

**Future IEC TR 63203-WXY-Z: Wearable devices and technologies
Part WXY-Z Wearable communications and interfaces technologies**

**Representation method of autonomic nerve activity index
based on heartbeat information
obtained from wearable devices**

**IEC/TC124 ESPOO MEETING
Wearable Workshop**

**IEC/TC124/WG2 Convenor
University of Tokyo
Toyobo MC Co., Ltd.**

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Future IEC TR 63203-8XX-1: Wearable devices and technologies Part 8XX-1:

Wearable communications and interfaces technologies –
Representation method of autonomic nerve activity index
based on heartbeat information obtained from wearable devices

1. Scope

This technical report as part of IEC 63203-XYZ introduce a user-friendly representation method for autonomic nerve activity index (SNA: sympathetic nerve activity index and PNA: parasympathetic nerve activity index) calculated from heart rate variability analysis based on heart rate information obtained from wearable devices.

This technique is not intended for medical applications.



ANAC: Autonomic Nerve Activity Chart

The purpose of this proposal is to provide a means of processing and representation data obtained from wearable smart textiles (mainly clothing-type ECG device) in an easy-to-understand format for general consumers who do not have specialized knowledge in the medical field.

The autonomic nerve activity index (SNI: sympathetic nerve activity index and logarithm of PNI: parasympathetic nerve activity index) derived from heart rate variability measured by a wearable smart textile are plotted on the X-Y plane, it is possible to read the subject's (wearer) mental and physical state.

In principle, this method can monitor a subject remotely and with a delay of several minutes from real time.



Simple and Basic Questions

The wristband-type pulse wave monitor (Smart Watches) already have gotten the consumer market. However, **Garment type (E-Smart textiles) products are rarely on store show windows.**

Why the consumer market for Garment type (E-Smart textiles) has not expanded?

What are the problems in the field of E-Smart textiles technology?

Various vital sensors (ECG, EMG, respiratory rate, Pulse meter, pedometer, blood sugar sensor, blood pressure monitor, skin electrometer, etc.) are being developed.

However, they don't give me an answer.

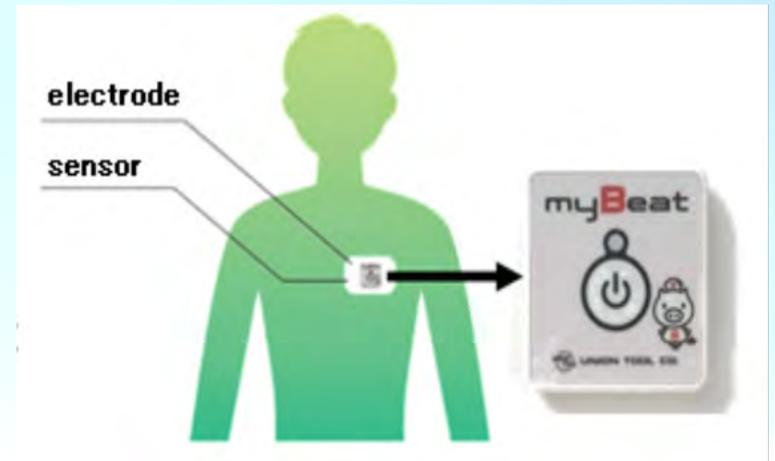
Is the medical field an attractive market?

Applying wearable devices are expected to realize systems that monitor people's health. But how many years will it take? In companies can only research and develop items that are currently selling or likely to sell in the near future.

Garment type Wearable Devices (E-smart textiles) for ECG

Since the early 2000s, clothing-type devices that measure ECG applying E-textiles have been researched.

As of today, several companies are commercializing them.

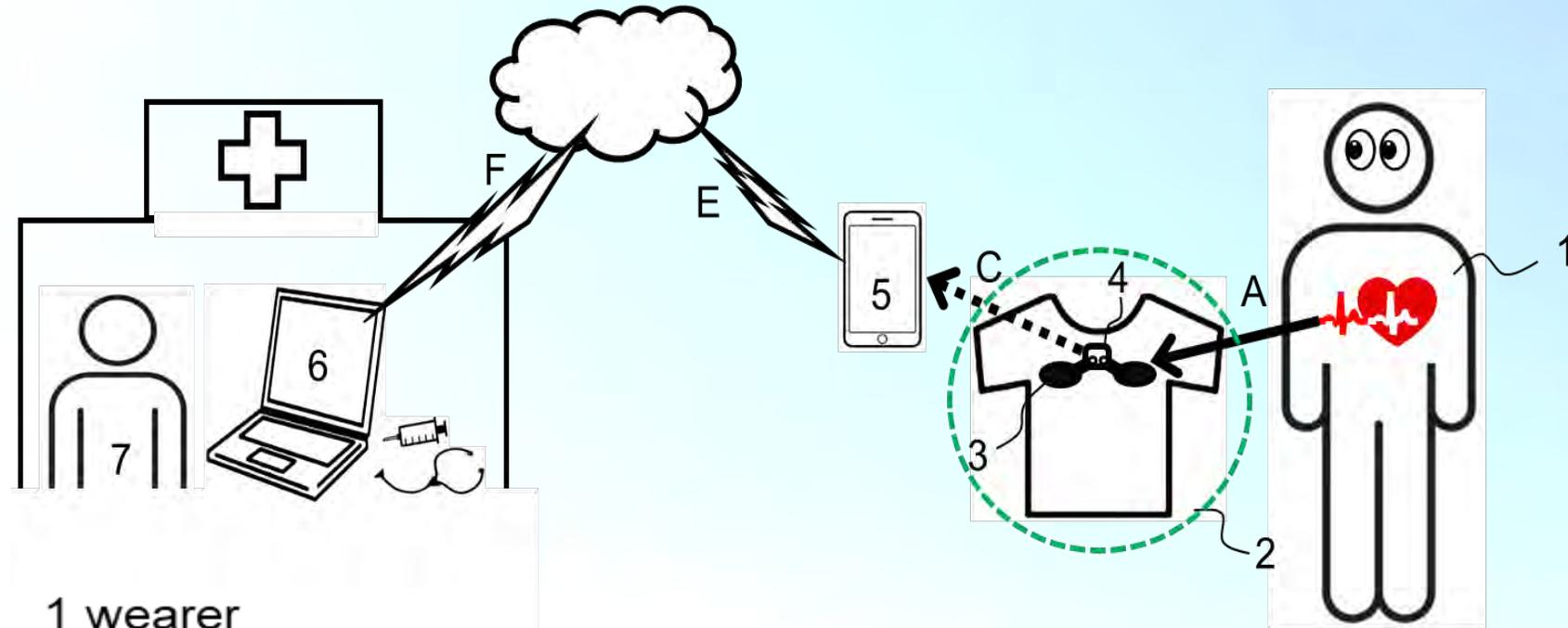


<https://cocomi.toyobostc.com/>

<https://www.uniontool-mybeat.com/SHOP/8600112.html>

<https://www.toyobo-cocomi.com/>

Monitoring by medical doctors via network of bio-signals obtained from wearable devices

