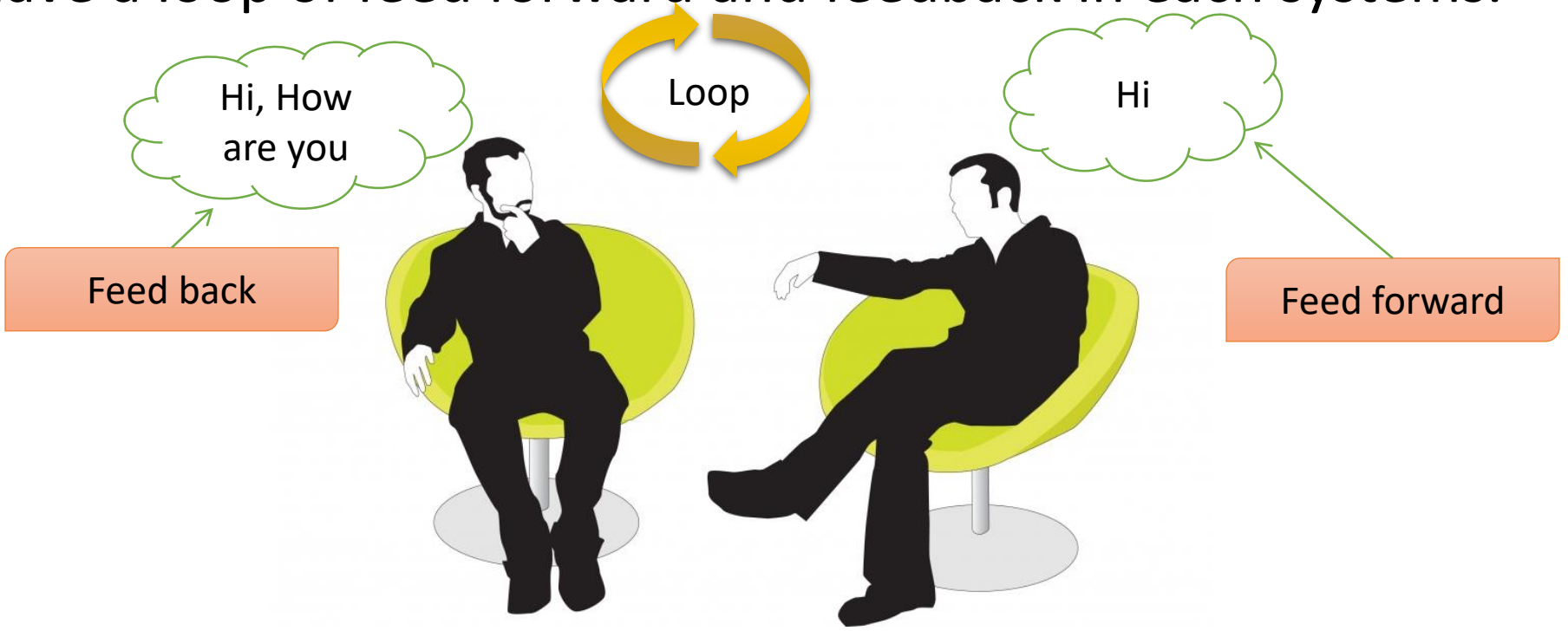
PhD in Health Psychology

What is Biofeedback

- We have a puzzle for understanding Biofeedback mechanism
  - A) Feedback
  - B) Learning psychology

- In general theory of systems, each system has at least tow parts which communicate with each other
- We have a loop of feed forward and feedback in each systems.



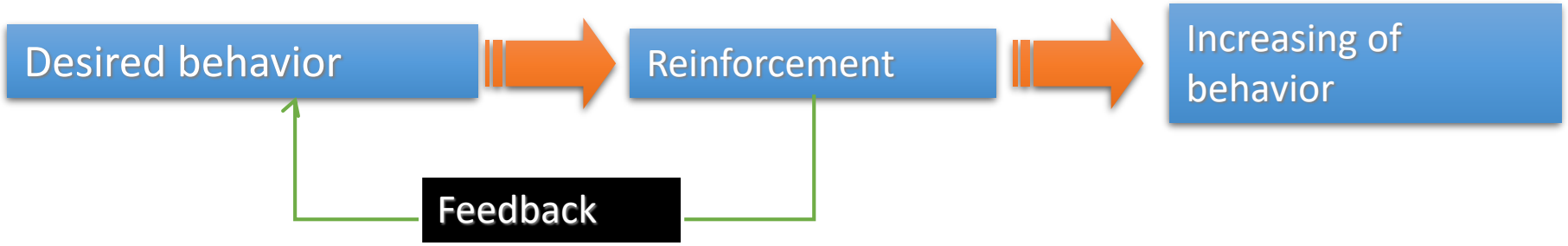
- Our brain works based on feed forward and feedback loops too.
- The result of this loop is **Self Regulation**.

Learning Psychology

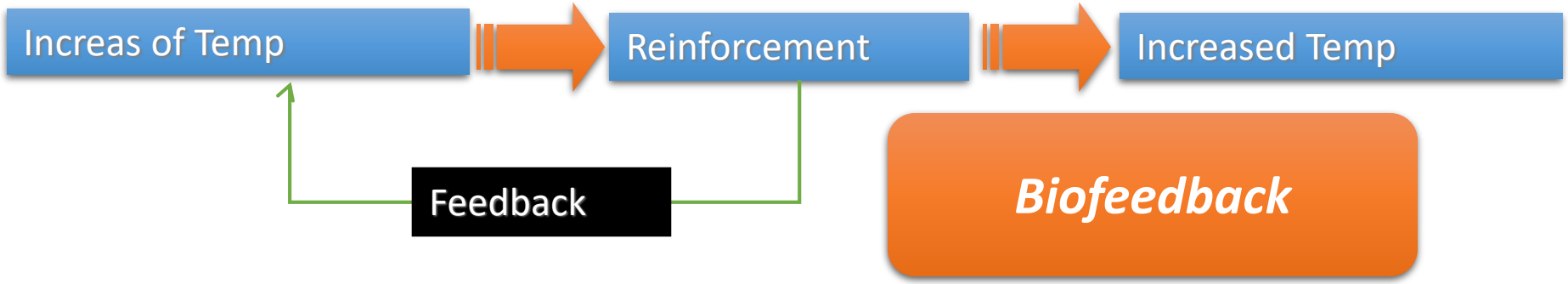
- One of main subjects in learning psychology is conditioning.
- We have two type of conditioning: Classic conditioning & Operant Conditioning.
- Neurofeedback generally works based on Operant conditioning.

