The Second ENRI International Workshop on ATM/CNS

Development of "cereameter"

--- Cerebral Resource and Activity Measurement Equipment ---

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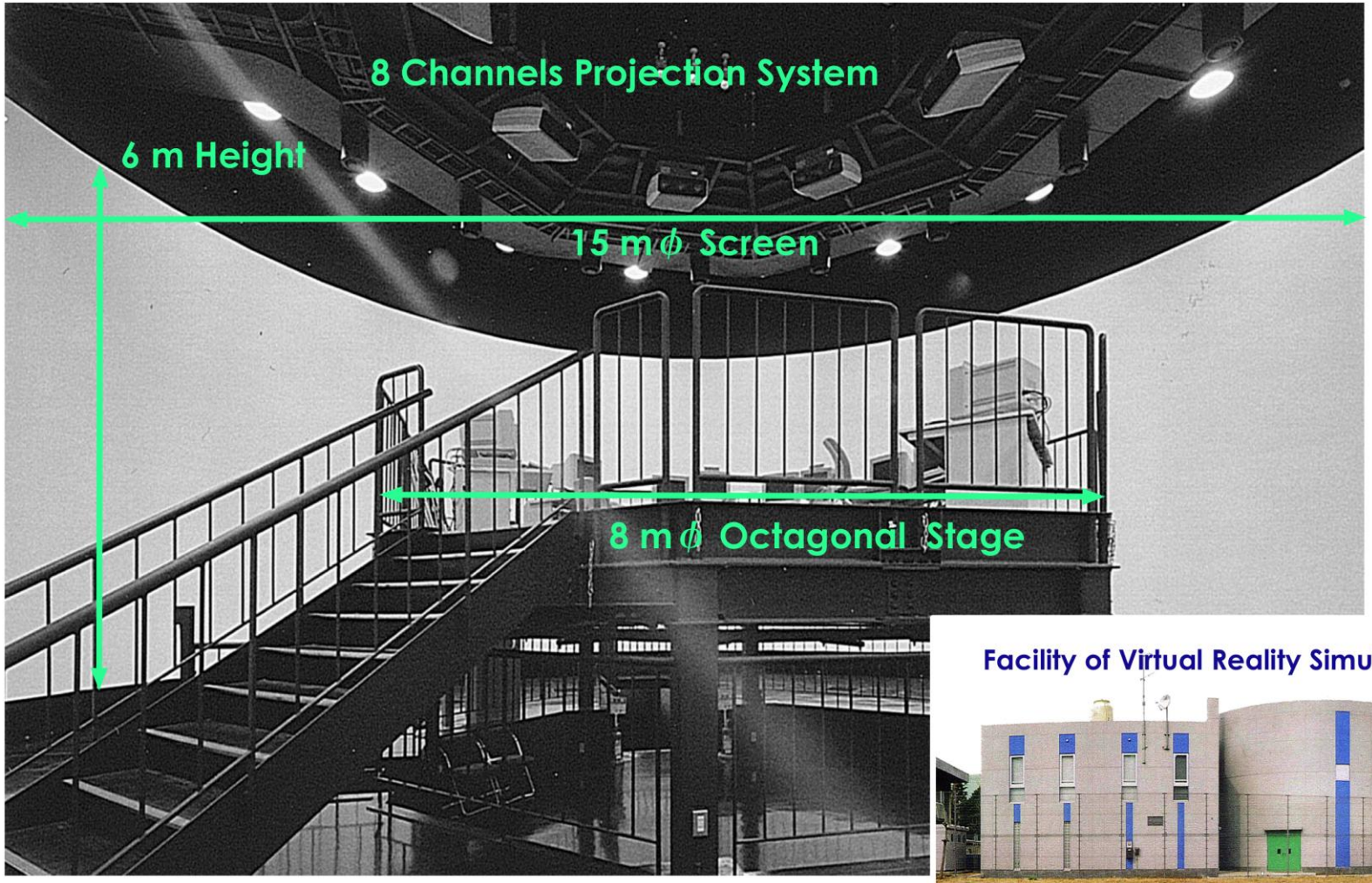
Development of "cereameter"



Facility of Virtual Reality Simulation

Development of "cereameter"

On 26 April 1994, China Airlines Flight 140 was crashed at Nagoya Airport. A human error attracted attention as a cause of the accident.

China Airlines Flight 140 was a route from Taipei, Taiwan to Nagoya, Japan. On April 26, 1994, the Airbus A300 on the route was due to land at Nagoya Airport. The Airbus A300 was completing a routine flight and approach, however just before landing, the First Officer pressed the Takeoff/Go-around button (also known as a TO/GA) which raises the throttle position to the same as take offs and go-arounds.
Pilot Wang Lo-chi and copilot Chuang Meng-jung attempted to correct the situation by manually reducing the throttles and pushing the yoke downwards. The autopilot then acted against these inputs (as it is programmed to do when the TO/GA button is activated), causing the plane to have a very nose-high attitude. This nose-high attitude, combined with decreasing airspeed due to insufficient thrust, resulted in an aerodynamic stall of the aircraft. With insufficient altitude to recover from this condition, the subsequent crash killed 264 (15 crew and 249 passengers) of the 271 (15 crew and 256 passengers) people aboard. All passengers who survived the incident were seated at the starboard side of the aircraft in coach class.
The crash which destroyed the aircraft (delivered less than 3 years earlier in 1991) was attributed to crew error for their failure to correct the controls as well as the airspeed. It is the second highest death toll of any incident involving an Airbus A300 anywhere in the world after Iran Air Flight 655. (from WIKIPEDIA)