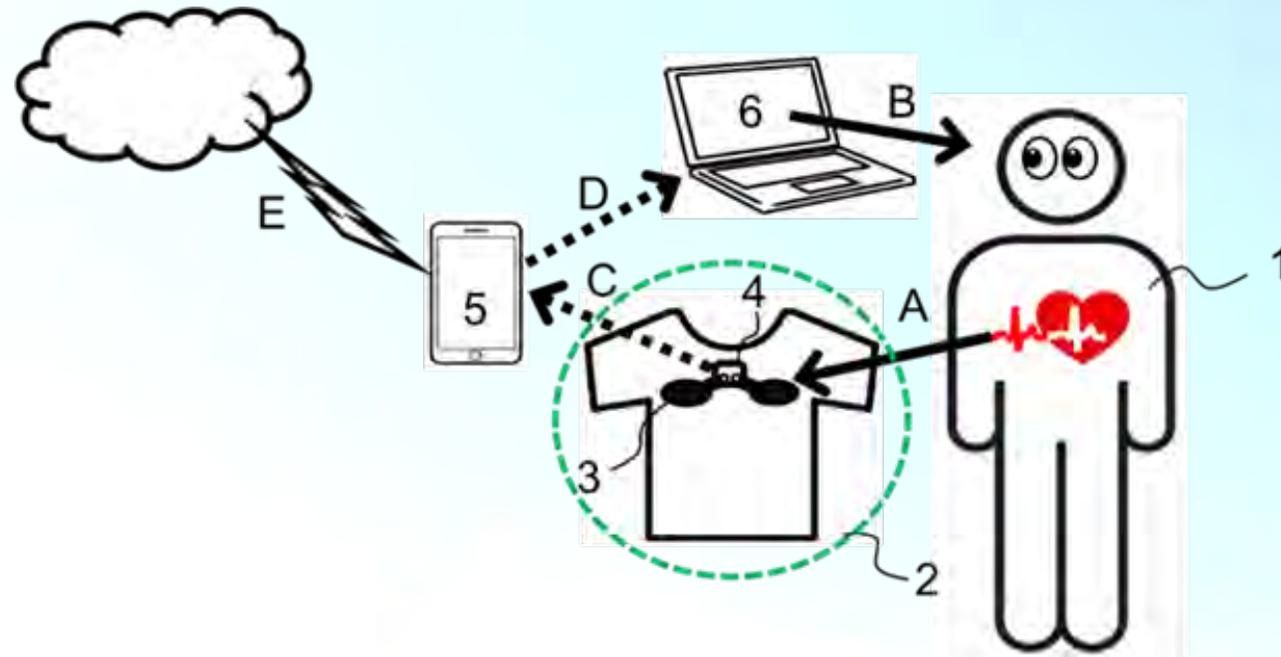


- 1 wearer
- 2 garment type ECG device
- 3 electrode
- 4 transmitter
- 5 S-mart BAN router
- 6 proccing and display device
- 7 medical doctor

- A input interface (electrode)
- C body area communication
- E internet communication
- F internet communication



Monitoring by wearer own or supervisor via BAN and **human-machine interface**



- 1 wearer
- 2 garment type ECG device
- 3 electrode
- 4 transmitter
- 5 S-mart BAN router
- 6 proccing and display device
- 7 medical doctor

- A input interface (electrode)
- B output interface (display)
- C body area communication
- D personal area communication
- E internet communication

Autonomic nerve activity index read from ECG

A method for obtaining autonomic nerve activity from frequency analysis of heart rate variability was developed in the early 1980s.

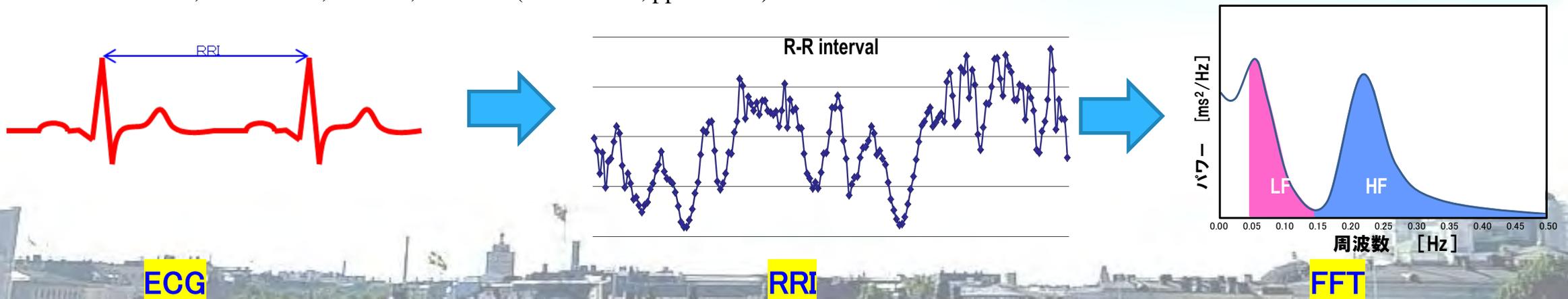
A method of reading the activity state of autonomic nerves by analyzing heart rate variability is well known in the field of physiology.

The autonomic nerves are composed of the sympathetic nerves that work predominantly when the mind and body are active and the parasympathetic nerves that work when the mind and body are relaxed. The sympathetic nerve and parasympathetic nerve activity indices can be obtained by the following method.

The RRI recorded for a certain period of time is FFT-transformed to the frequency axis, and the integral value of the power spectrum above 0.15 Hz is taken as the HF
Let LF be the integrated value of the power spectrum in the range of 0.05 to 0.15 Hz.
LF/HF is the sympathetic nerve activity index, and HF is the parasympathetic nerve activity index.

References

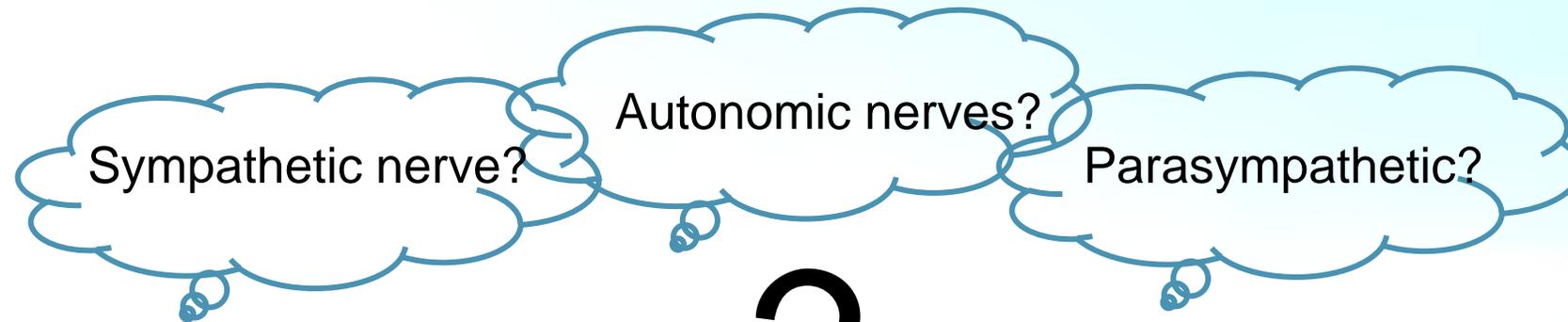
Solange Akselrod, et al, "Power spectrum analysis of heart rate fluctuation : a quantitative probe of beat-to-beat cardiovascular control", Science, New Series, vol.213, No.4504 (Jul.10.1981, pp220-222)



Difficult medical terminology and specialized knowledge

An advantage of the ECG device is that the autonomic nerve activity index can be obtained. The autonomic nervous system contains various information related to the mind and body.

However, that results is hard to understand for the general people who does not have medical knowledges.



?

what is that ????????