Learning Psychology

- Learning of a behavior



- Learning of a change in biological responses



Snap Electrodes

EXG 8 connector

EXG connector

EEG Electrodes

Skin Conductance

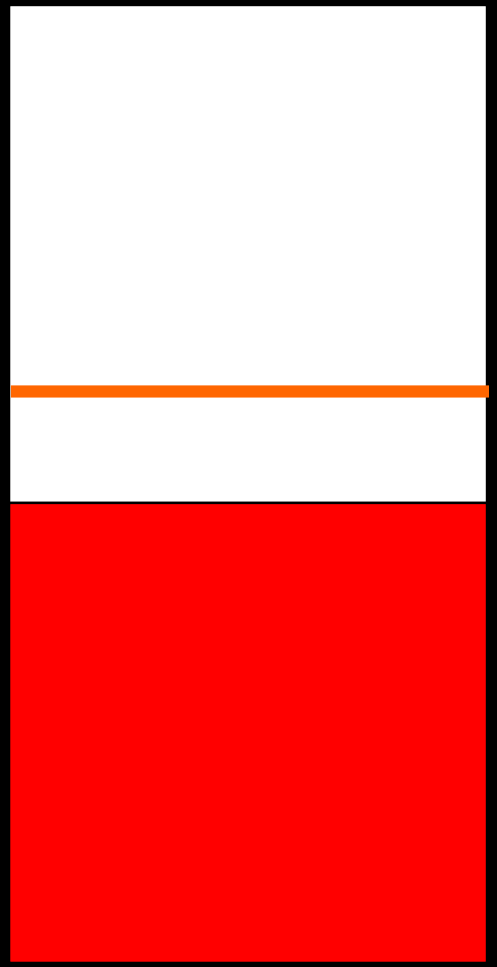
Temperature

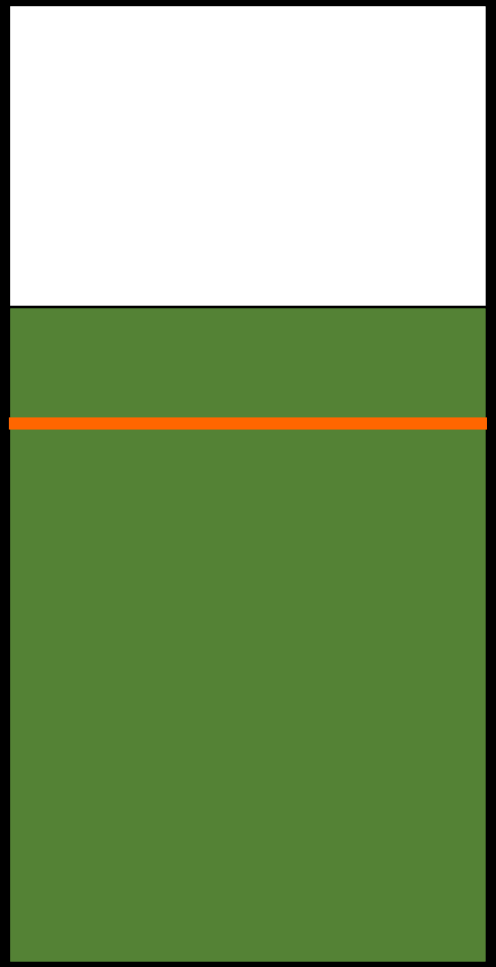
Respiration

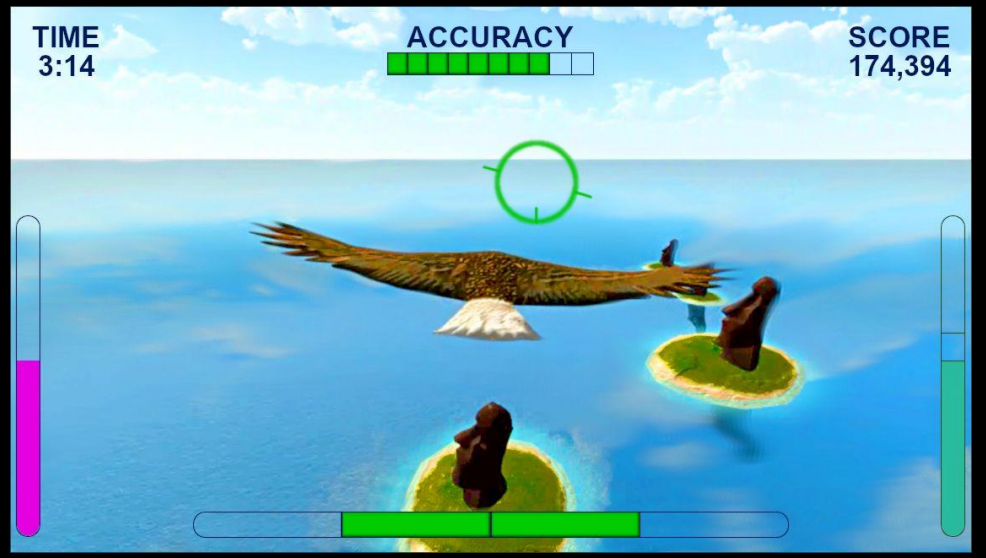
BVP

Types of Biofeedback

- Temperature Biofeedback
- EMG Biofeedback
- Heart Rate biofeedback
- Heart rate variability (HRV) Biofeedback
- Respiration Biofeedback
- GSR/SC/EDA Biofeedback
- EEG Biofeedback (Neurofeedback)






TIME
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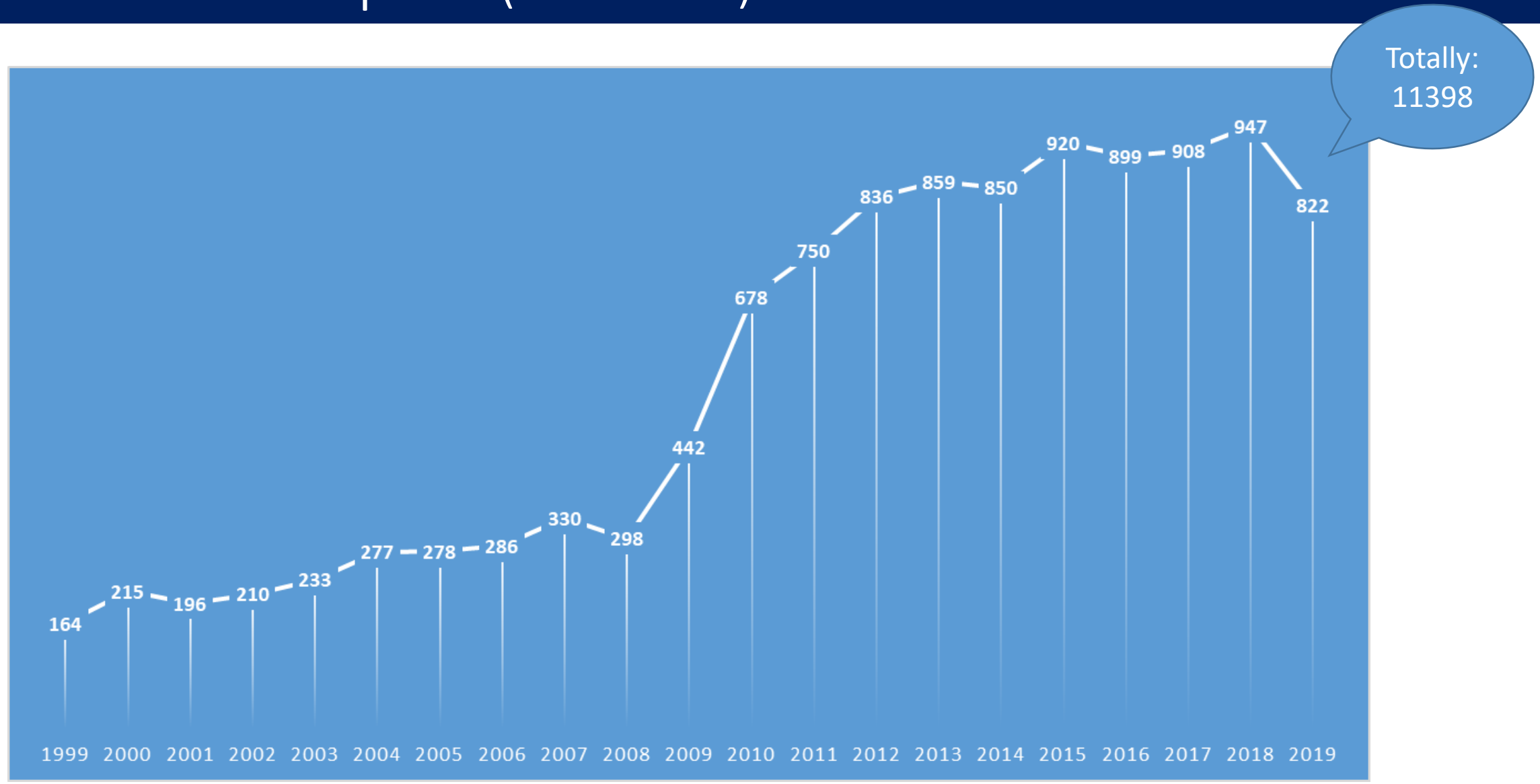
ACCURACY
SCORE
174,394