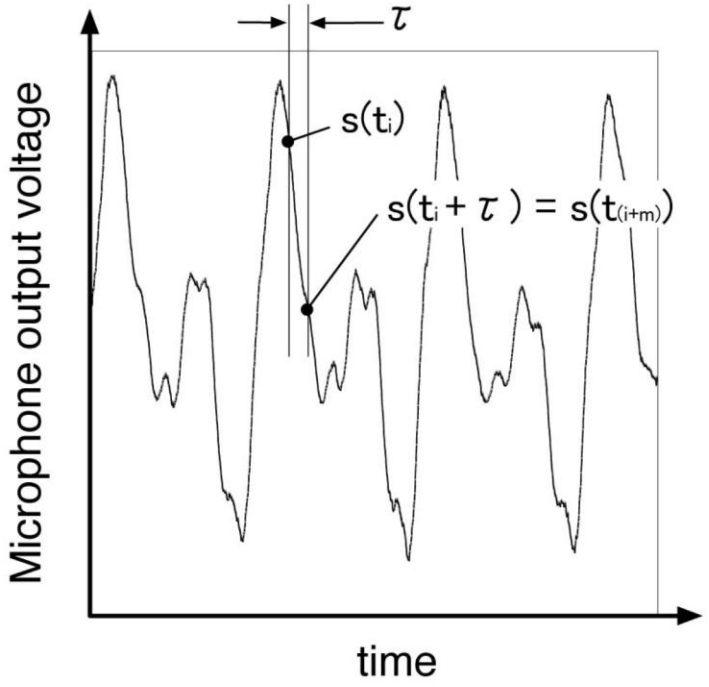
In 1994, the author started to develop software to discriminate human voices from mechanical noises in order to extract pilots' voices from recordings re-trieved from aircraft cockpit voice recorders.

Development of "cereameter"

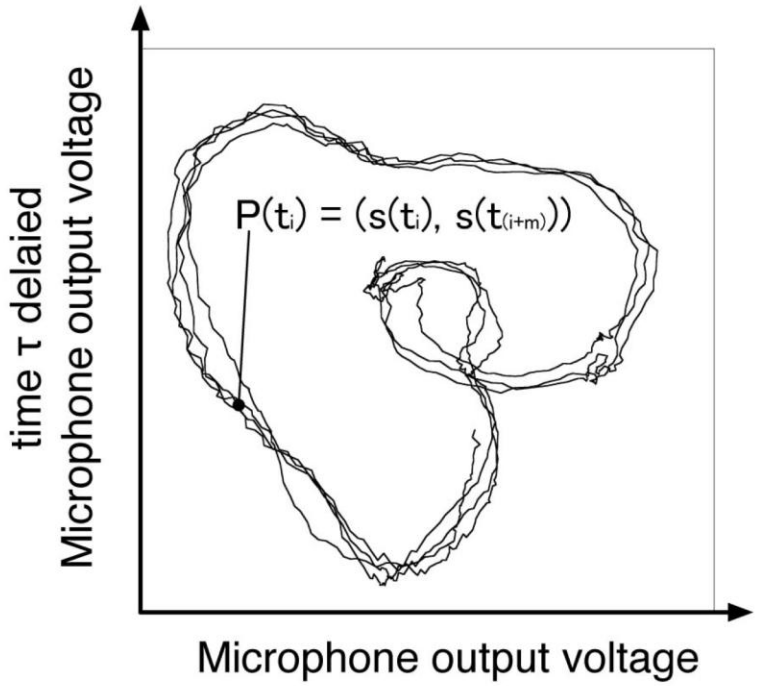
Long Reading Aloud Exprm.

L&F of GUI of Voice Analysis System

In 1998, the author and Mr. Shozo Hirose discovered that the time-averaged value of the first Lyapunov exponent calculated from a human voice signal changes according to the speaker's psychosomatic condition.



Human Voice Waveform



Human Voice Strange Attractor

The strange attractors are reconstructed in phase space according to Takens' embedding theorem.

