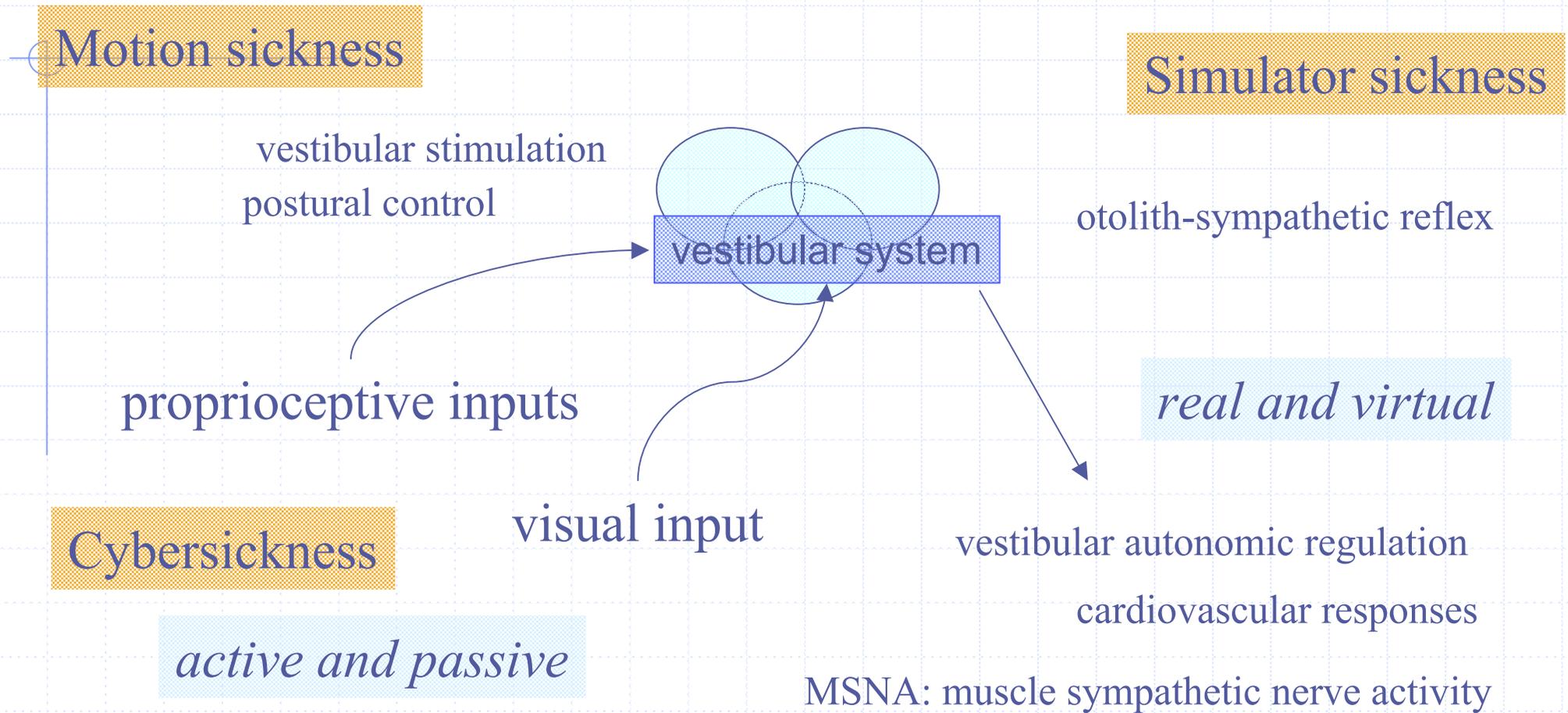


Motion Vectors of Images and Cybersickness

Tohru Kiryu
Graduate School of Science and Technology,
Center for Transdisciplinary Research
Niigata University

Physiological Background



Approaches

- 1 . **Database of Biosignals under Vection-Induced Images**
- 2 . **Featuring the Components of Image by Motion Vectors**
- 3 . **Analysis by Synthesized Images (random dot pattern)**
- 4 . **Estimation of System Function by Multivariate ARX Model**