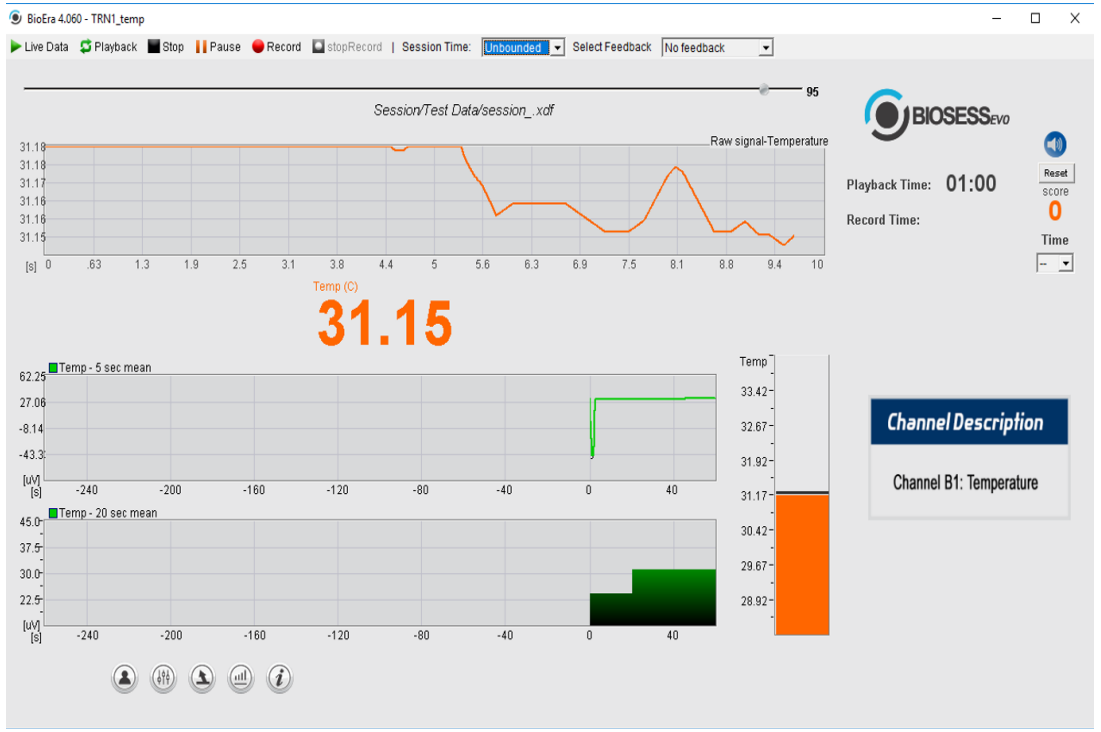
Research Papers (PubMed)