An Example of the Result of Autonomic Nerve Activity Analysis

Heart Rate

BPM
心拍数

presentation

leaving work

At home

Before presentation

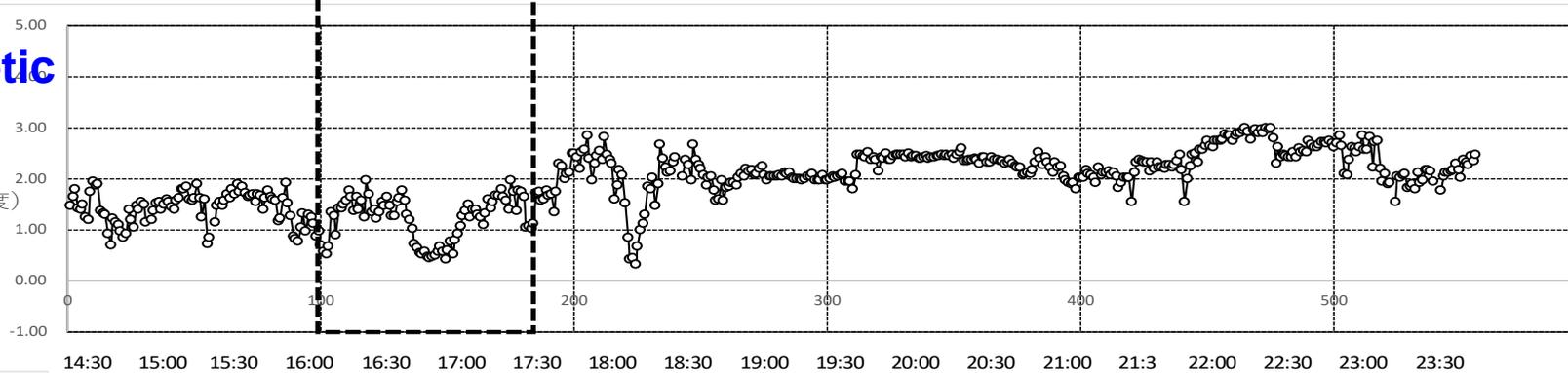
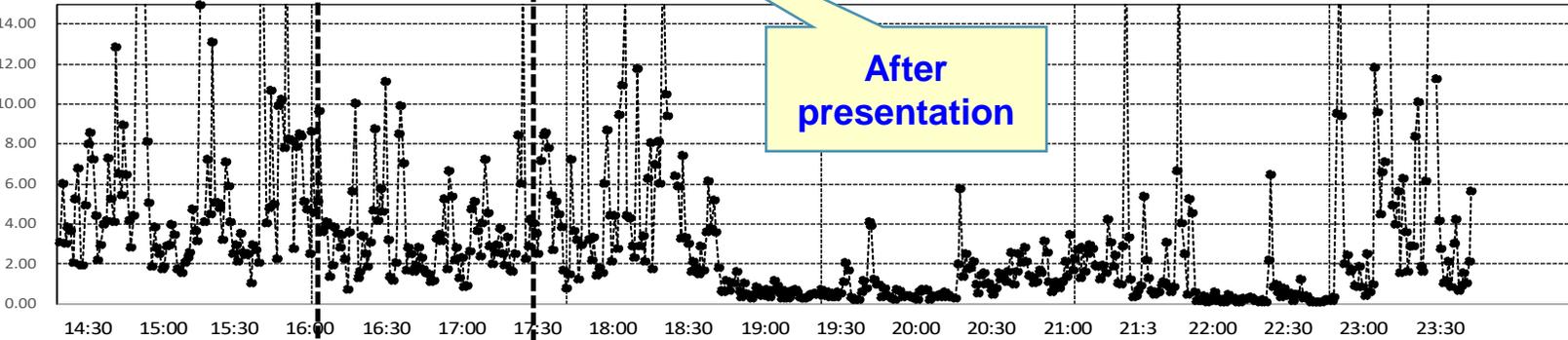
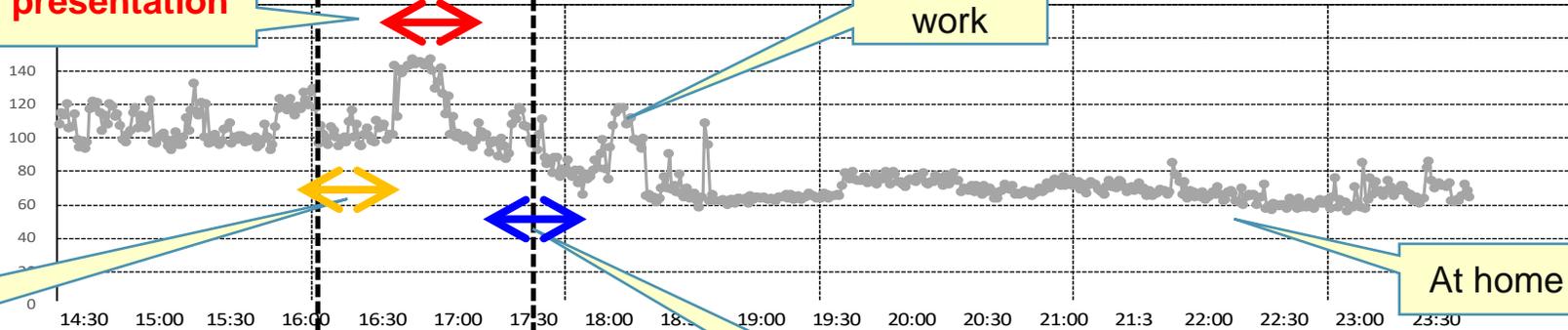
After presentation

Sympathetic Nerve Activity

LF/HF
交感神経
活動指標
(興奮度)

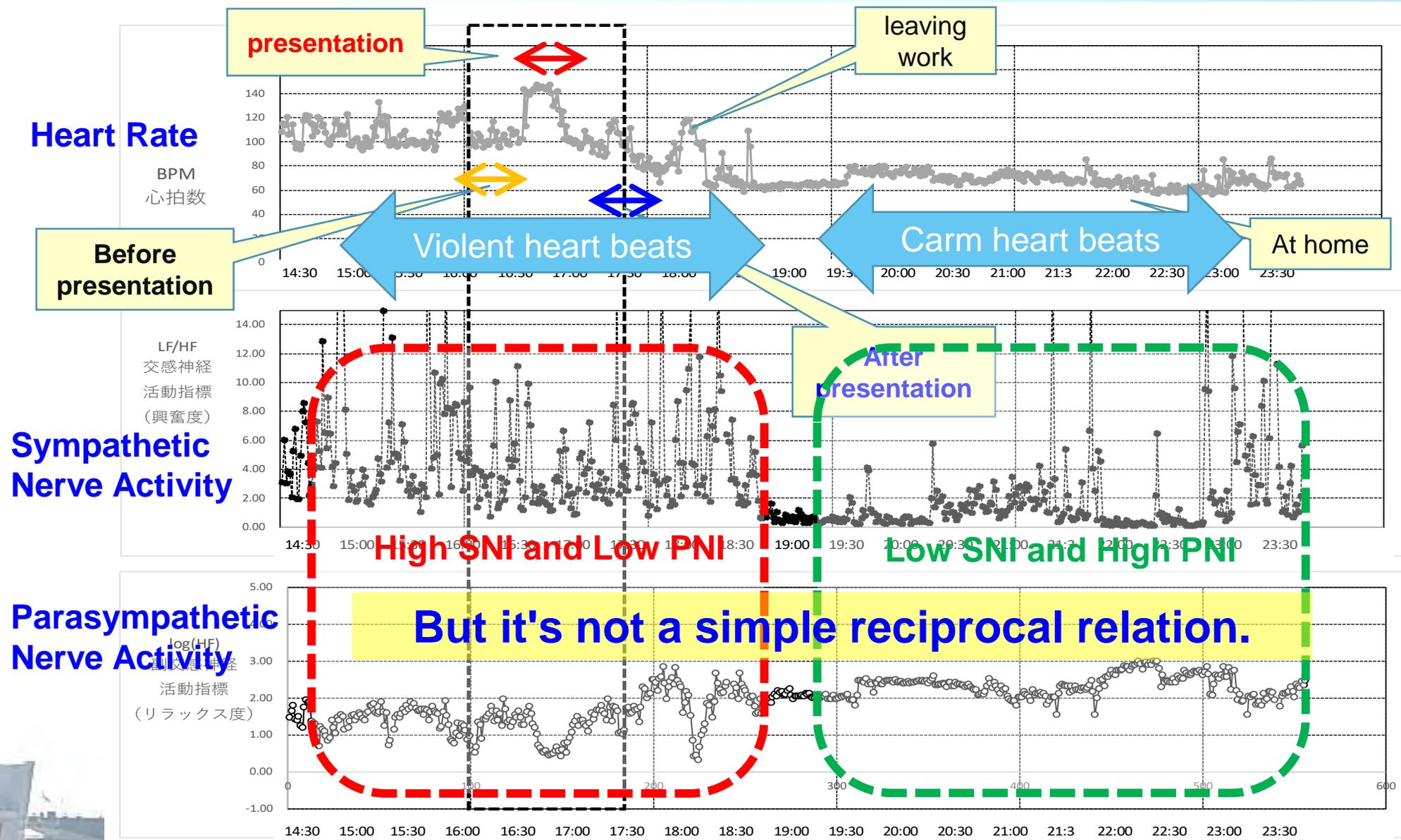
Parasympathetic Nerve Activity

log(HF)
副交感神経
活動指標
(リラックス度)



at one day
afternoon,
a young woman
employee who
gave a
presentation to a
VIP for the first time