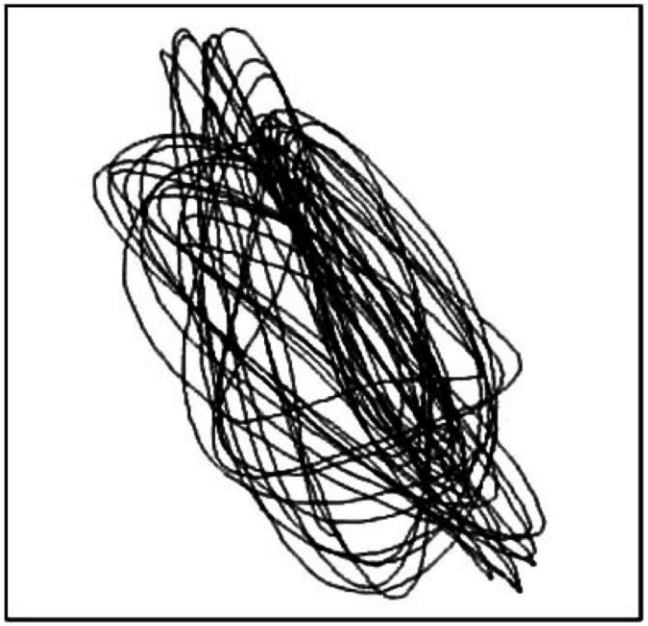


Figure 1. Tens of minutes after the start of a driving exercise

changes to

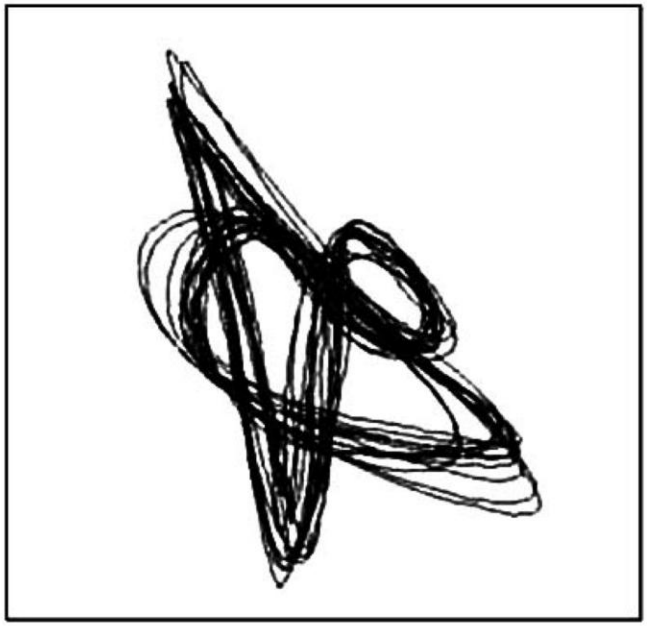
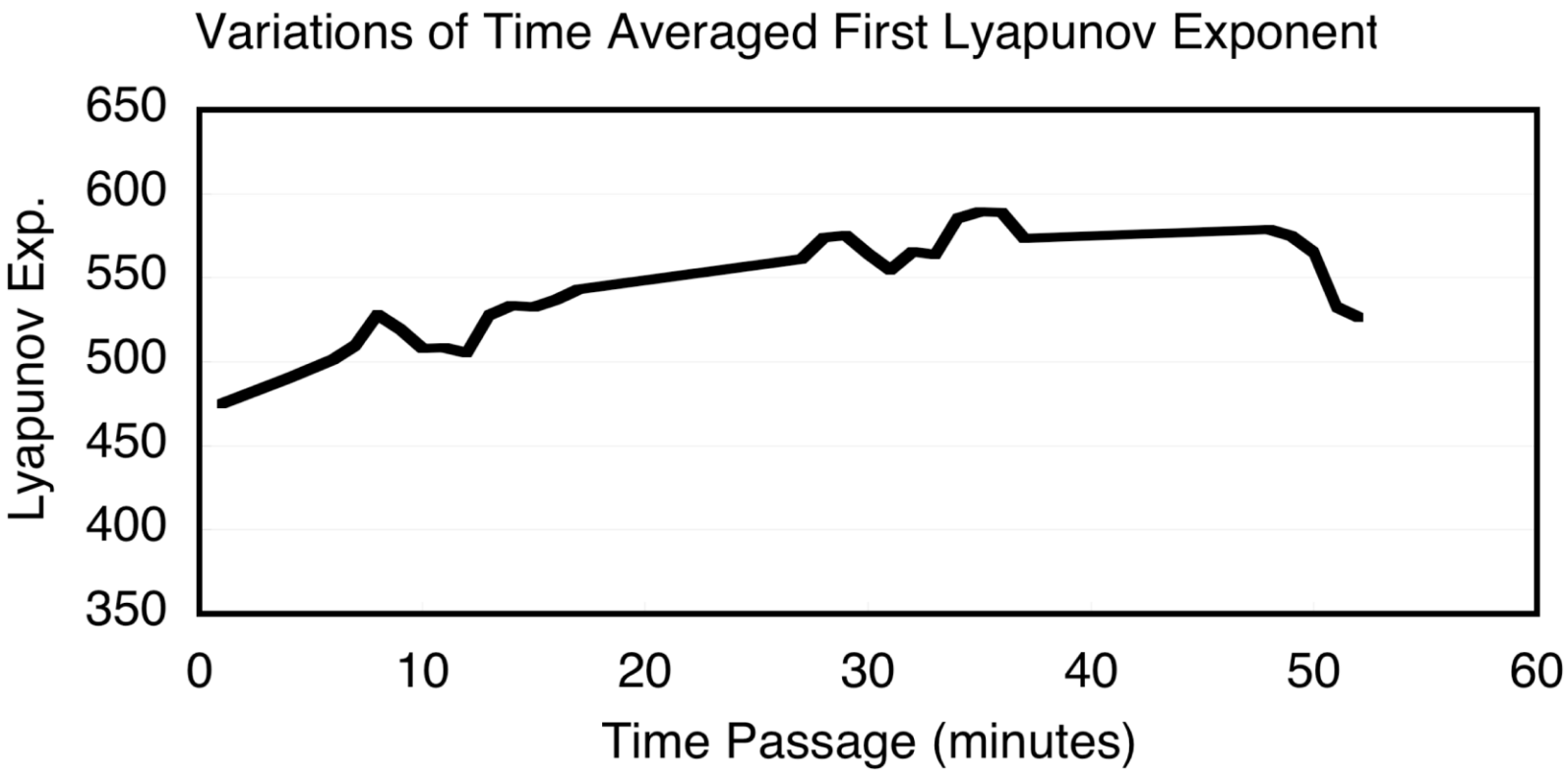
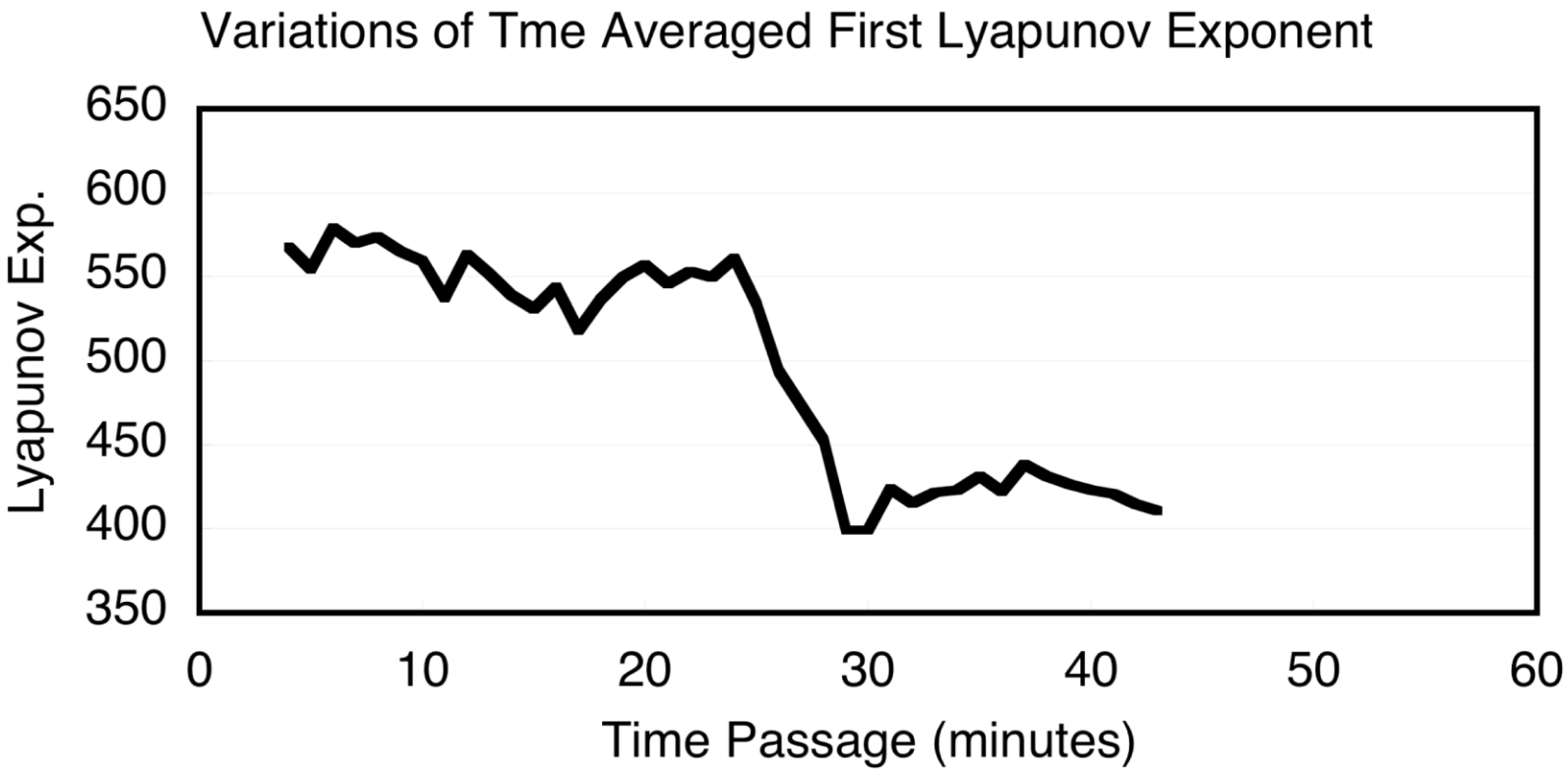