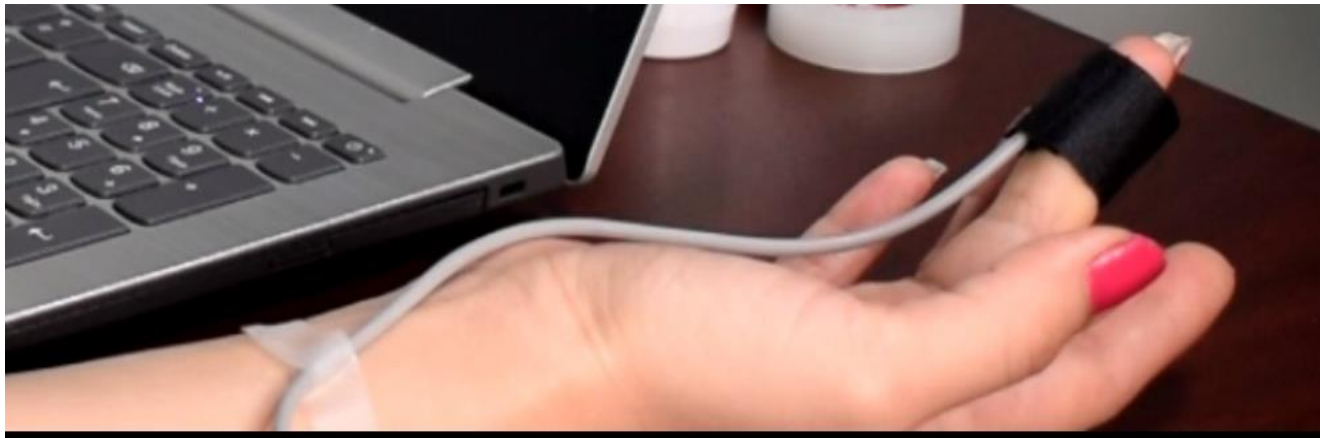


Clinical Applications

Temperature Biofeedback

- Migraine Headache
- Reynaud Syndrome





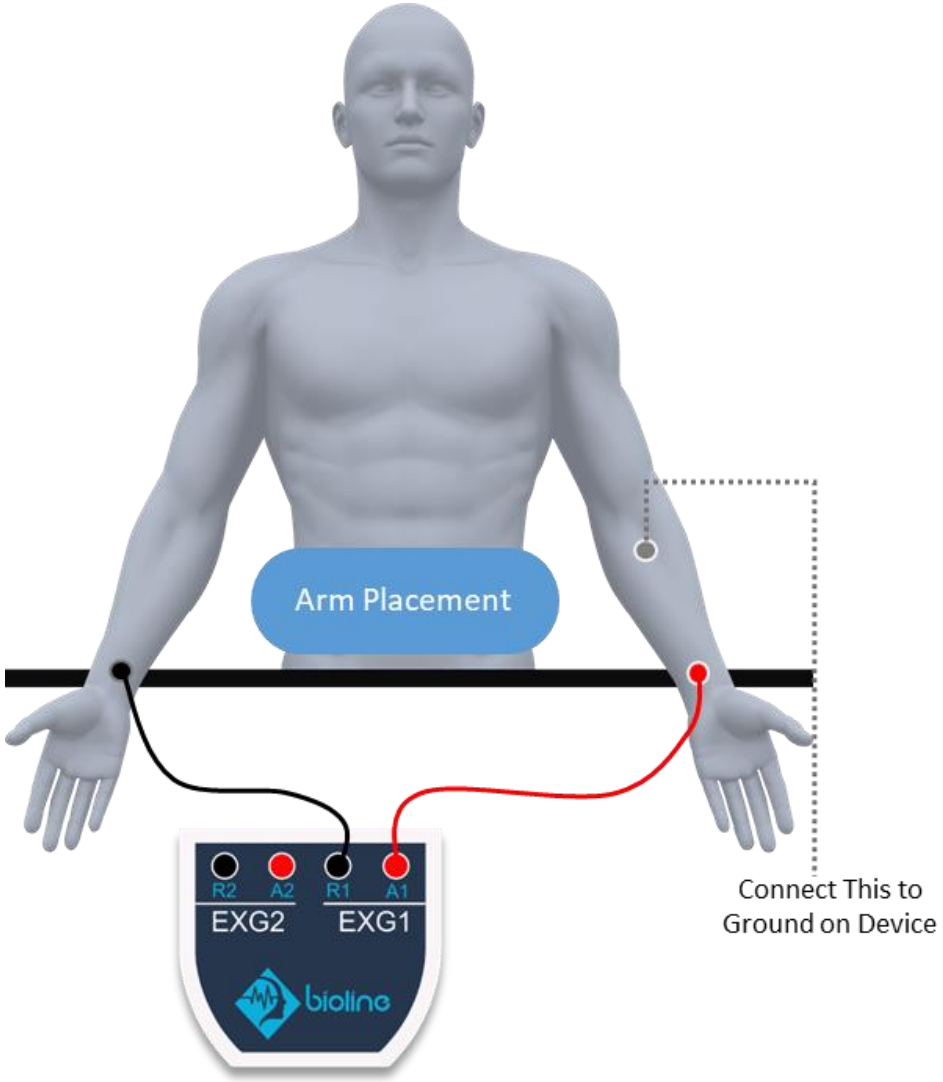
Skin Conductance Biofeedback

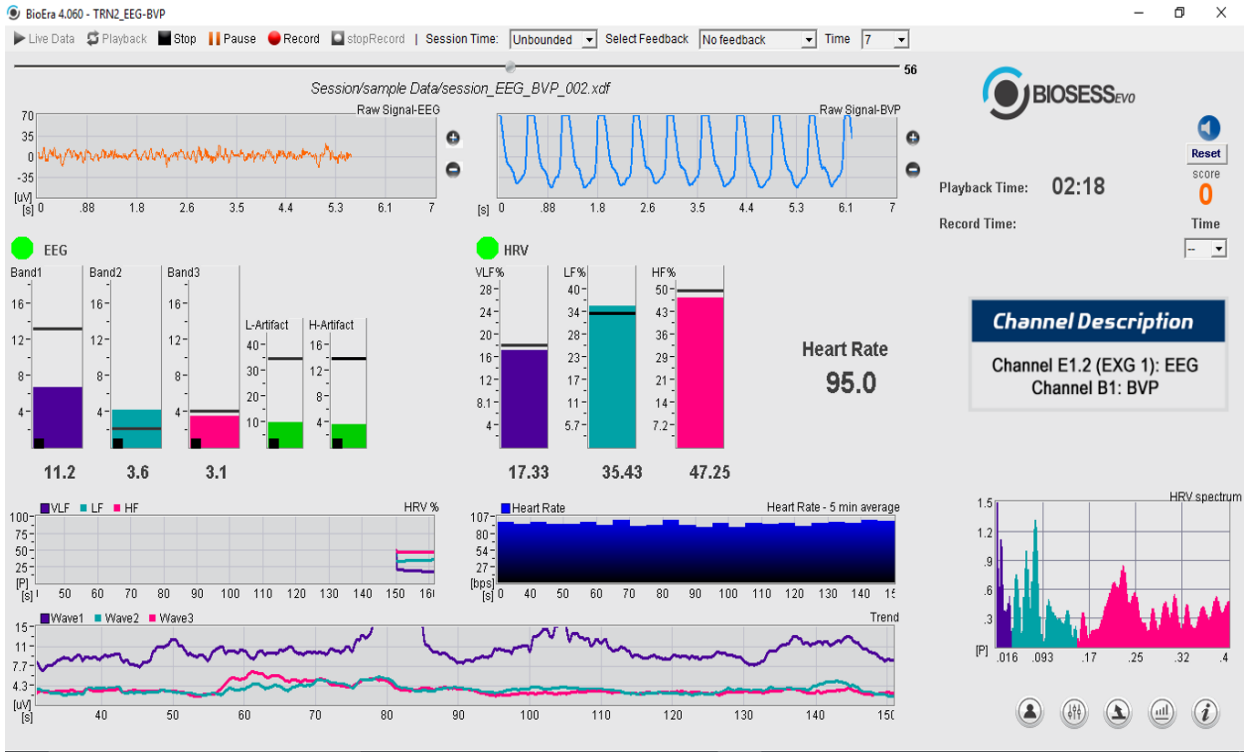
- Anxiety
- Arousal modification

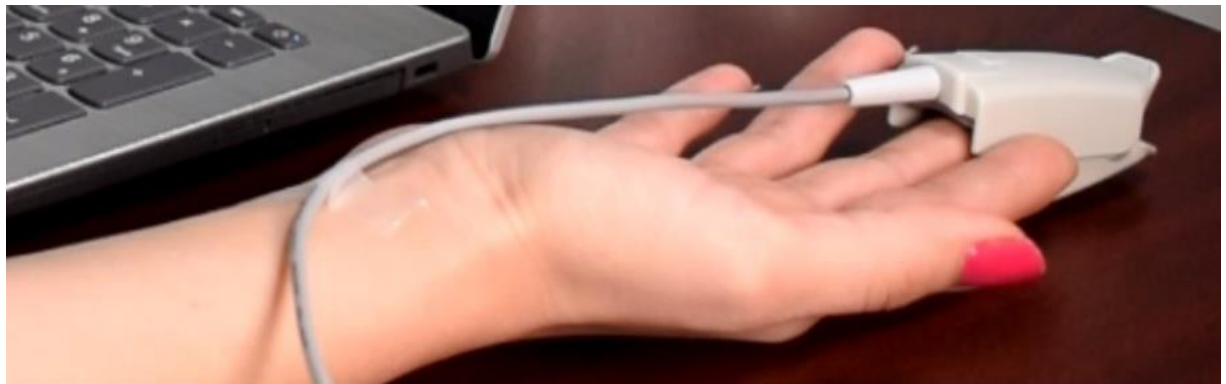
Electromyography (EMG) Biofeedback

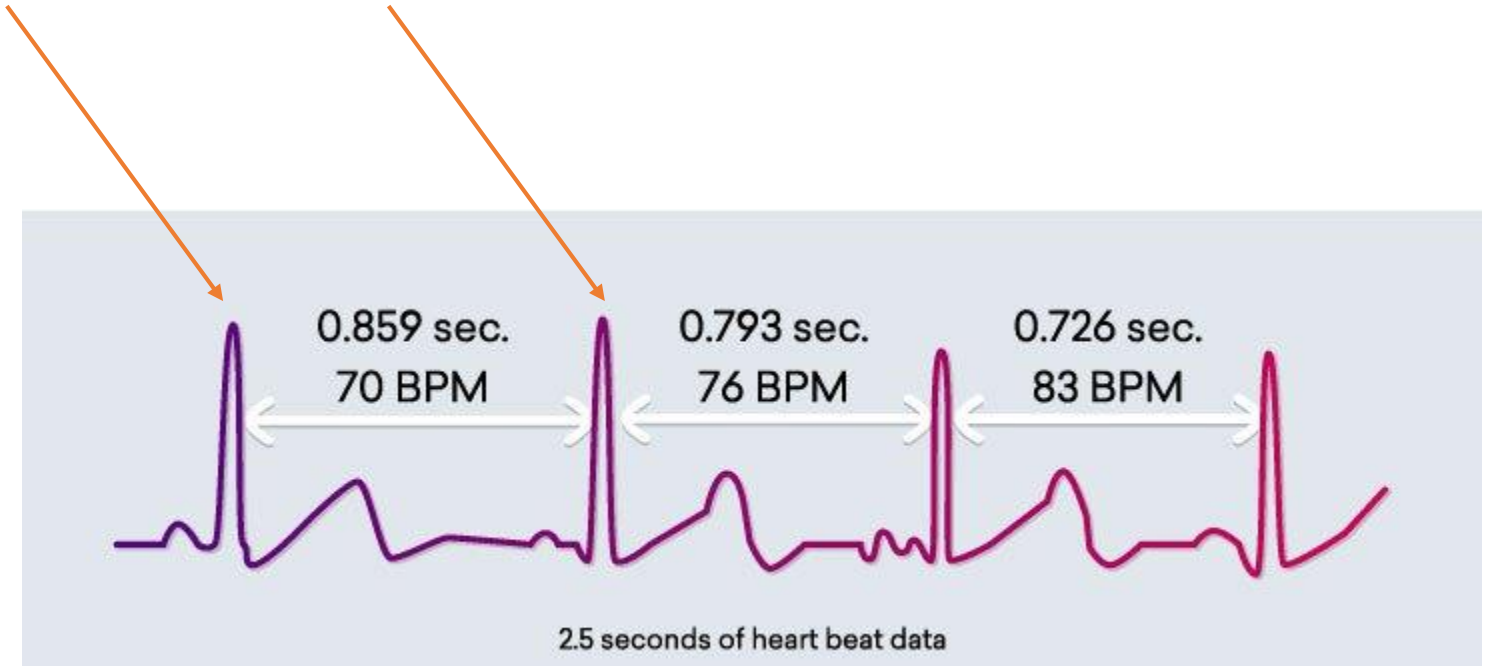
- Muscle Pattern Training
- Stroke Rehabilitation
- Pelvic Floor

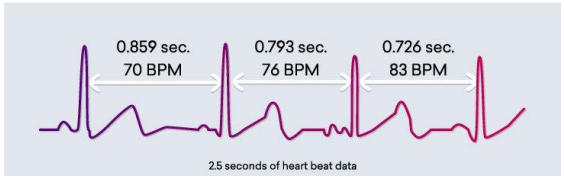
Heart Rate Variability (HRV) Biofeedback





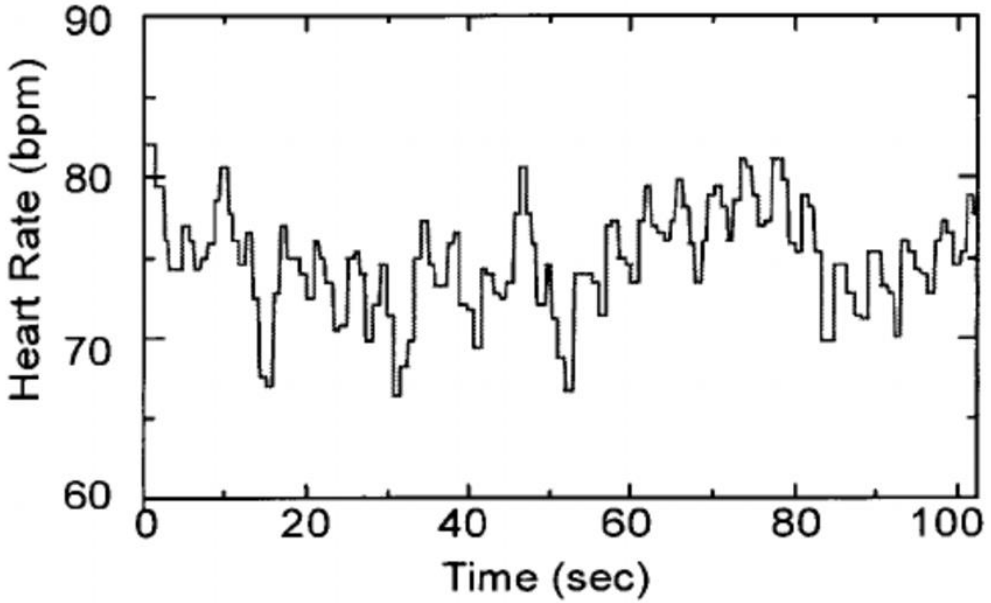



0.859 sec.
70 BPM
0.793 sec.
76 BPM
0.726 sec.
83 BPM
2.5 seconds of heart beat data