An Example of the Result of Autonomic Nerve Activity Analysis

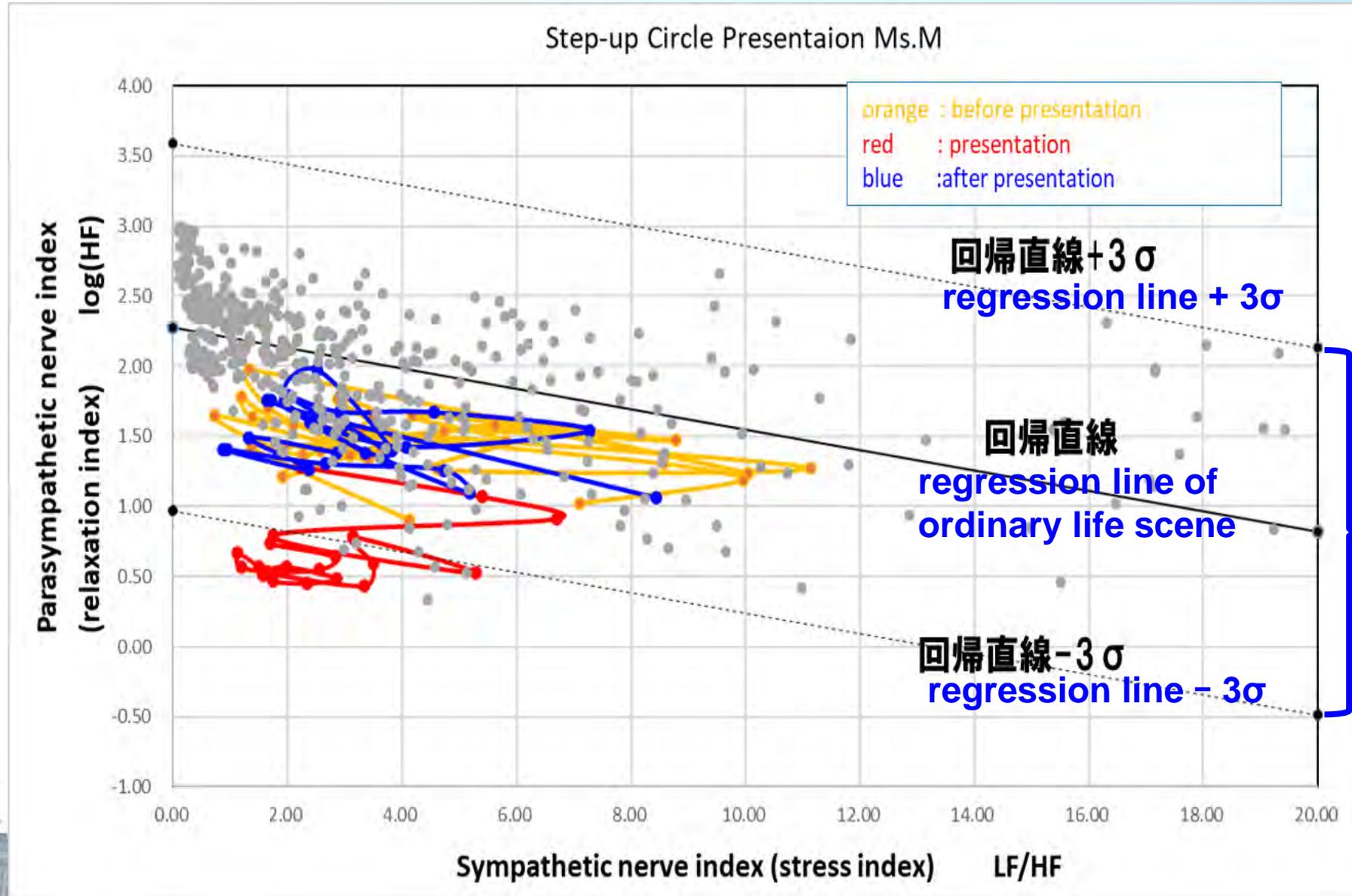


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time



New Proposed Expressions ANAC

The autonomic nerve index obtained from the RRI for the past 3 minutes is plotted every minute.



Gray: ordinary life scene
Orange: before presentation
Red: Presenting
Blue: After presentation

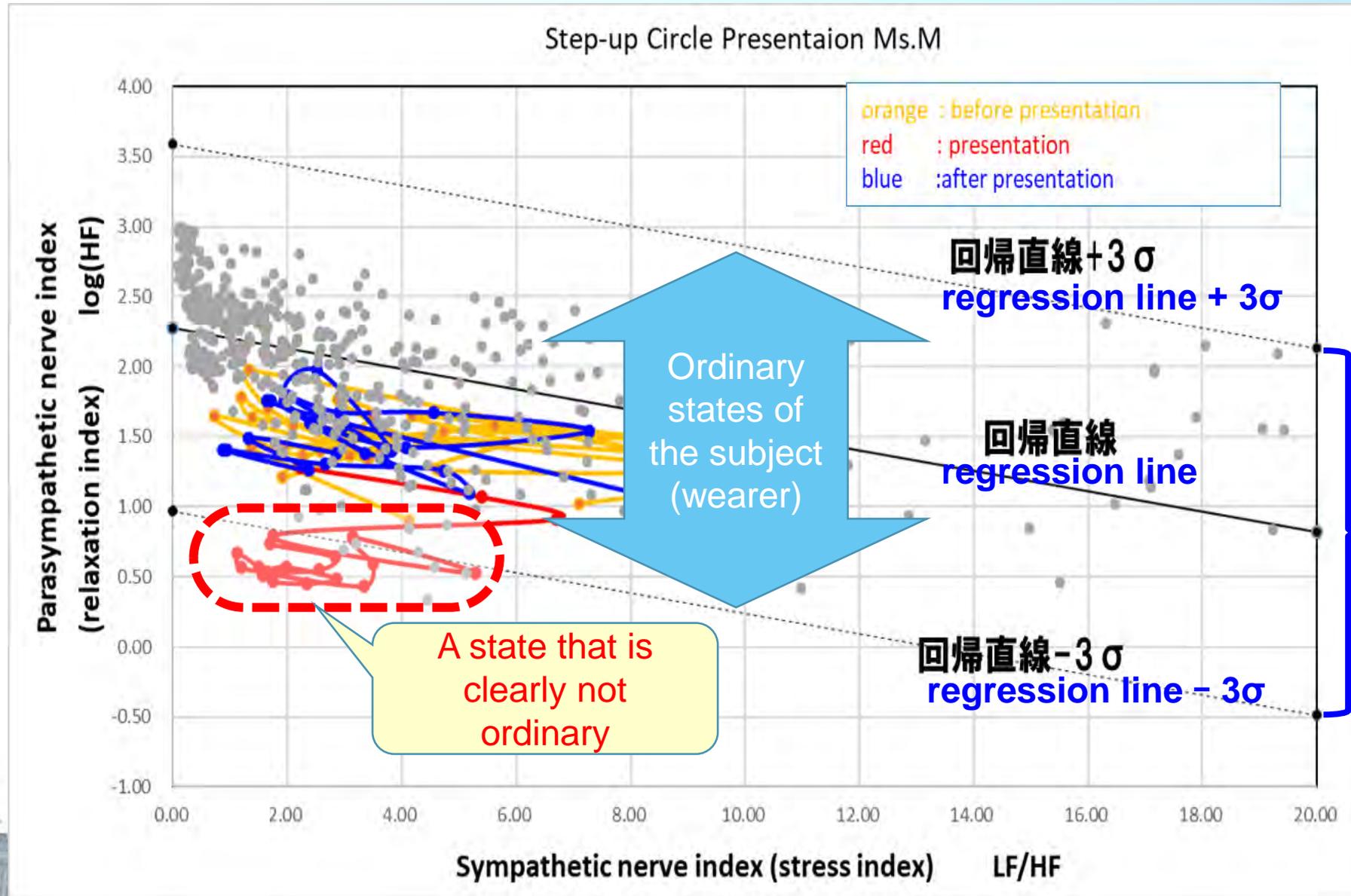
The autonomic nervous system during the presentation is clearly active in a different area from the ordinary life scene.