Rating of Image

Strength of Sickness under Vection-Induced Images

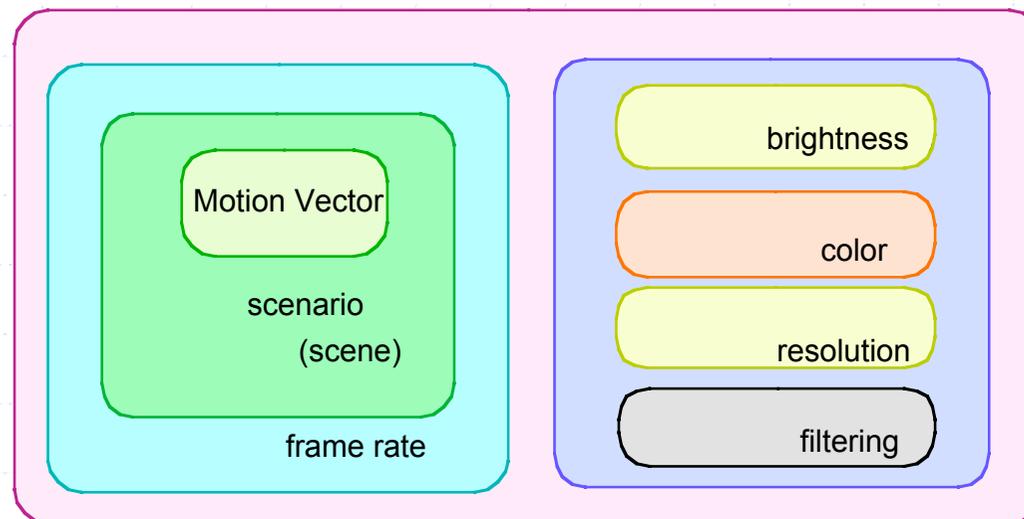
$$\begin{aligned}
 &= (\textit{prediction-required level for images}) \\
 &\quad \times (\textit{experience for image contents}) \\
 &\quad \quad \times (\textit{brightness, frame size, and frame rate etc.})
 \end{aligned}$$