Figure 2. Five hours after the start of exercise

Figures 1 and 2 each show a “strange attractor” generated from a vocalized “o” sound. Each “strange attractor” is generated from the last 80ms of the vocalized “o" sound of call-out made by railway drivers immediately before departure, “Shu-ppatsu Shinkooo!”



In 1998, the author and Mr. Shozo Hirose had found that the first Lyapunov exponent calculated from a human voice changed according to the speaker's increase of tiredness.



The time-averaged value of the first Lyapunov exponent calculated from a reading voice changed according to the speaker's mental condition.

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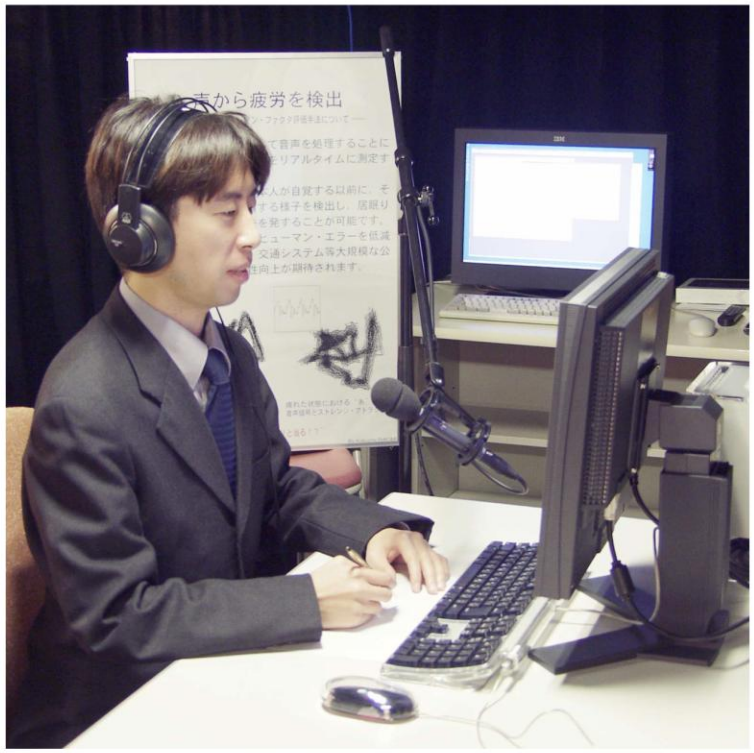


As seen in the right picture, the test subject wore a head-set, and his reading voice could be able to give as feedback.
The author thought that the feedback voice would give some kind of stress to the test subject.

Development of "cereameter"

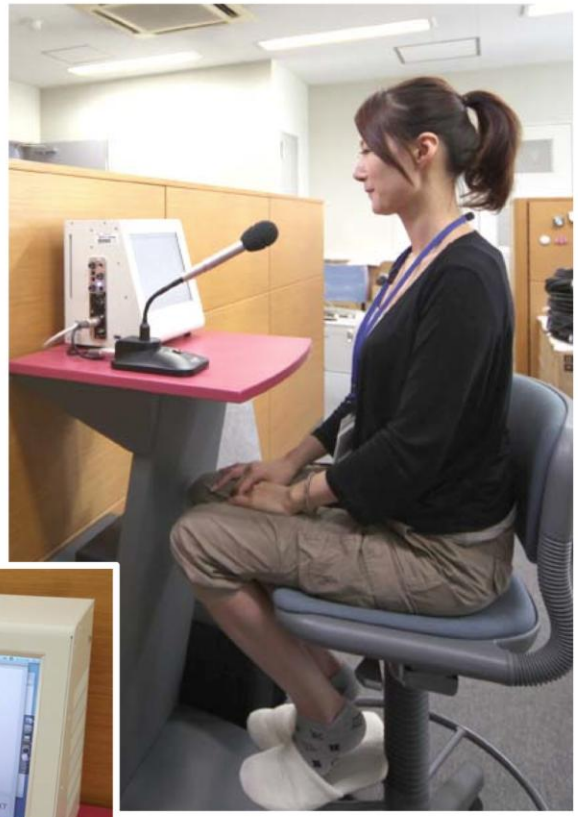
The average value of the first Lyapunov exponent (FLE) was increased from about 500 to 540.
Increase of the FLE means that voice feedback gave stress to the test subject.
Cerebral activity level of the test subject was changed to higher.