99.7%
statistics
confidence
interval



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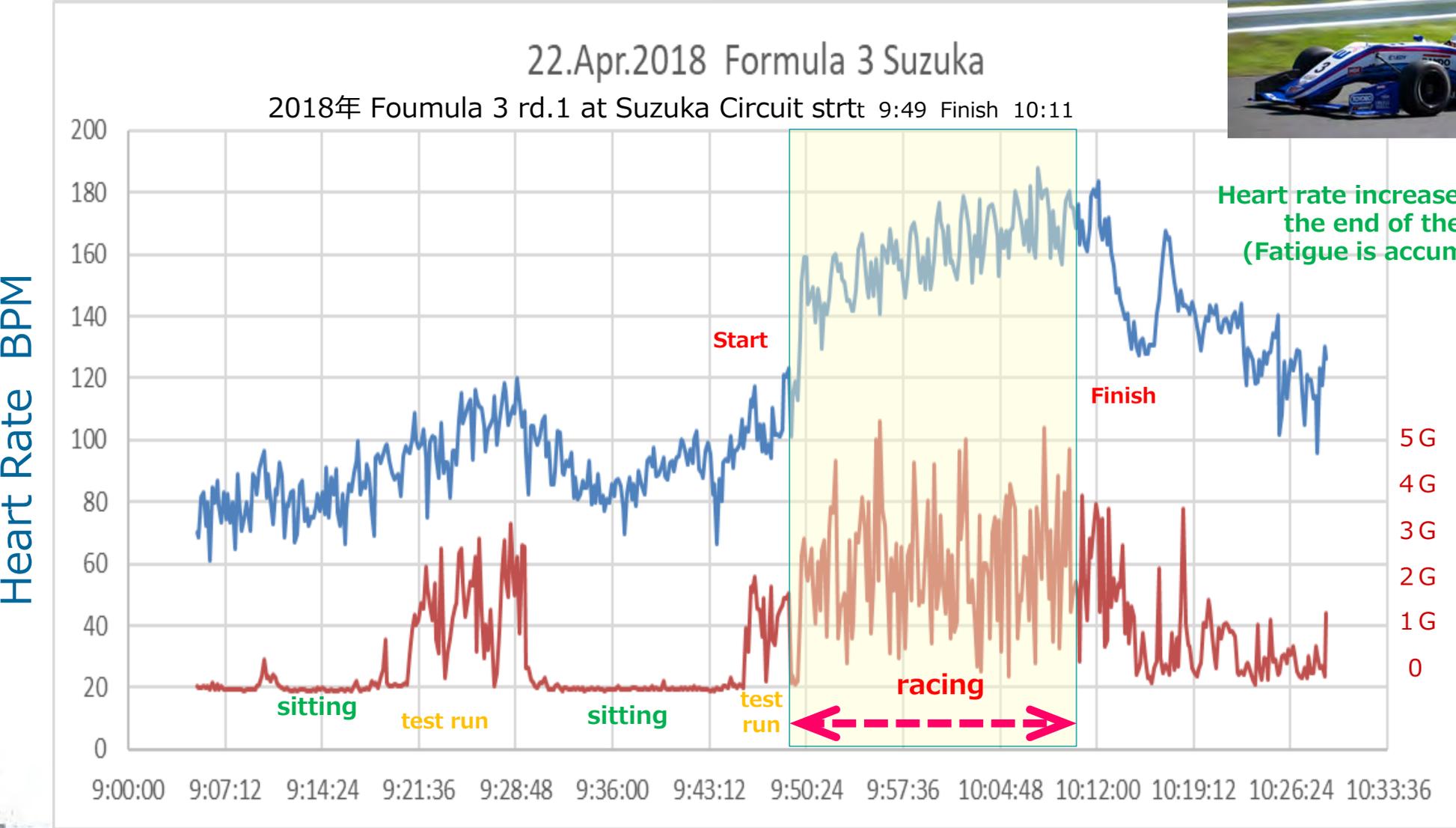
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2nd example, Professional Racing driver Ms. Ai Miura

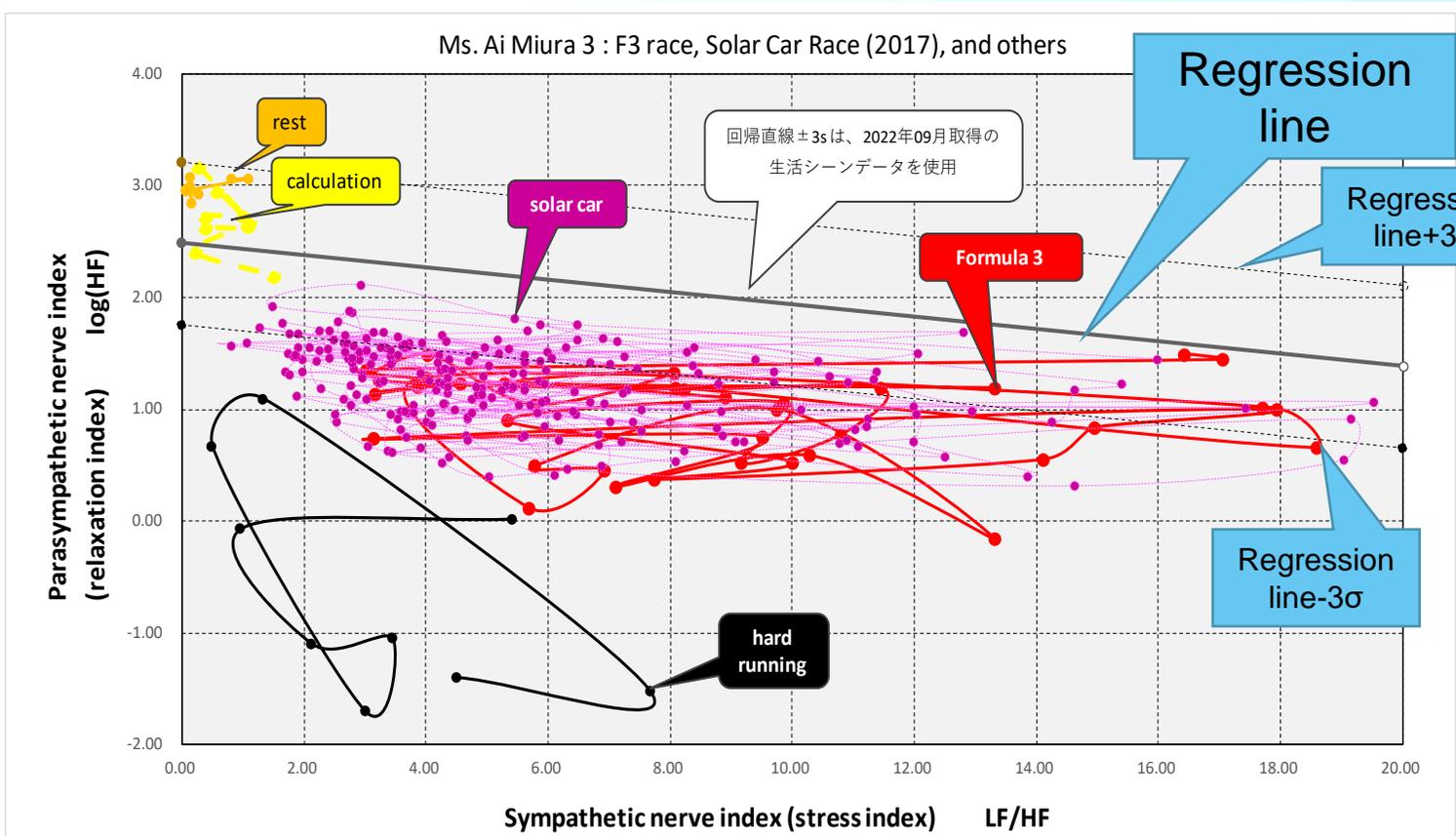
2021 Formula Regional Winner, 2023 KYOJO Cup Champion



ECG measurement during Formula 3 Race



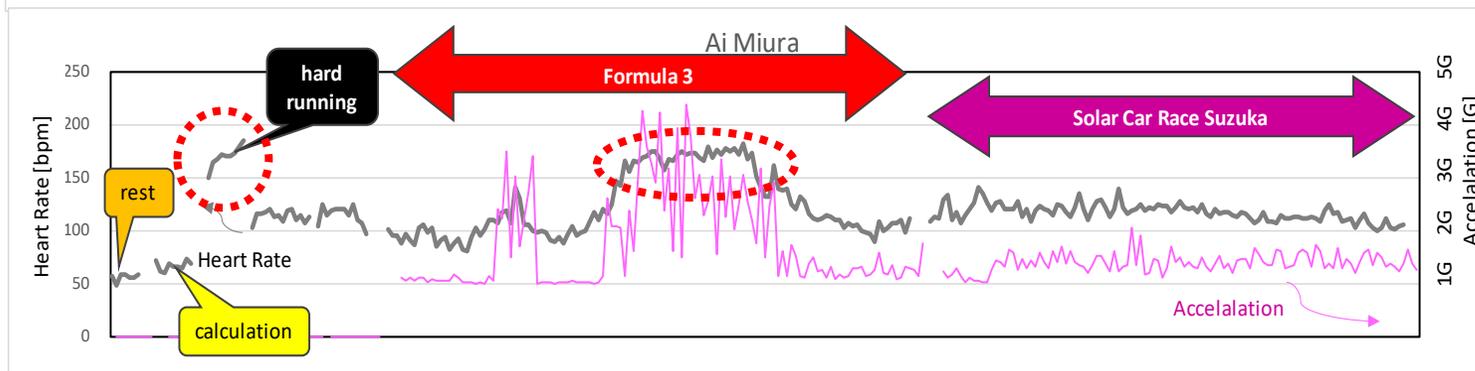
Professional Racing Driver Ms. Ai Miura



Her heart rate reaches 180 BPM in both Formula 3 races and sprinting on a treadmill.

But her autonomic activity is a completely different area.

In other words, this method of expression allows us to understand physical and mental states that cannot be expressed by just heart rate only.