← targets for evaluation

Hierarchy of Image Components

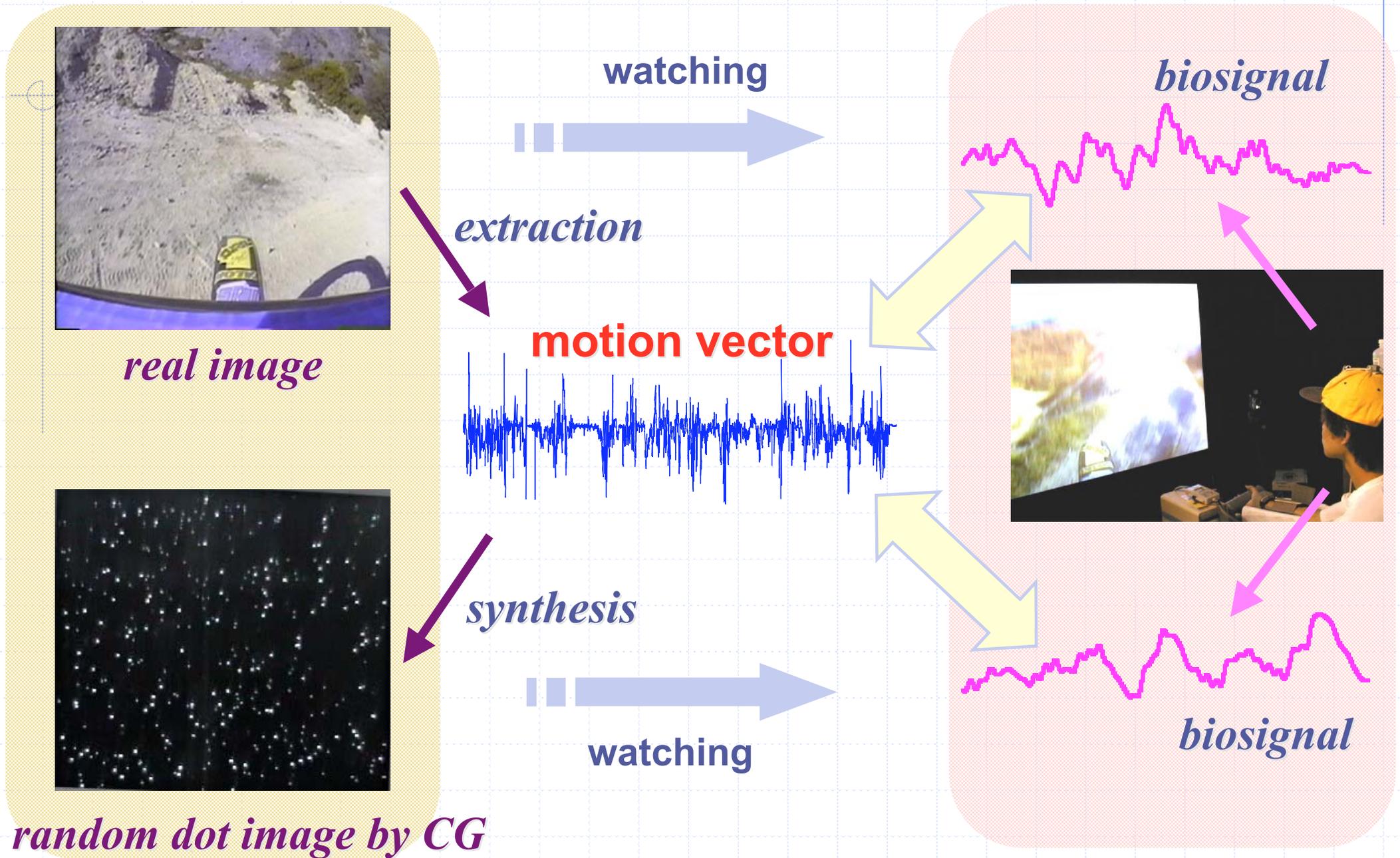
visual characteristics

prediction



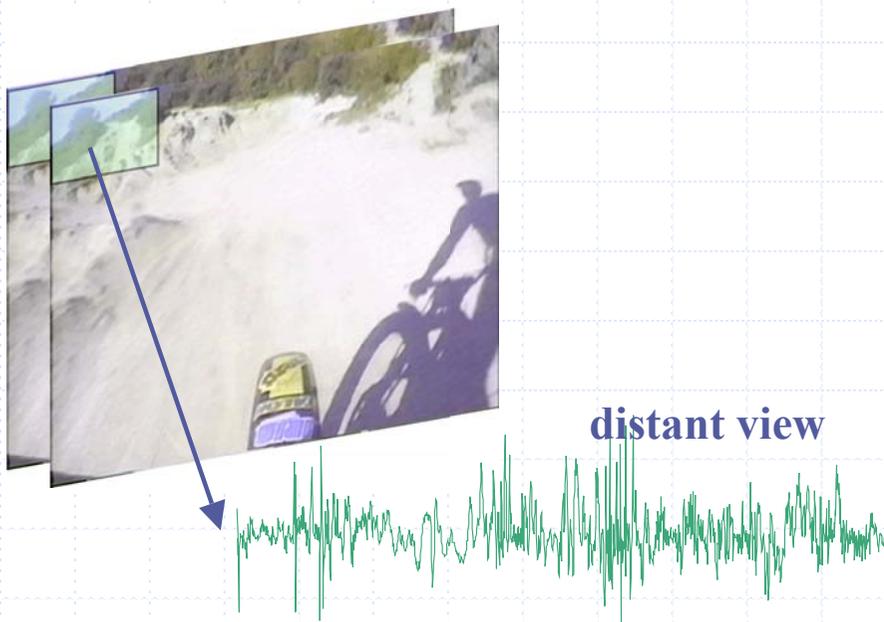
Specification of Display

Overview

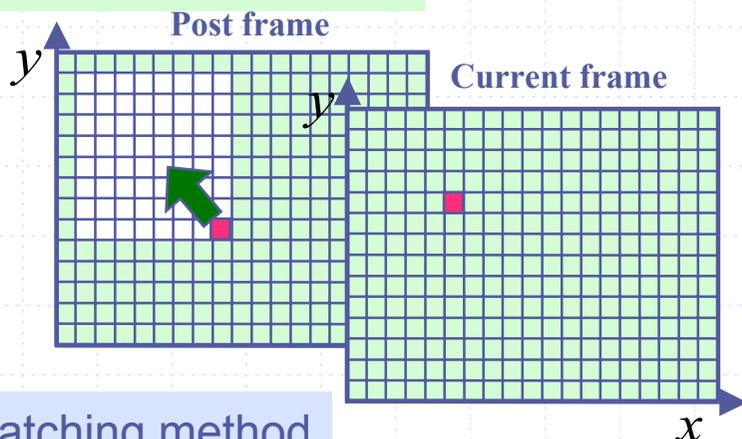


Quantization of Image by Motion Vector

Local Motion Vector

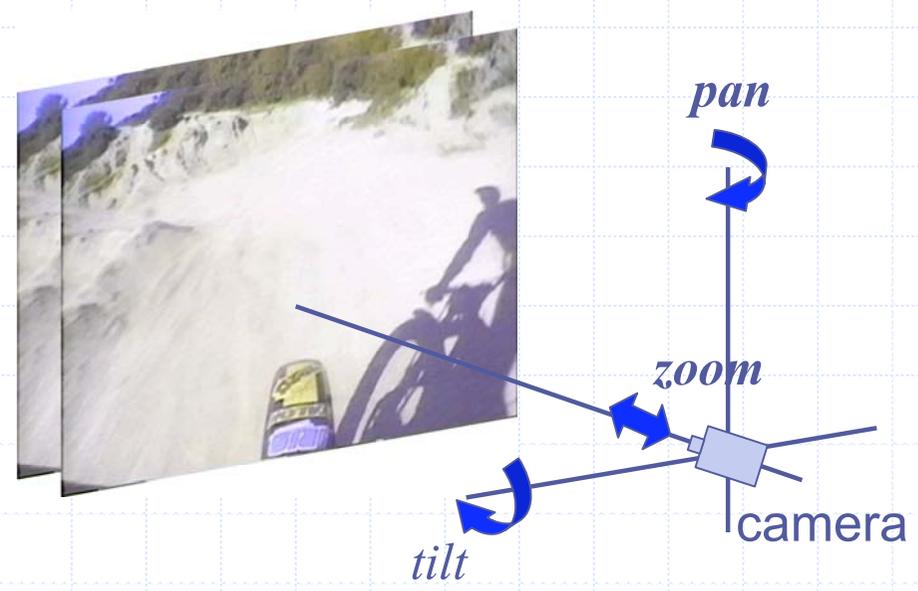


local motion in a screen

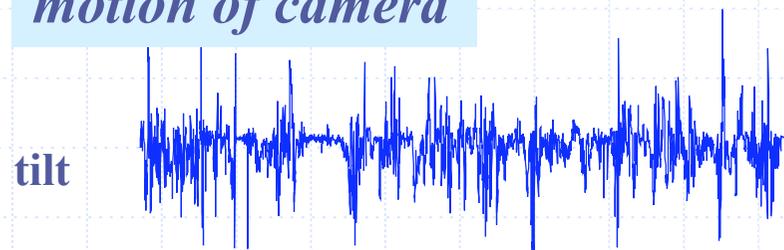


Block matching method

Global Motion Vector



motion of camera



Bottom up approach

Experiments under Real Images

real images

Parachute

Bobsleigh

boat

Go cart

Hang glider

Mountain-bike

Car race

Bungee jump

diving

Bike race

**Vehicle
experiencing video**



subjects

ten healthy young subjects (eight males and two female from 21 to 24 yrs. old)