Development of "cereameter"

CRAY-MTA2 System (2002)

10,000kg-100kVA → 3kg-100W

CENTE Ver.8 (2010)



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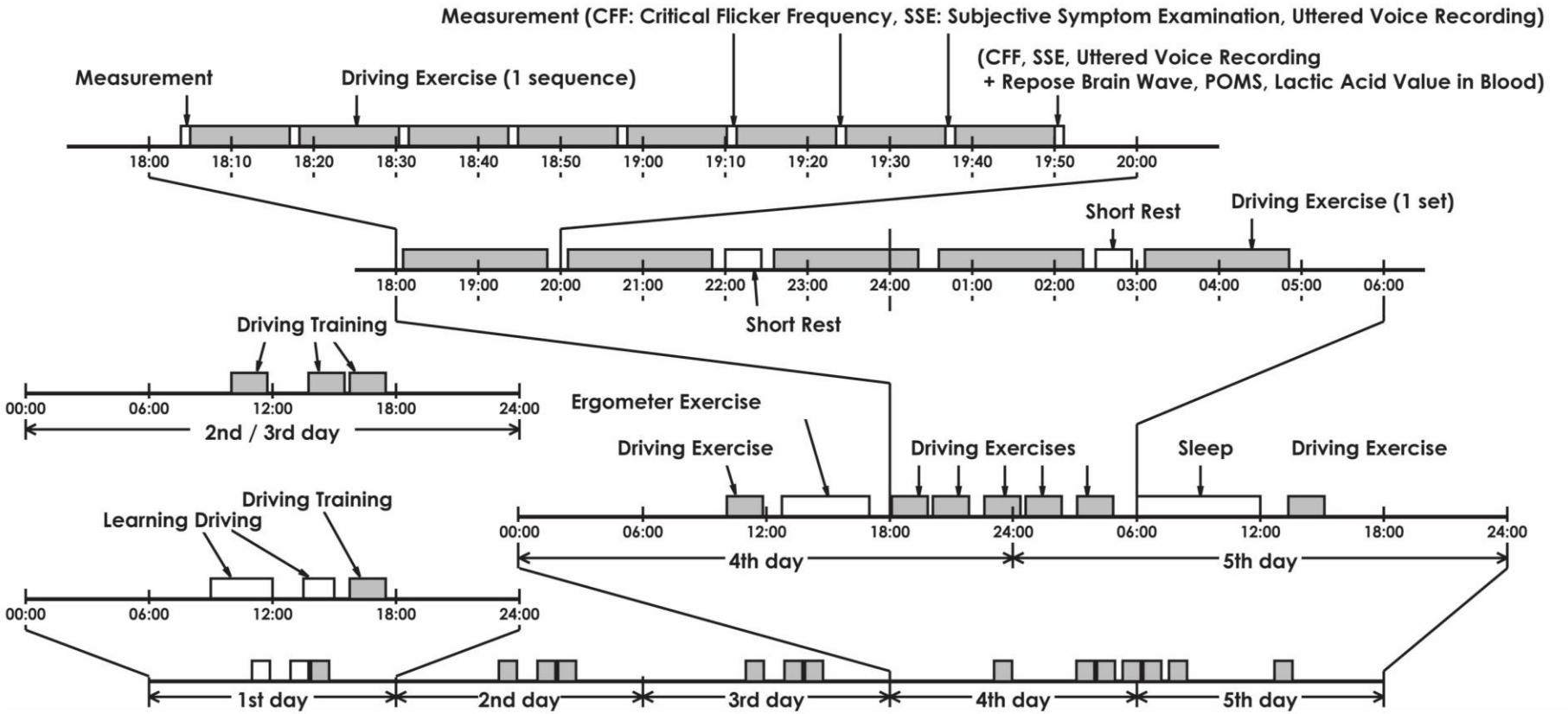