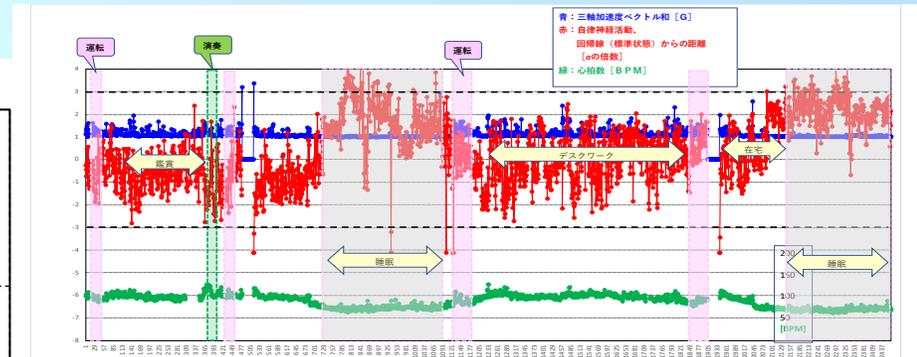
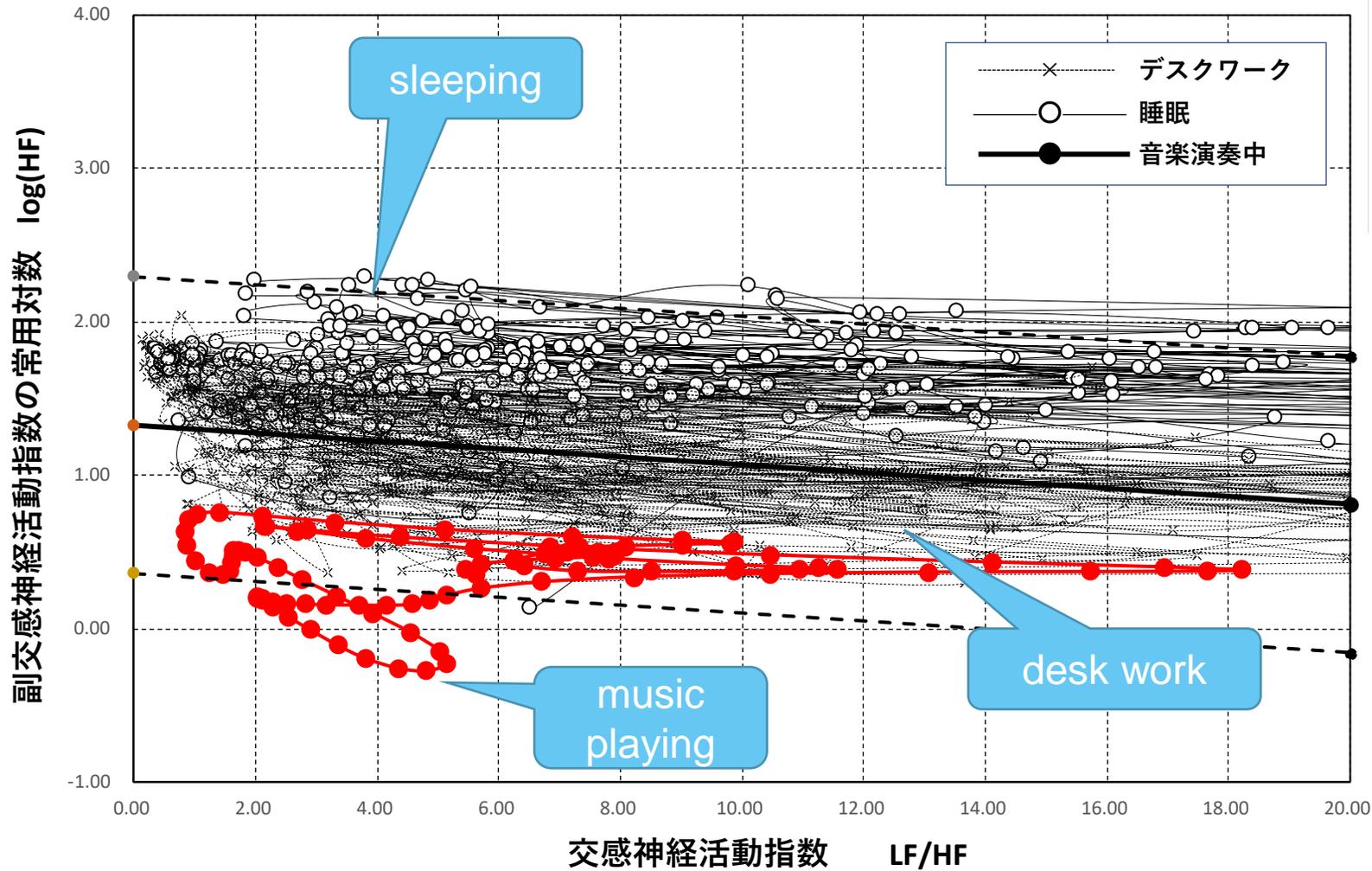
3rd example

ANAC caught my anxious feeling during a live music performance.



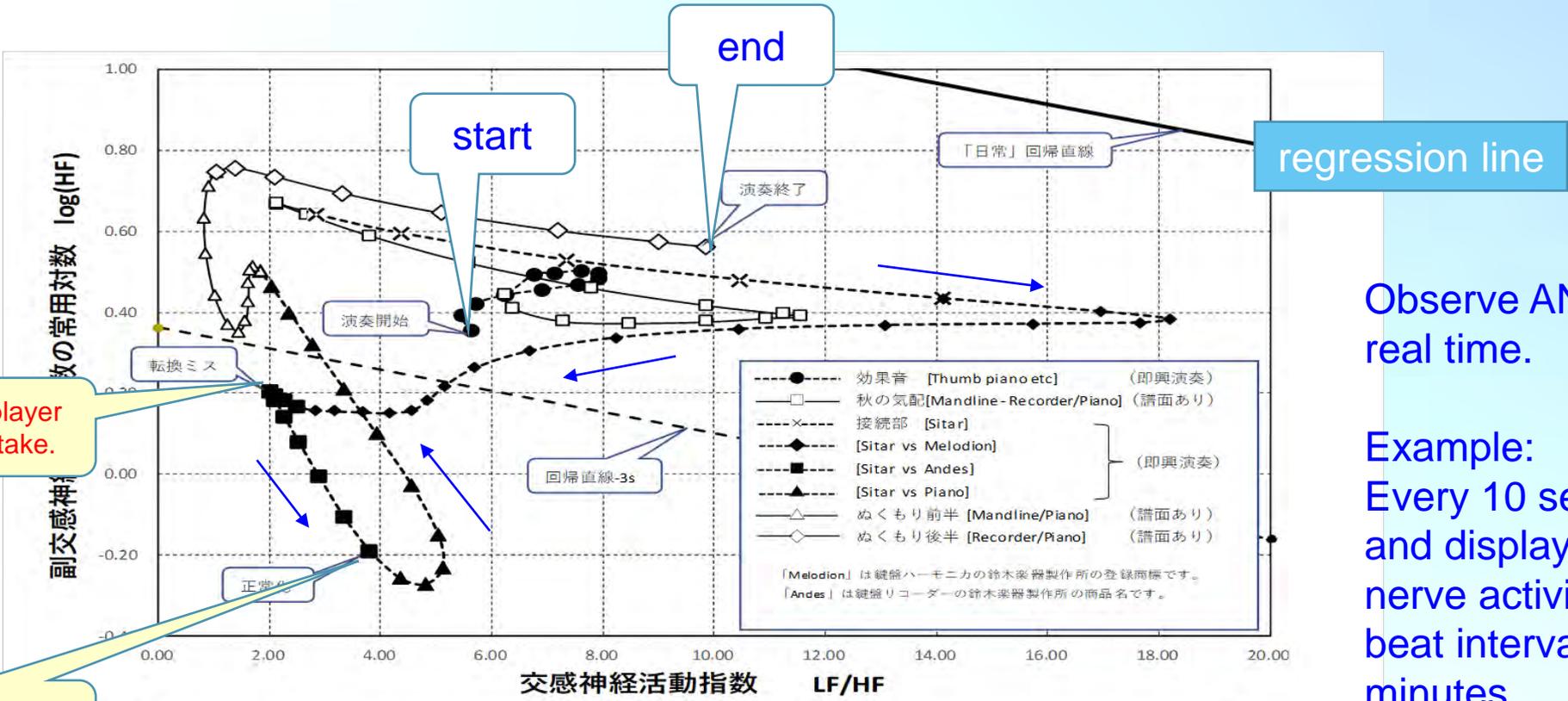
<https://www.youtube.com/watch?v=1j6sBhX7oNs>

Some examples of my heart rate



The areas of autonomic nerve activity are different during sleep, desk work, and music performance.