Measured Biosignals

ECG: chest

Respiration: tube sensors around the chest and the abdomen

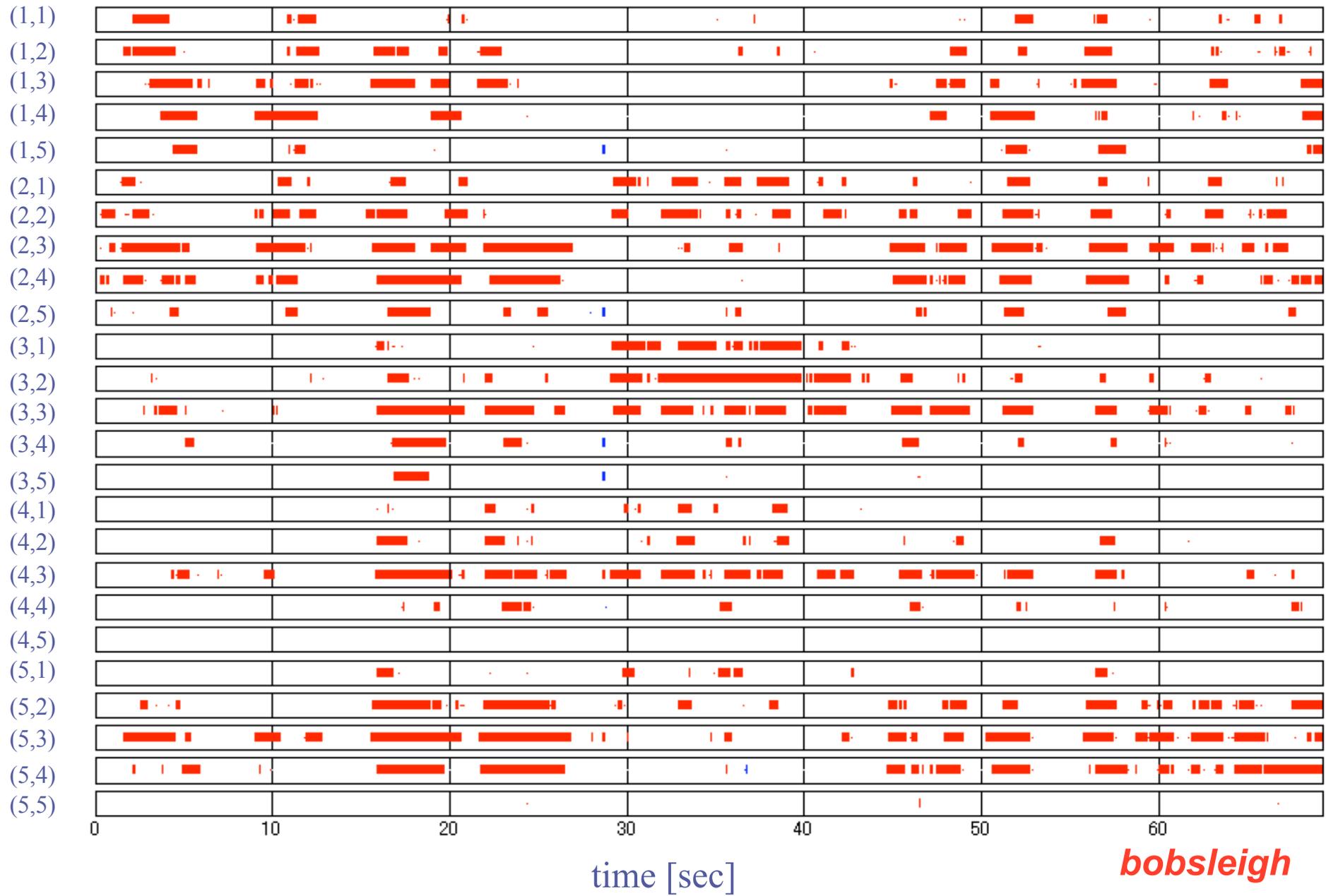
Blood Pressure: tonometry method

Blood flow: Laser Doppler at thumb sphere of left hand