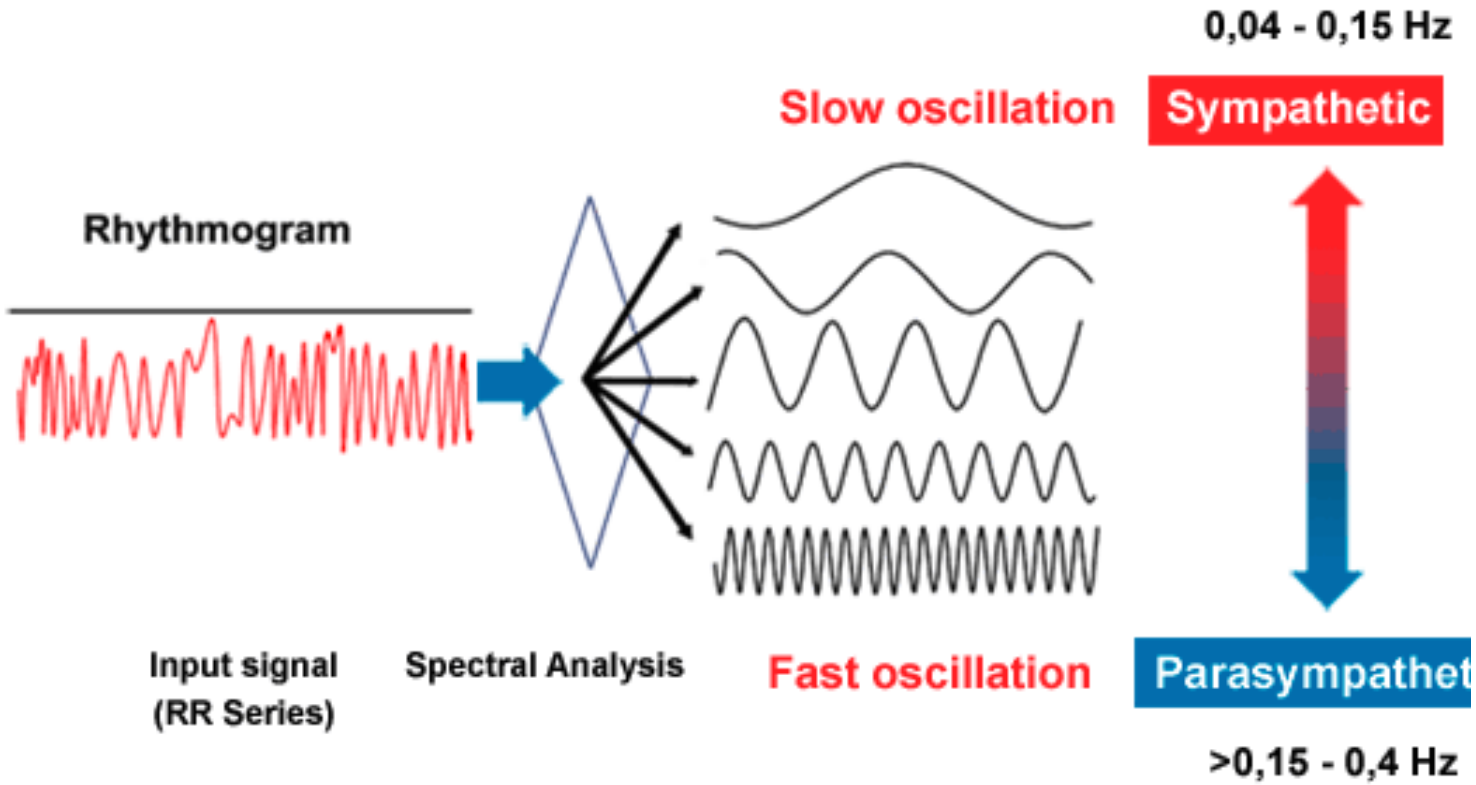


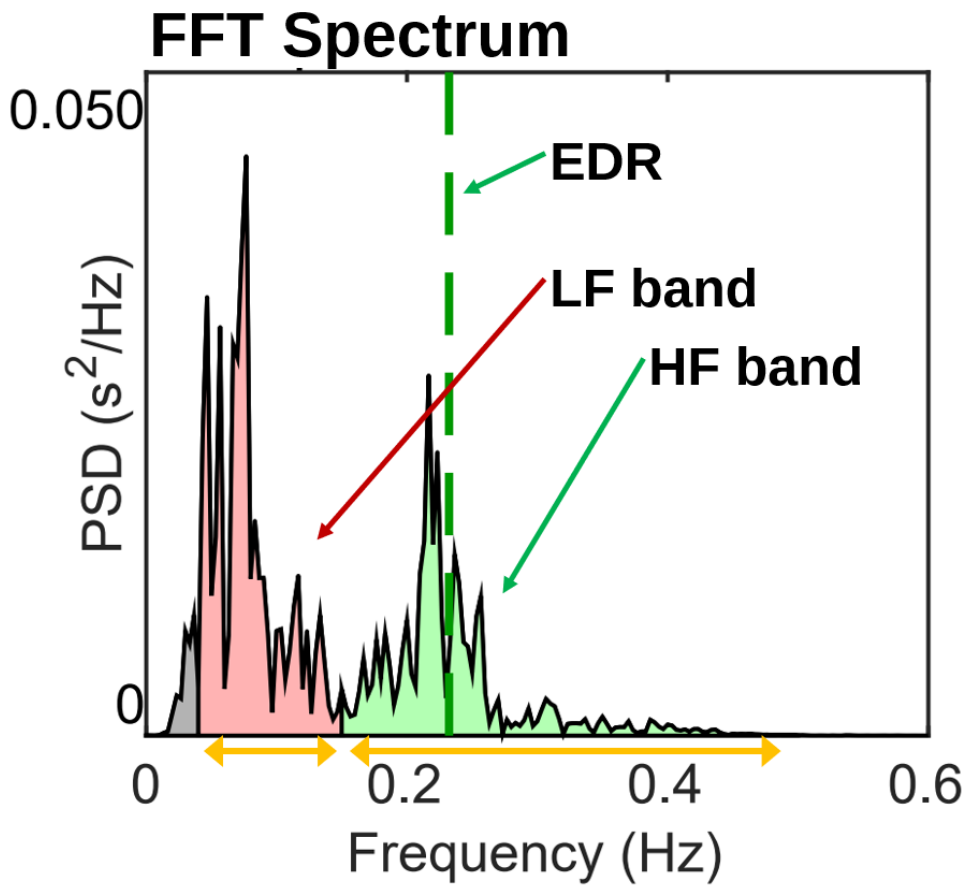
Frequency domain

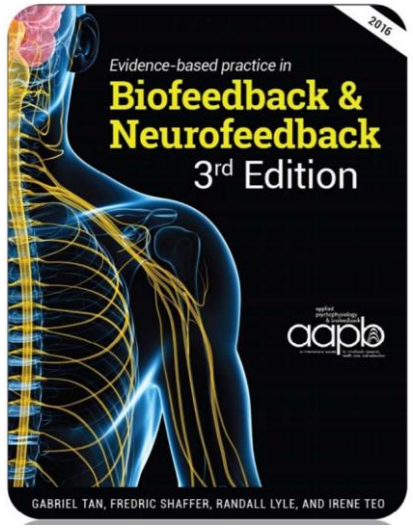
Time domain



SDNN
Normal range: 50-100 ms


0,04 - 0,15 Hz
Slow oscillation
Sympathetic
Rhythmogram
Input signal
(RR Series)
Spectral Analysis
Fast oscillation
Parasympathet
>0,15 - 0,4 Hz


FFT Spectrum
0.050
0
PSD (s²/Hz)
EDR
LF band
HF band
0
0.2
0.4
0.6
Frequency (Hz)