Close-up of autonomic nerve activity during music performance



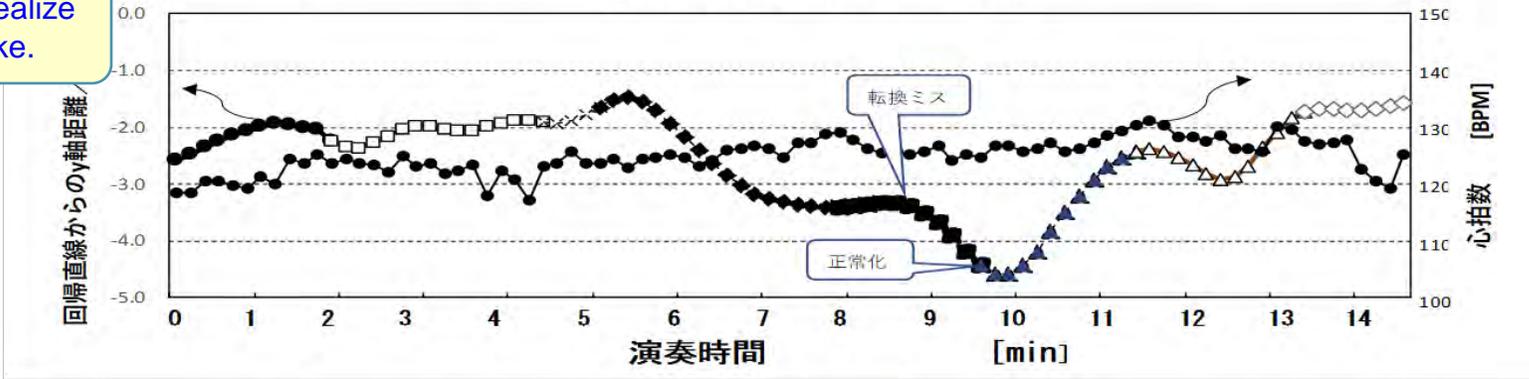
My partner player made a mistake.

My partner realize her mistake.

Observe ANAIM_{TM} in near real time.

Example:
Every 10 seconds, calculate and display the autonomic nerve activity index at the beat interval of the past 3 minutes

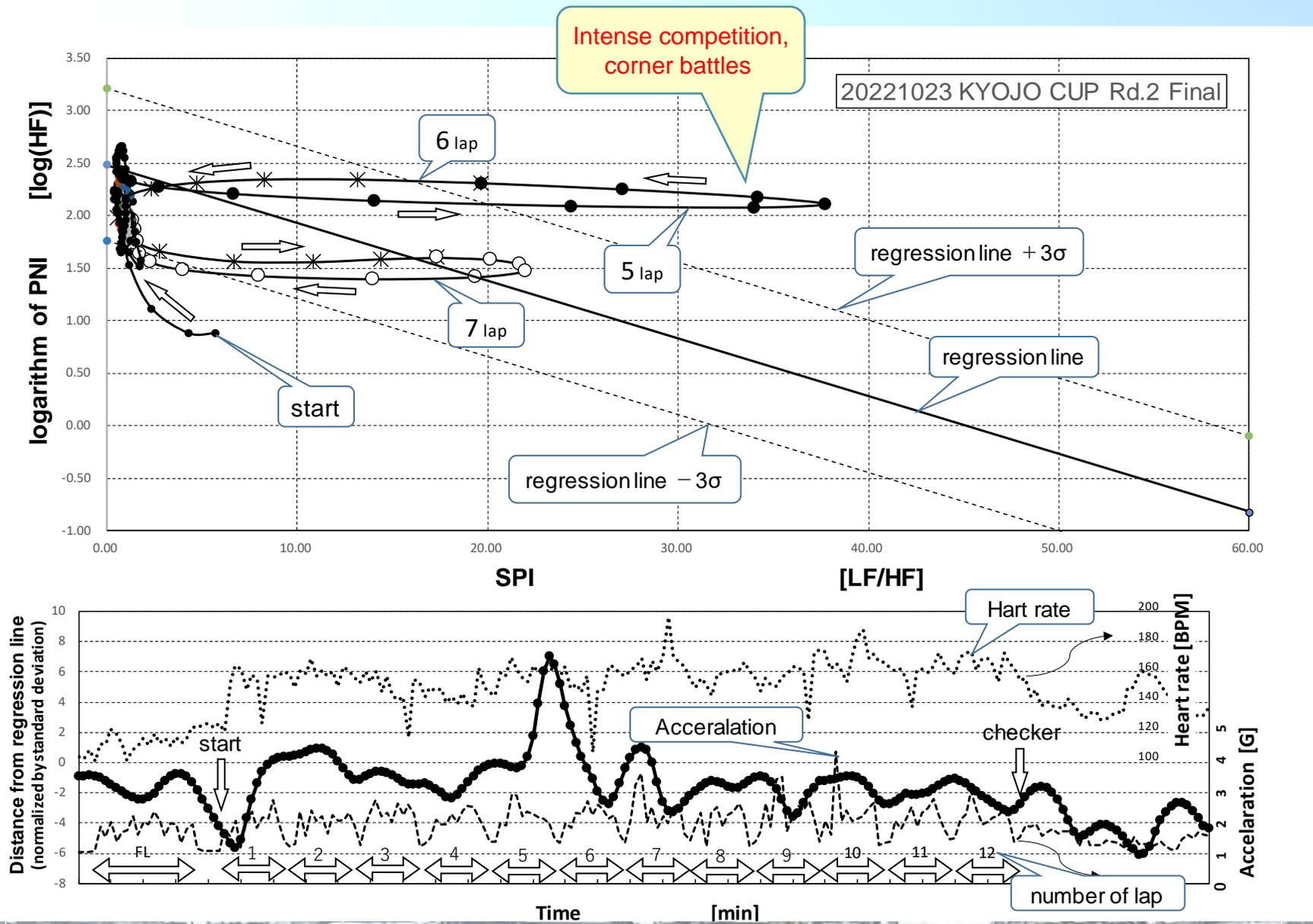
You can observe the movement of the autonomic nerve that reflects the psychological state during action.