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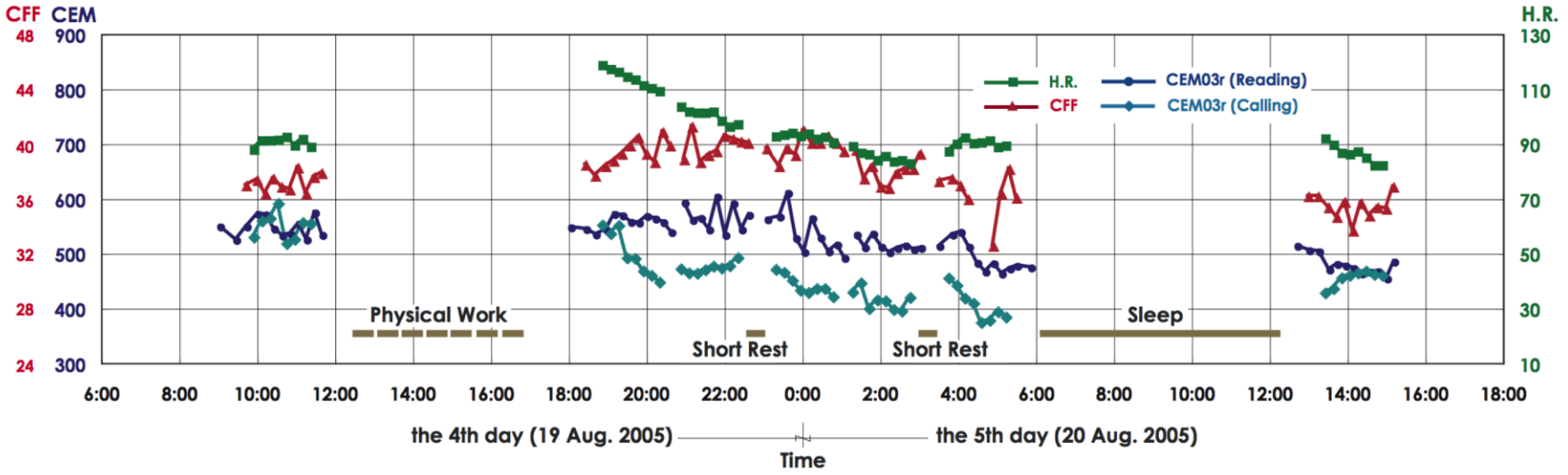
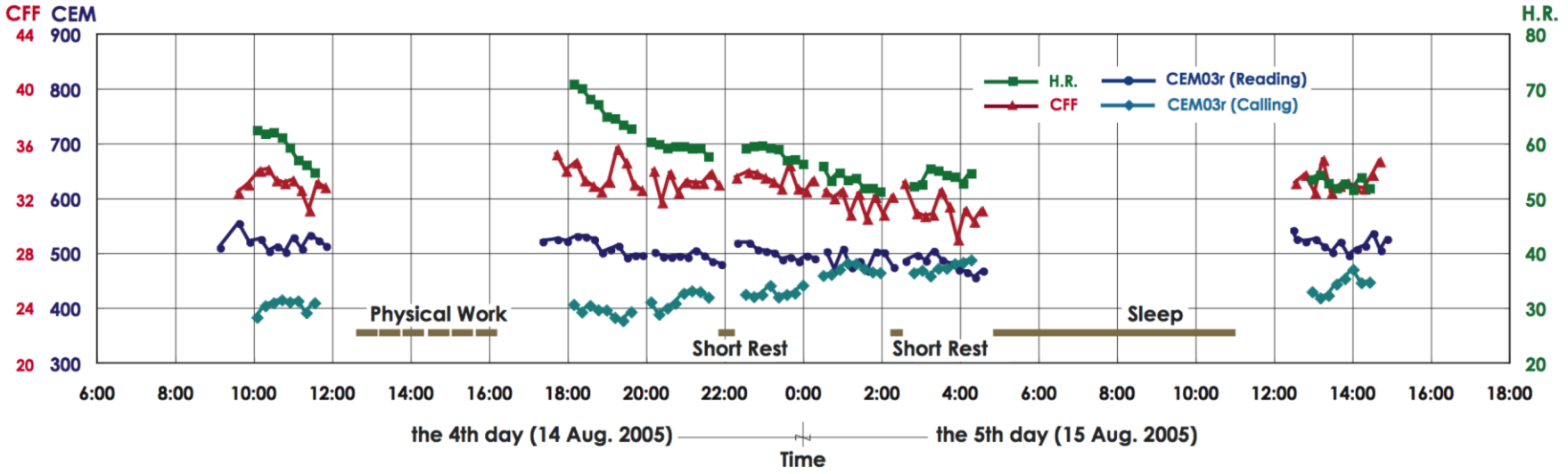
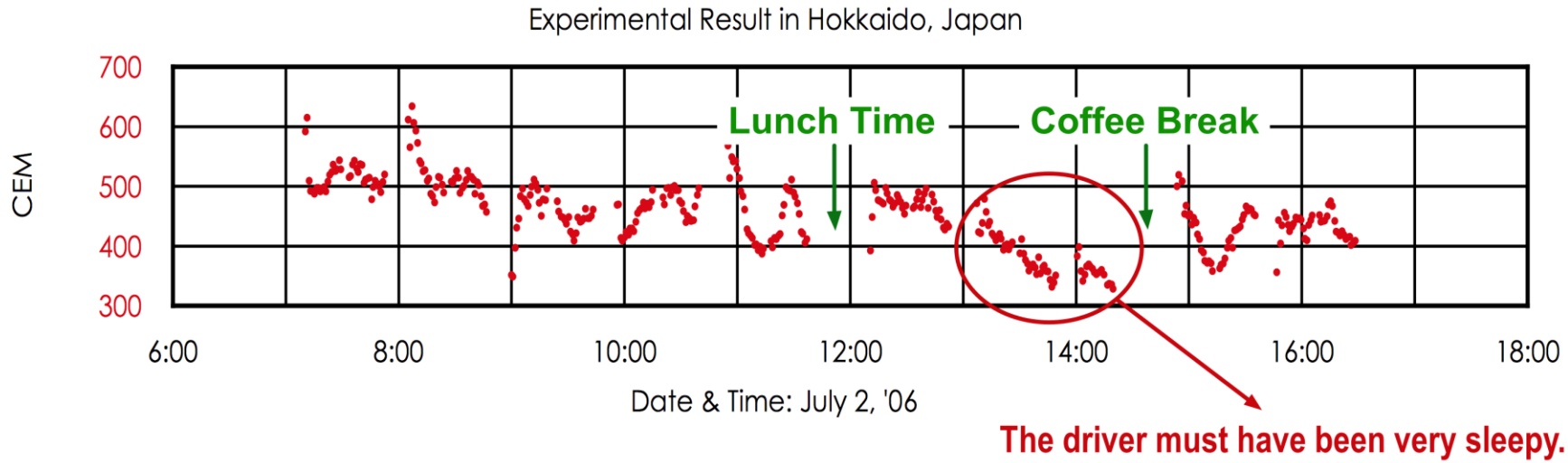


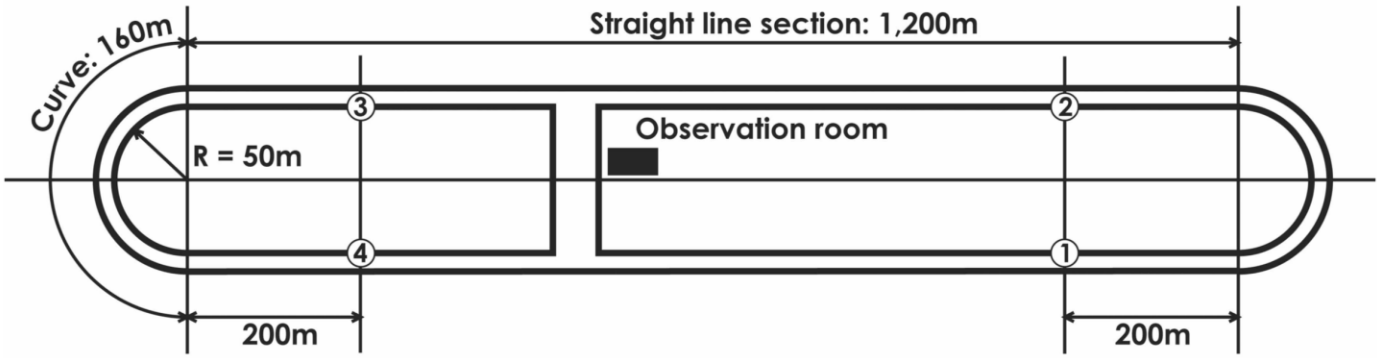


Development of "cereameter"