اختلال/مشکل	سطح اثربخشی	ماژول مورد استفاده
سوء مصرف مواد/الکل	سطح ۳	نوروفیدبک
اضطراب	سطح ۴	نوروفیدبک/HRV/EMG
بیش‌فعالی/نقص توجه	سطح ۵	نوروفیدبک
اتیسم	سطح۳	نوروفیدبک
افسردگی (غیر از MD)	سطح ۴	نوروفیدبک/HRV
صرع	سطح ۴	نوروفیدبک
فیبرومایالژیا	سطح ۳	نوروفیدبک/EMG
اختلال خواب (Insomnia)	سطح ۳	نوروفیدبک
بیماری مزمن انسداد ریوی (COPD)	سطح ۲	HRV
تینیتوس	سطح ۳	EMG/SC
	سطح ۲	نوروفیدبک
آسیب‌های مغزی (TBI)	سطح ۳	نوروفیدبک
بهبود کارکردهای شناختی	سطح ۳	نوروفیدبک/ سایر ماژولهای بیوفیدبک
ناتوانی یادگیری	سطح ۳	نوروفیدبک
سردرد (تنشی/میگرن)	سطح ۴	نوروفیدبک/Temp/EMG
آرتروز	سطح ۳	EMG
آسم	سطح ۳	HRV/Resp
فلج مغزی (بهبود مولفه های حرکتی)	سطح ۲	EMG
یبوست	سطح ۴	EMG/Pelvic Floor
بیماری عروق کرونر	سطح ۲	HRV
اختلال استرس پس از سانحه (PTSD)	سطح ۳	نوروفیدبک/HRV
فشار خون	سطح ۴	EMG/HRV
فشار خون حاملگی	سطح ۴	SC/HRV

بی اختیاری مدفوع		سطح ۴	EMG/Pelvic Floor
بی اختیار ادرار (کودکان، مردان، زنان)		سطح ۳	EMG/Pelvic Floor
سندروم روده تحریک پذیر (IBS)		سطح ۴	HRV
رینود		سطح ۴	Temp/EMG
تعریق زیاد		سطح ۲	Temp
سکته (بهبود عملکرد حرکتی)		سطح ۲	EMG
فلج صورت		سطح ۳	EMG
بیماری حرکت (motion sickness)		سطح ۳	HRV/SC
درد مزمن	دردهای سینه بدون منشا قلبی	سطح ۴	EMG
	دردهای عضلانی صورت	سطح ۴	EMG
	درد عضو خیالی (Phantom Pain)	سطح ۳	EMG
	ضعف عضلات لگن	سطح ۳	EMG/Pelvic Floor
	سندروم تونل کارپل	سطح ۲	EMG
	سندروم پیش از قاعدگی (PMS)	سطح ۲	EMG
	درد اسپاسم عضلانی	سطح ۲	EMG
دیابت (کنترل گلیسمی)		سطح ۴	EMG Biofeedback Assisted Relaxation

Other Applications

Biofeedback and Brain performance- (Heart and Brain)

heart actually sends more signals to the brain than the brain sends to the heart! Moreover, these heart signals have a significant effect on brain function – influencing emotional processing as well as higher cognitive faculties such as attention, perception, memory, and problem-solving.

https://www.heartmath.com

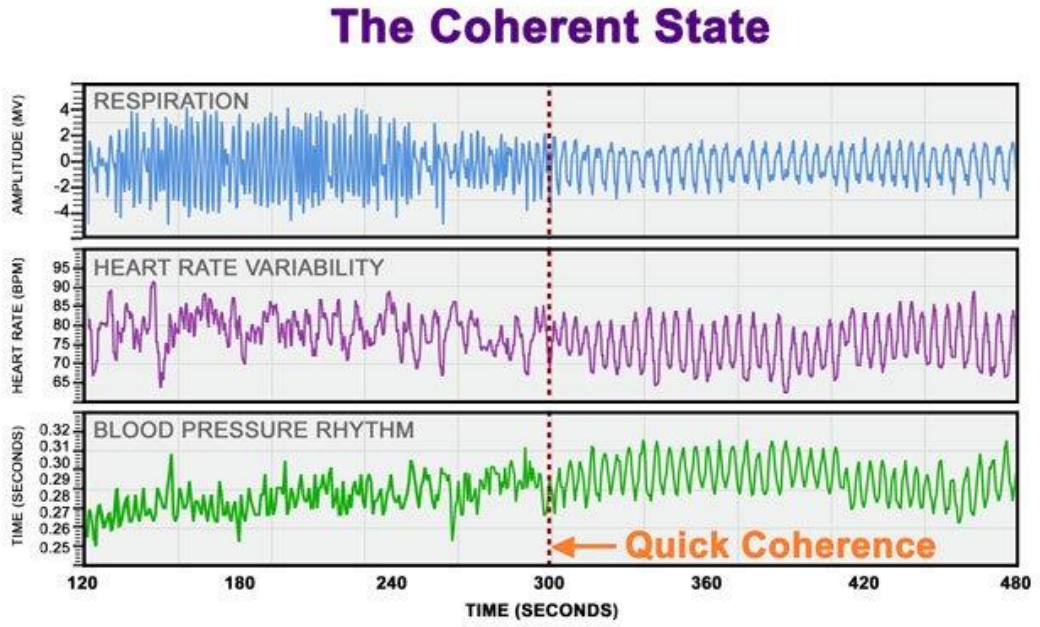


TABLE 1 | Participants' characteristics, cognitive domains analyzed, HRV measurements, and links to cognitive performances in the selected studies.

Study	Participants				Cognitive Domain								
	Group	N	Age M (SD)[a]	Sex (% men)[a]	GC	ME	EF	LG	AT	PS	VS	Domain HRV	Relation between HRV and cognitive performances
Melis and Van Boxtel, 2001		52	22.0 (3.0)	48	✓							HF; MF*	Positive
Hansen et al., 2003		53	23.0				✓		✓			HF	Positive
Hansen et al., 2004		37	19.1				✓		✓			HF	Positive
Kim et al., 2006		311	65–85	0	✓							RMSSD; HF	Positive
Britton et al., 2008		5375	58.0 (6.0)	72	x	x	x	x	✓			SDNN; LF; HF.	No Relation
Duschek et al., 2009		60	24.5 (3.7)	47								MF*	Positive
Drucaroff et al., 2011		18	47.7 (15.7)	27.8			✓					SDNN; LF; HF	Positive
Shah et al., 2011		416	55.0 (2.9)		✓							HF	Positive
Solernó et al., 2012		19	21.5 (0.5)	47	✓						✓	RMSSD; SDNN; HF.	Positive
Frewen et al., 2013	Male Female	2145 2618	61.8 (8.3) 61.5 (8.39	100 0	✓	✓	x	✓	x		✓	SDNN; LF; LF/HF	Positive
Kimhy et al., 2013		817	57.11 (11.15)	44.2			✓					HF	Positive
Gillie et al., 2014		75	18.4	36.4		✓[b]						HF; LF	Positive
Zeki Al Hazzouri et al., 2014		869	76.0 (6.0)	41	✓			✓				SDNN; RMSSD	Positive
Mann et al., 2015		533	54.9 (10.7)	46.3			✓					HF	Positive
Williams et al., 2016		104	19.25 (1.43)	54					✓			HF	Positive
Mahinrad et al., 2016		3583	75.0 (3.0)	47	✓	x	✓			✓		HF	Positive
Colzato and Steenbergen, 2017	High HRV Low HRV	44 44	21.3 (0.3) 21.1 (0.3	43.2 43.2			✓	.				HF	Positive
Zeki Al Hazzouri et al., 2017		2118	45.0 (4.0)	42		x	✓					SDNN; RMSSD	Positive
Colzato et al., 2018		90	22.1 (2.5)	33.3			✓					RMSSD; HF	Positive
Ottaviani et al., 2018		50	24.2 (4.0)	38			✓					RMSSD; HF	Positive