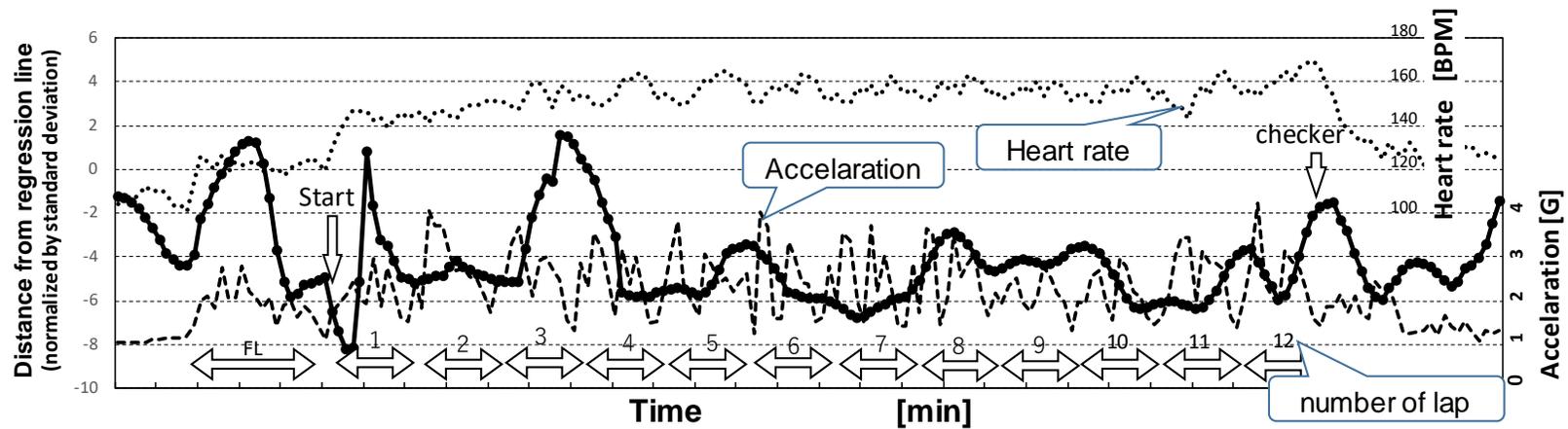
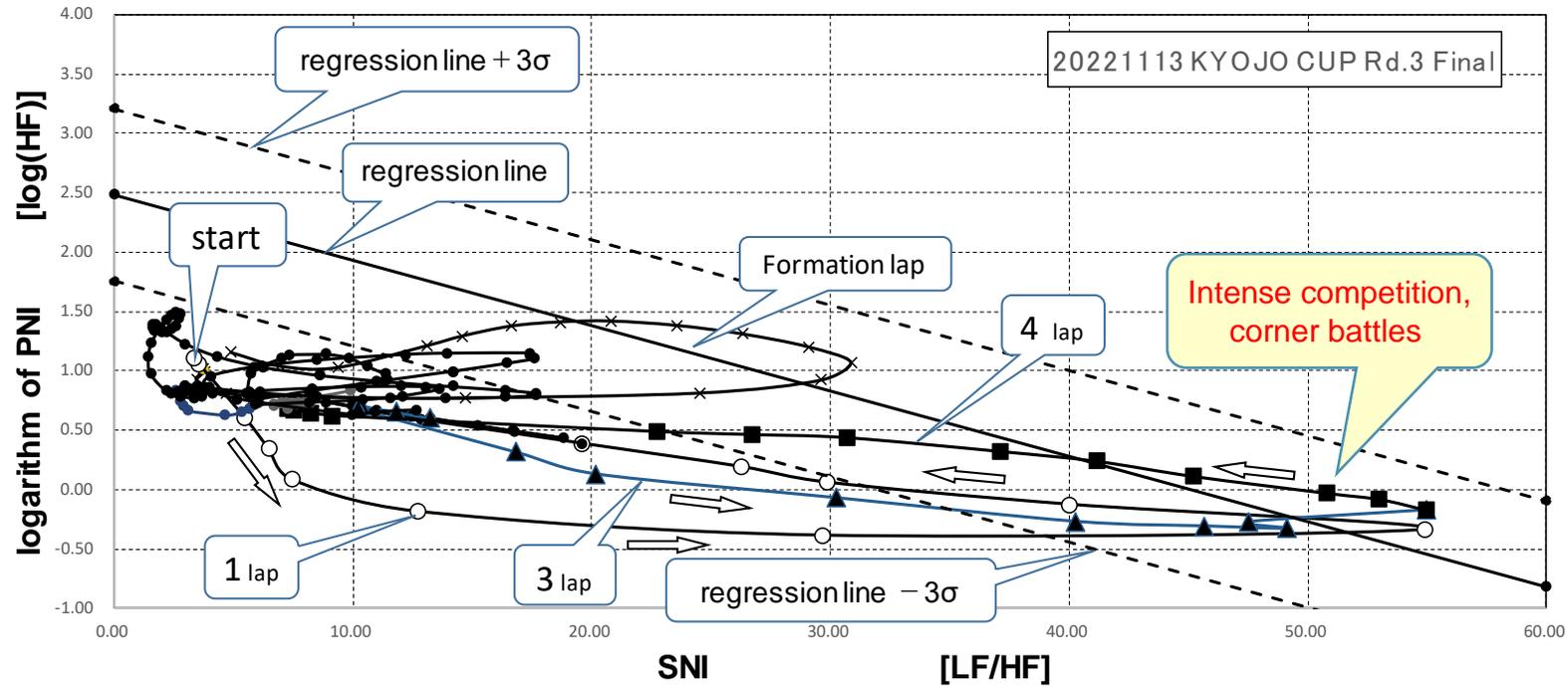
4th example 2022 FCR-VITA and KYOJO CUP at Fuji Speed Way



KYOJO CUP Rd.2 2022

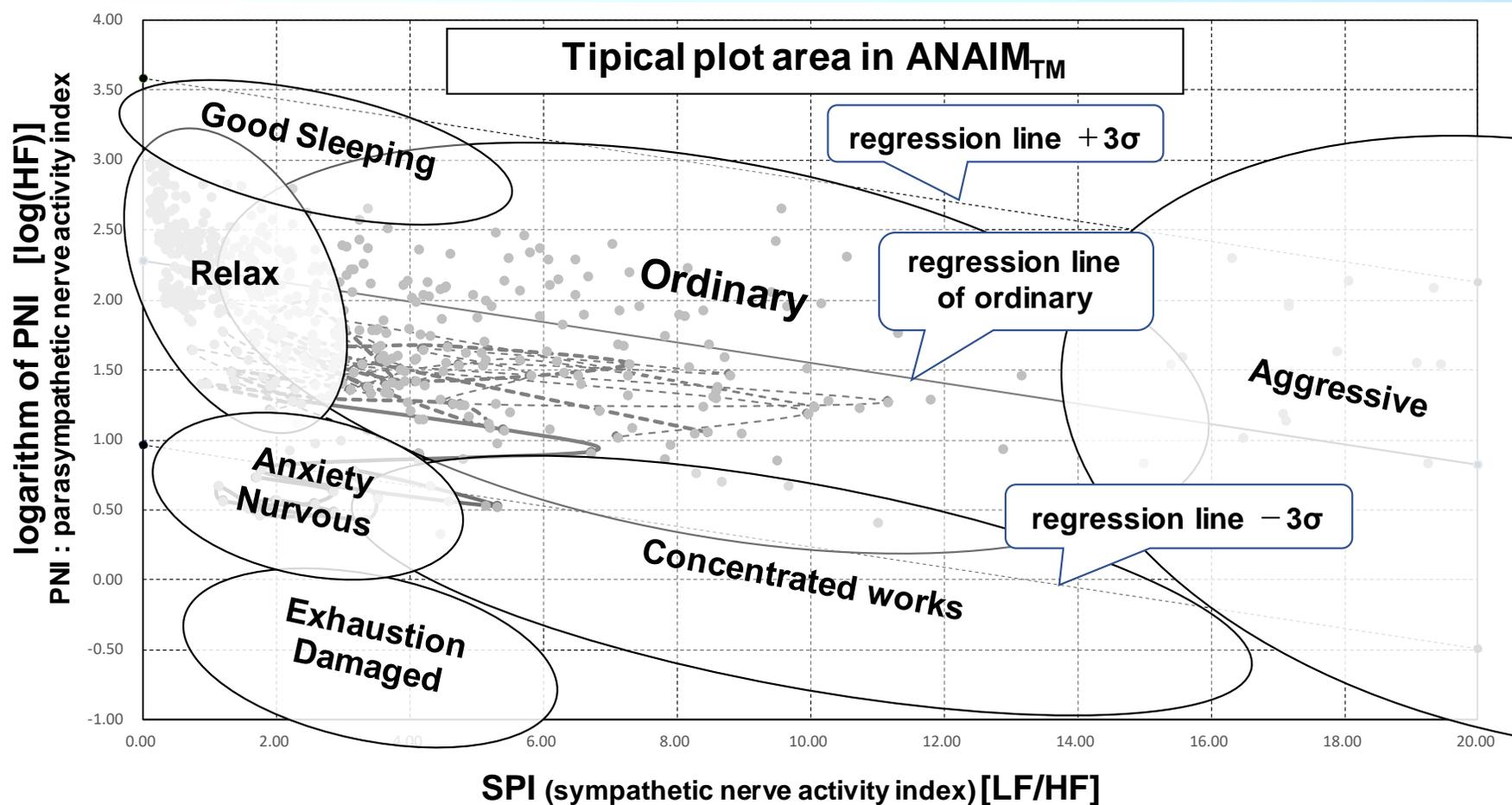


KYOJO CUP Rd.3 2022



SUMMARY

According to ANAC, the subjects mental and physical states are generally displayed as shown in this figure.



In principle, this method can monitor a subject remotely and with a delay of several minutes from real time.

Bibliography

- 1) Solange Akselrod, et al, “Power spectrum analysis of heart rate fluctuation : a quantitative probe of beat-to-beat cardiovascular control”, Science, New Series, vol.213, No.4504 (Jul.10.1981, pp220-222)
- 2) Satoshi Maeda, “Expression of WEST wearer's physical and mental state using autonomic nerve activity visualization method "ANAIM®“”, Sen’I Gakkaishi, p-160,-171, May 2023. (Japanese)
- 3) Satoshi Maeda, “Autonomic Nerve Activity Index Representation Method based on Heartbeat Information obtained from Wearable Devices”, Proceedings of TBIS 2023, pp1.-8. Aug. 2023.
- 4) Registered patent number 7248204 (Japanese)
- 5) WO-A1-2023/282175 “AUTONOMIC NERVE ACTIVITY STATE DISPLAY SYSTEM, AUTONOMIC NERVE ACTIVITY DISPLAY MAP, AUTONOMIC NERVE ACTIVITY MONITORING SYSTEM, VEHICLE, INFORMATION PROCESSING DEVICE, STORAGE MEDIUM, AND PROGRAM”

KIITOS

Thank you very much

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