声で"疲労度"が…
新システム実験中

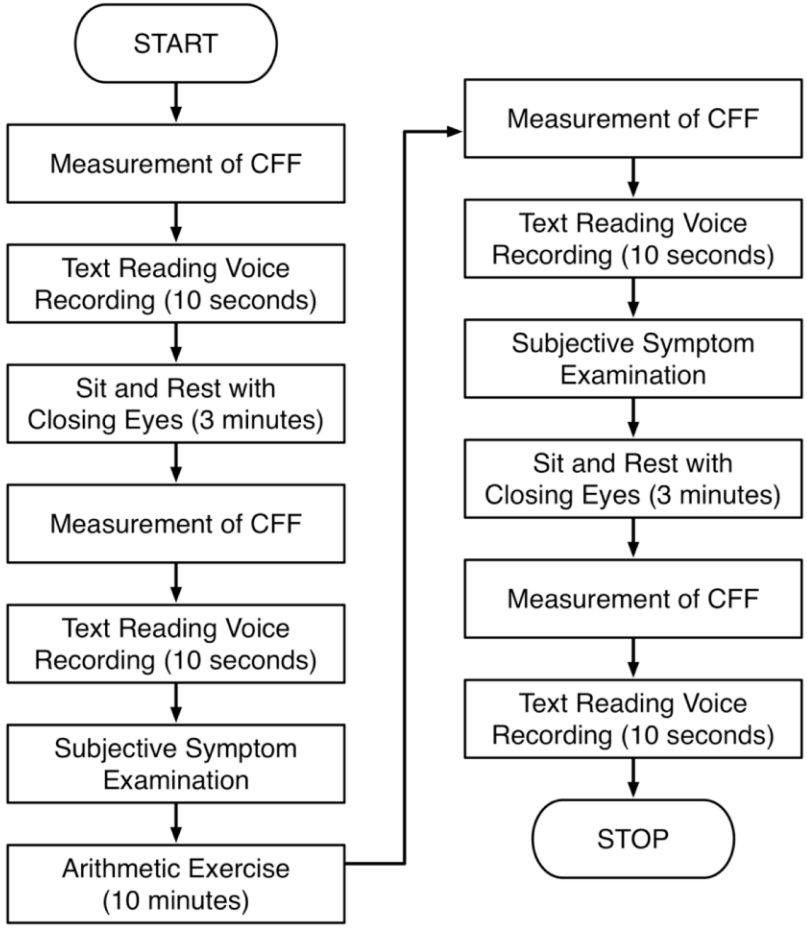
Change of CEM values calculated from call-out voice