M, mean; SD, standard deviation;, domain assessed but not resulted impairment in this study;, domain assessed and resulted impa
EF, executive functioning; PS, information processing speed; VS, visuospatial skills; HF, high-frequency band; RMSSD, root mean sq
*LF, low-frequency band; LF/HF, ratio of LF-to-HF power; [a]not reported in all studies; [b]ability to suppress unwanted memory; *MF, m*

frontiers in Neuroscience

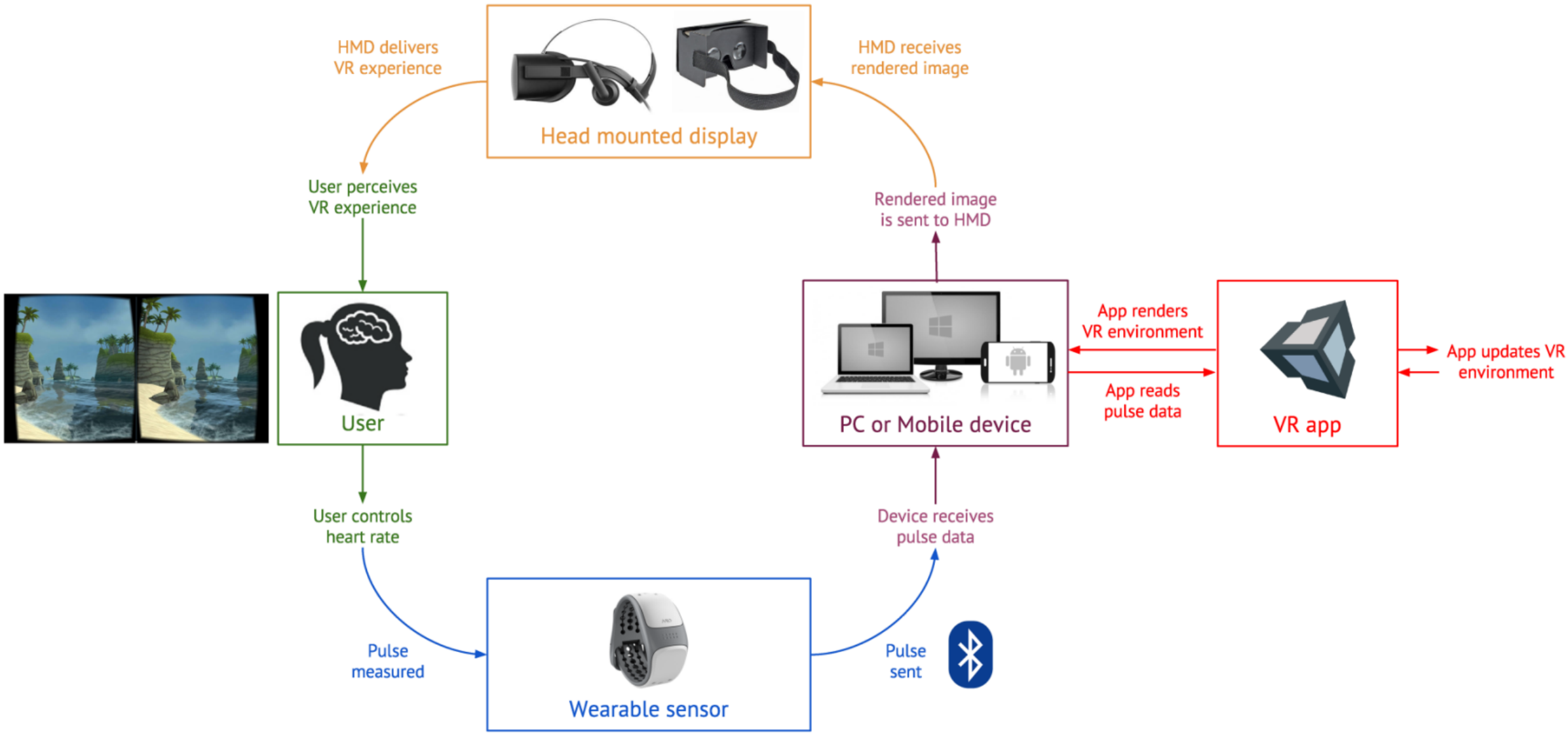
Front Neurosci. 2019; 13: 710.
Published online 2019 Jul 9. doi: 10.3389/fnins.2019.00710
PMCID: PMC6637318
PMID: 31354419

Heart Rate Variability and Cognitive Function: A Systematic Review

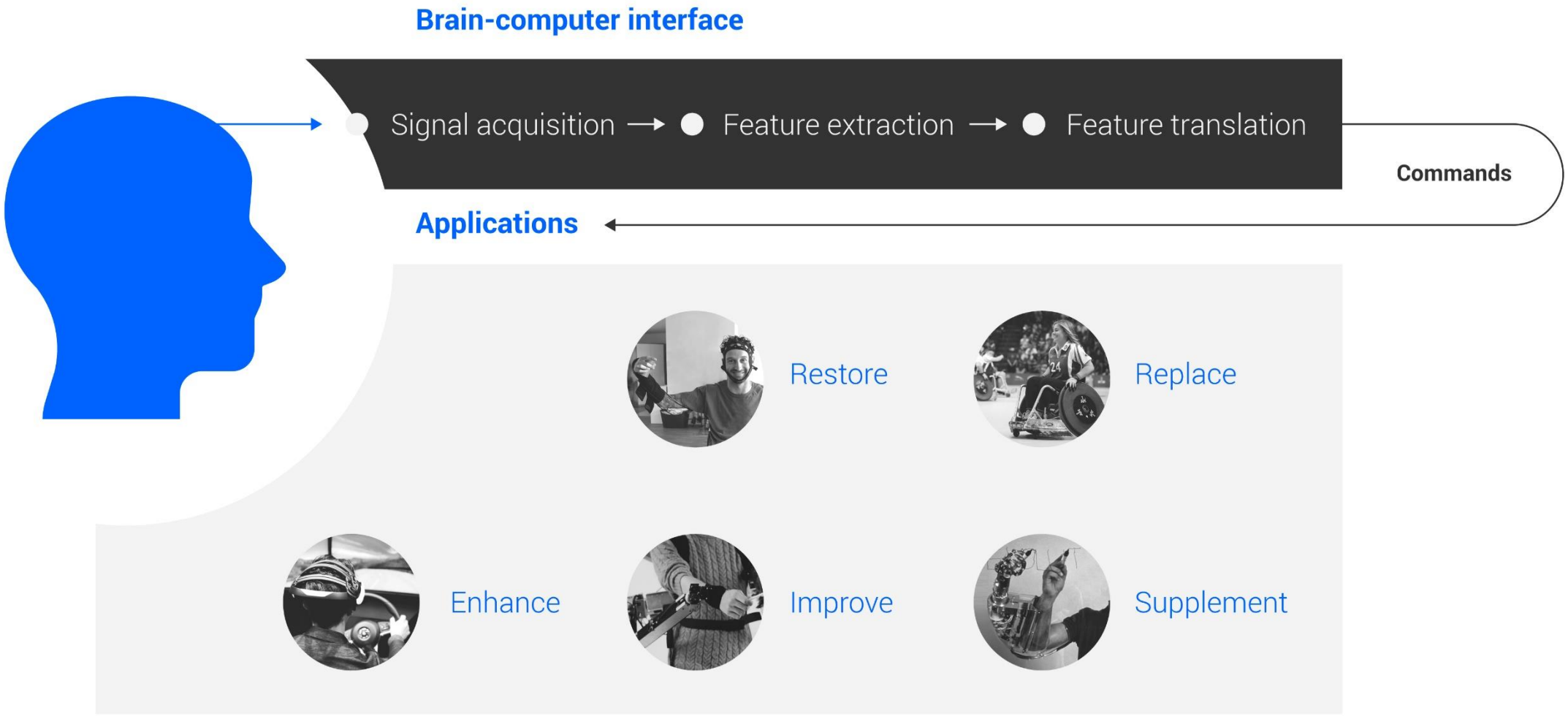
Giuseppe Forte,[1,*] Francesca Favieri,[1] and Maria Casagrande[2,*]