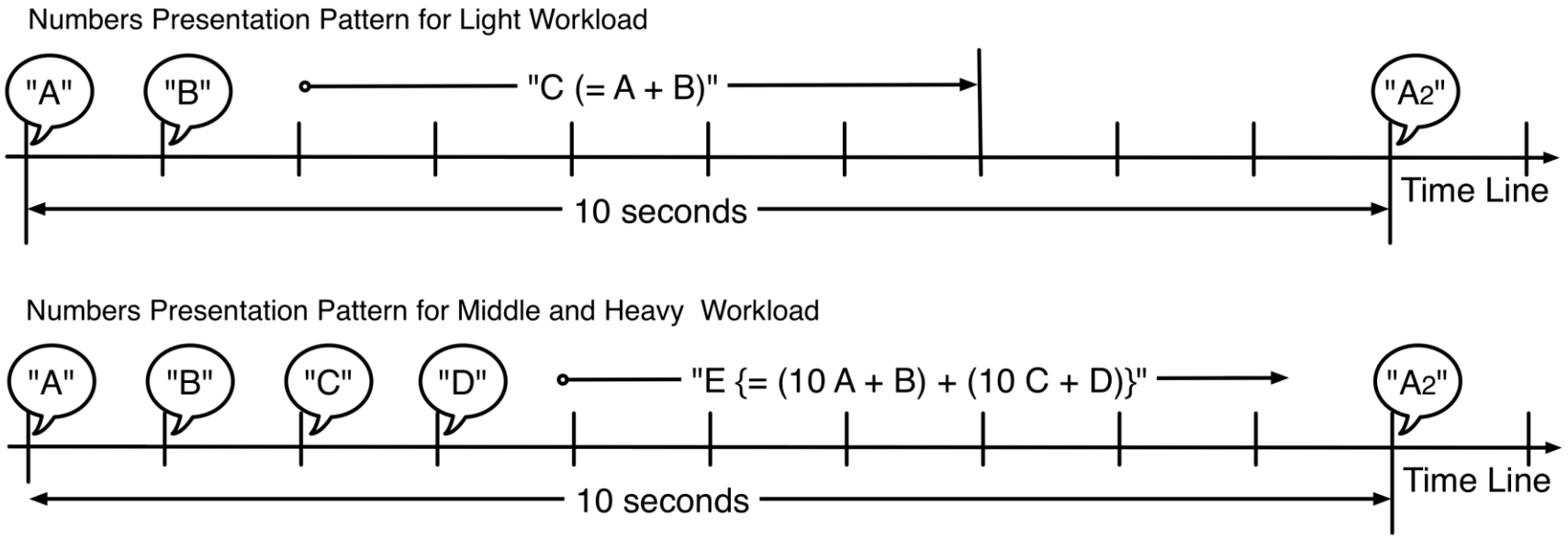




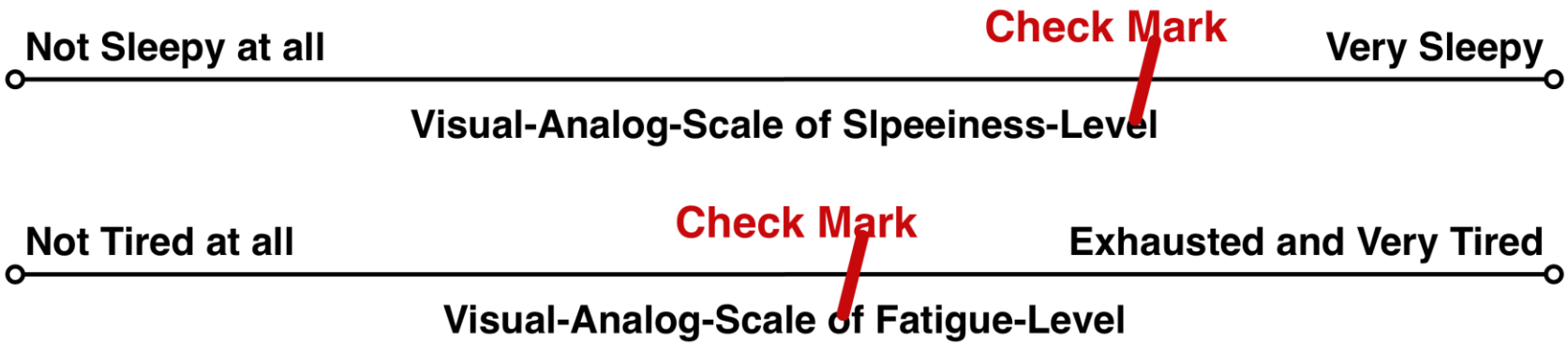
Mental workload was provided by simple mental arithmetic calculations: two one or two-digit numbers were presented aurally, and the subjects were required to speak the sum of the numbers within five seconds, or before the presentation of the next pair of numbers.

Each single exercise required the subject to perform 60 calculations in 10 minutes.





Before and after each exercise,
a subject's CFF value was measured, and
he read aloud from a text to obtain a "Reading-CEM" value.



The subject also made “check mark” indications to record his subjective sleepiness level on a VAS-SL scale, and his subjective fatigue level was on a VAS-FL scale according to how sleepy and tired he felt as shown in this Figure.

index \ Workload	Light		Medium		Heavy	
	Avrage	StdDev.	Avrage	StdDev.	Avrage	StdDev.
Ratio of Wrong Answers (%)	0.7	1.0	3.3	2.1	9.3	4.3
Calling CEM	271.7	32.4	317.9	34.3	329.3	28.1
Heart Pulse Rate (pulses/min)	65.7	9.6	68.7	9.0	77.3	13.0

index	Workload	Light		Medium		Heavy	
		Avrage	StdDev.	Avrage	StdDev.	Avrage	StdDev.
CFF (Hz)	before	35.5	1.9	35.3	2.6	35.1	3.4
	after	34.1	1.4	34.3	3.1	34.9	3.1
Reading CEM	before	414.0	19.9	405.0	16.4	409.0	22.7
	after	410.0	11.1	402.0	17.4	409.0	20.8
VAS of Fatigue Level	before	32.0	19.2	24.0	15.2	20.0	18.7
	after	34.0	13.4	32.0	21.7	38.0	21.7
VAS of Sleepiness Level	before	34.5	22.0	25.5	10.3	25.7	21.1
	after	55.1	14.3	23.1	16.9	21.4	20.0

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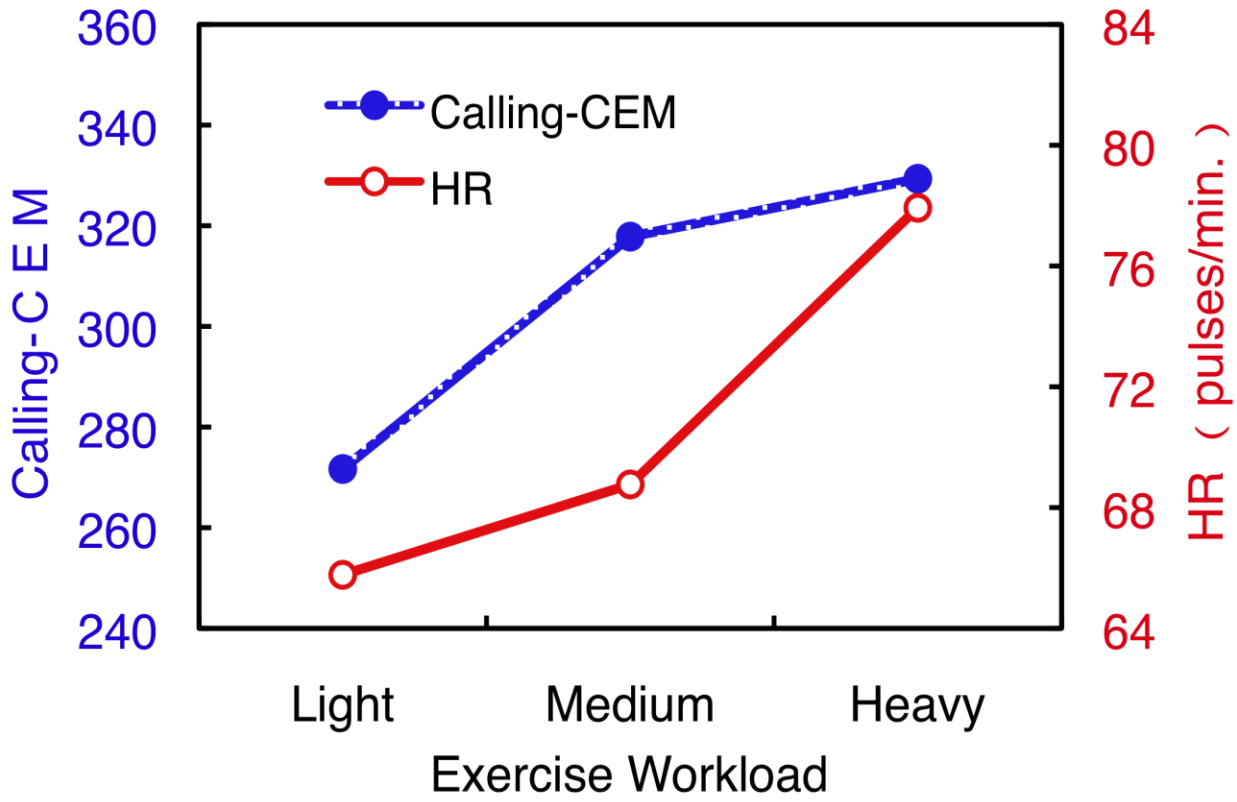

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The Figure shows the relationship between the Call-ing-CEM value and workload level of exercise (Relationship-A), and the relationship between HR and workload level of exercise (Relationship-B). The trend shown in Relationship-A is different from that of the Relationship-B.

The Calling-CEM seems to show the state of the function of the neo cortex while the HR shows the state of the function of the autonomic nervous system.

Thank you for your attention!