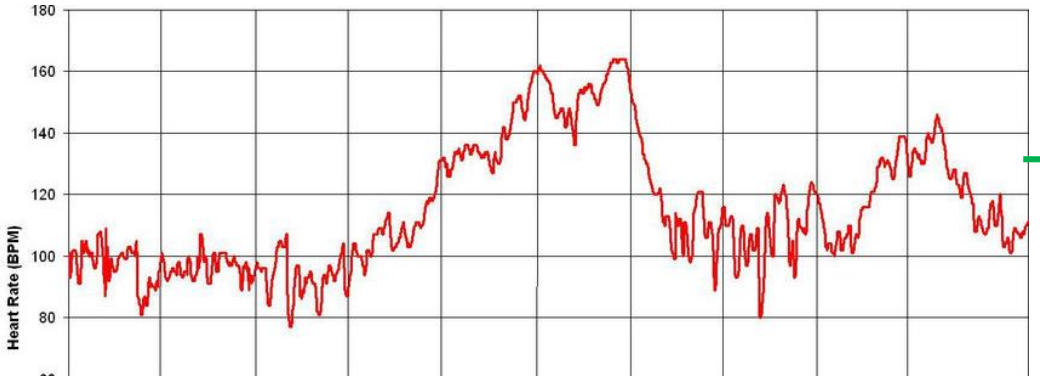
Biofeedback + VR

VR+HRV

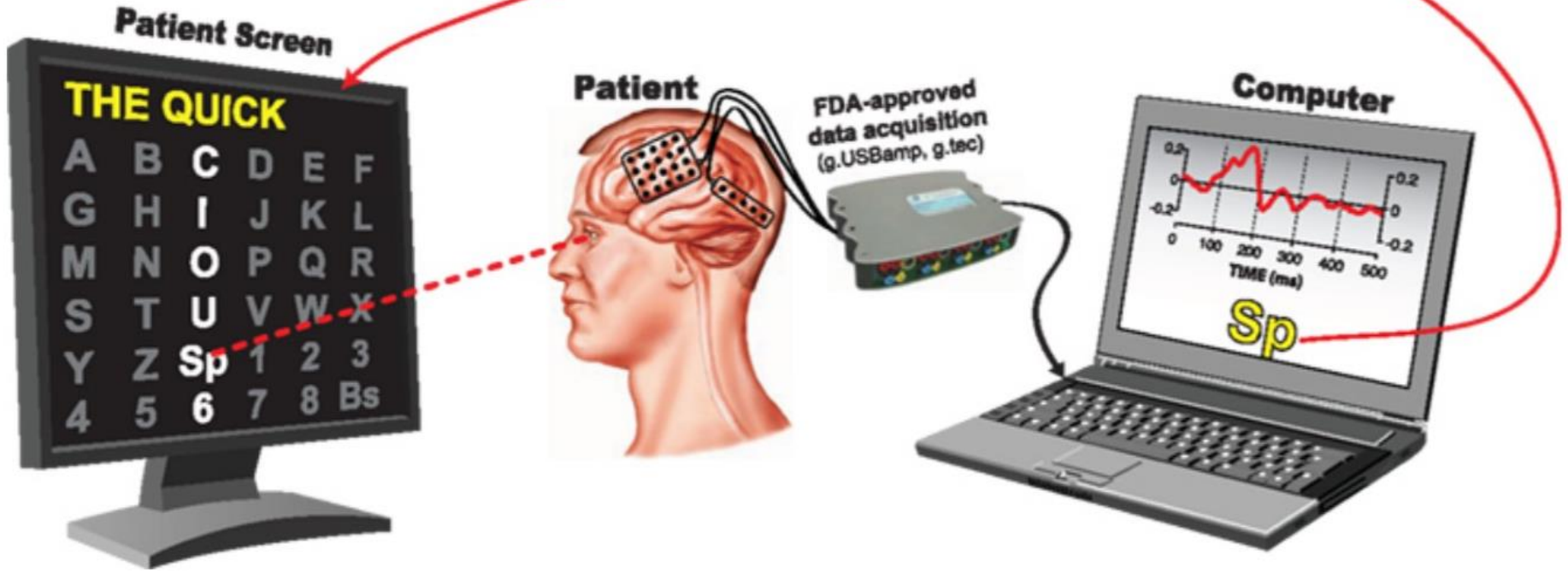

HMD delivers
VR experience
Head mounted display
HMD receives
rendered image
User perceives
VR experience
Rendered image
is sent to HMD
User
PC or Mobile device
App renders
VR environment
App reads
pulse data
VR app
App updates VR
environment
User controls
heart rate
Device receives
pulse data
Pulse
measured
Wearable sensor
Pulse
sent

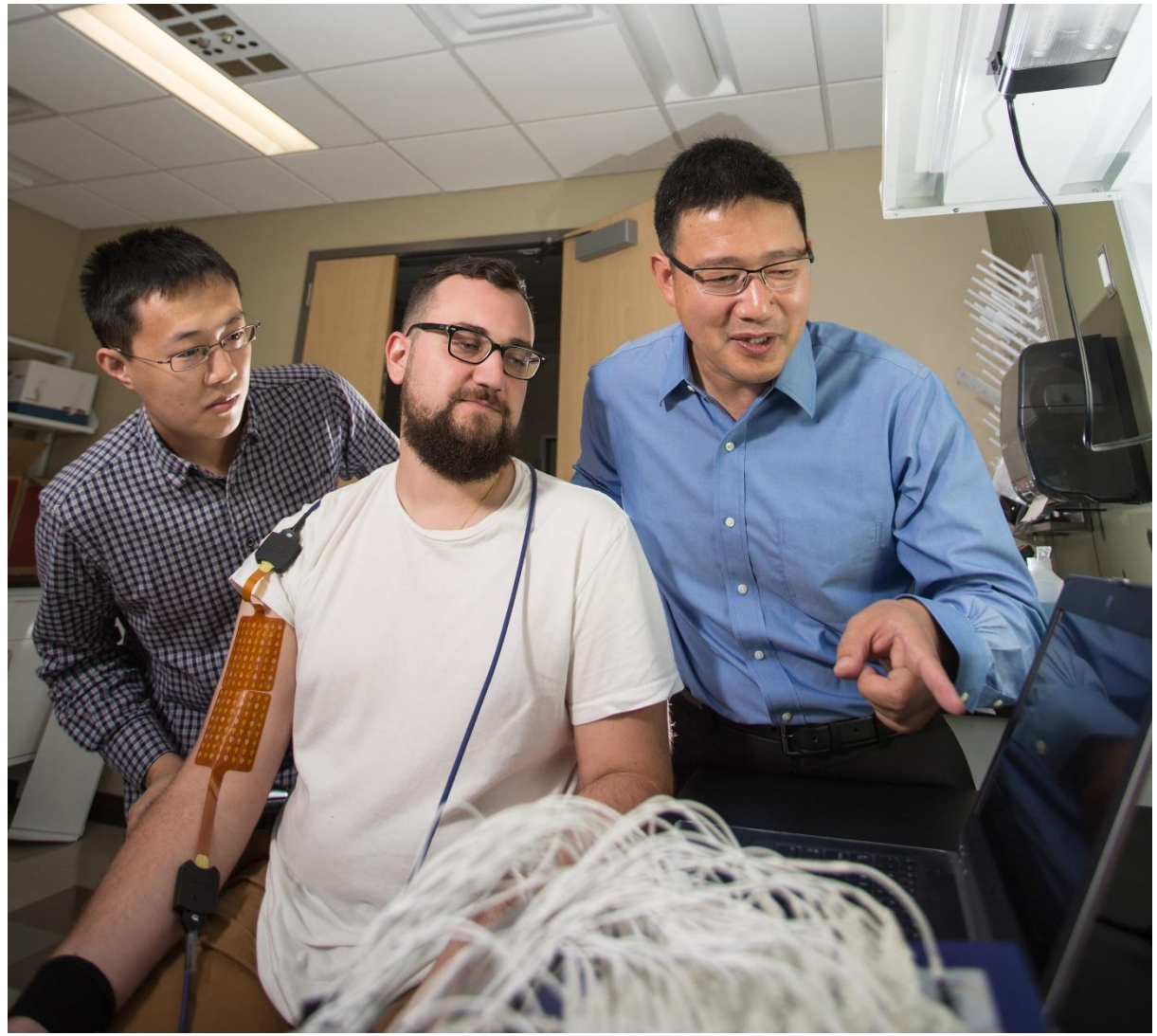
Biofeedback & BCI/HCI





Predictor of BCI success





Electrophysiological Signals as Biomarker

1. **Quantitative Analysis of Surface Electromyography: Biomarkers for Convulsive Seizures**
2. **Electromyography Signals as Biomarkers for Parkinson's Disease**
3. **Wrist-Worn Electrodermal Activity as a Novel Neurophysiological Biomarker of Autonomic Symptoms in Spatial Disorientation**
4. **The association between electrodermal activity (EDA), depression and suicidal behaviour: A systematic review and narrative synthesis**
5. **Heart Rate Variability as a Biomarker for Predicting Stroke, Post-stroke Complications and Functionality**
6. **Short-Term Heart Rate Variability and Blood Biomarkers of Gastric Cancer Prognosis**
7. **Heart Rate Variability as Early Biomarker for the Evaluation of Diabetes Mellitus Progress**