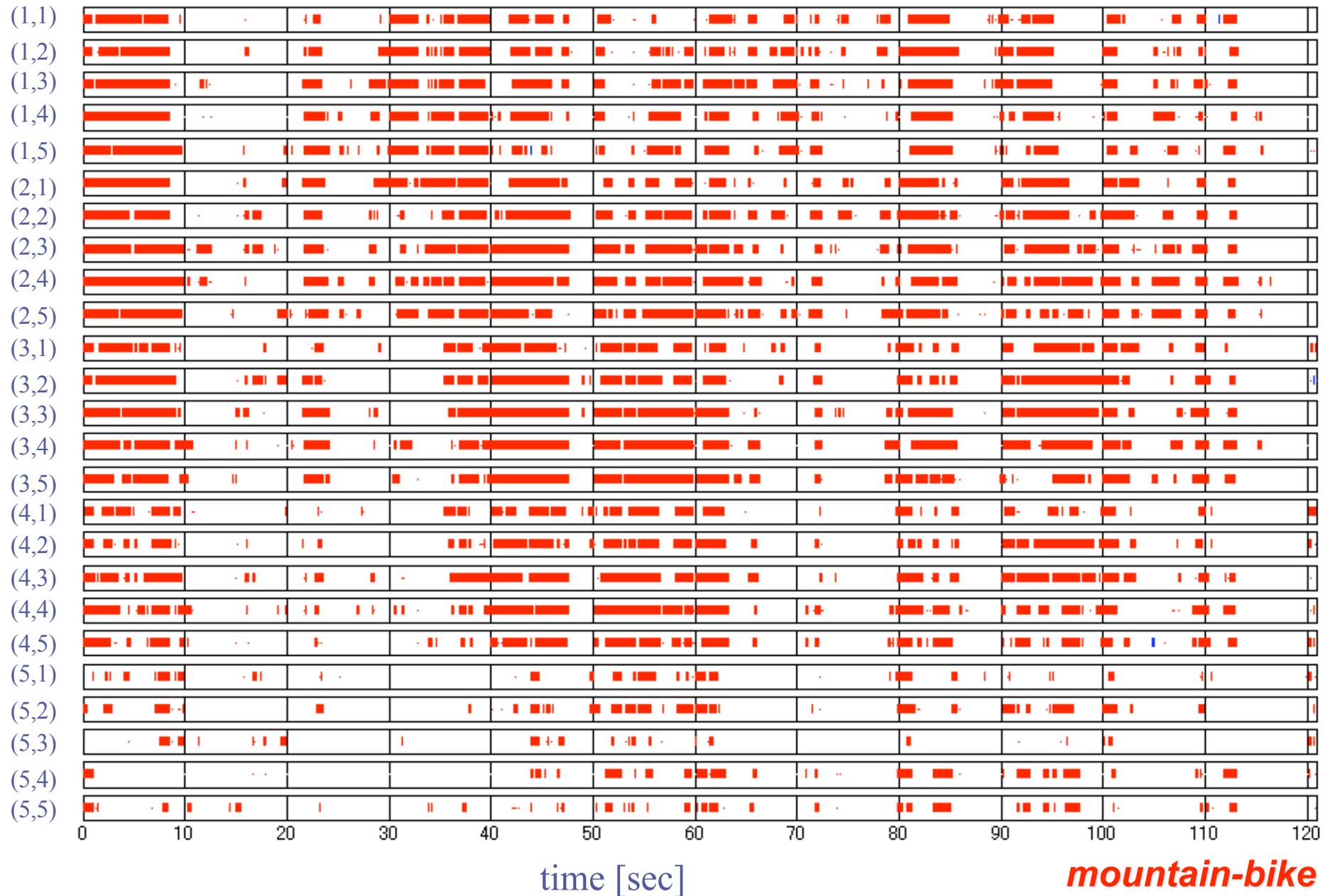
Perspiration: Capsule type sensor at thumb sphere of left hand

at Niigata University (December, 2002)

Correlation between Pan and Right/Left



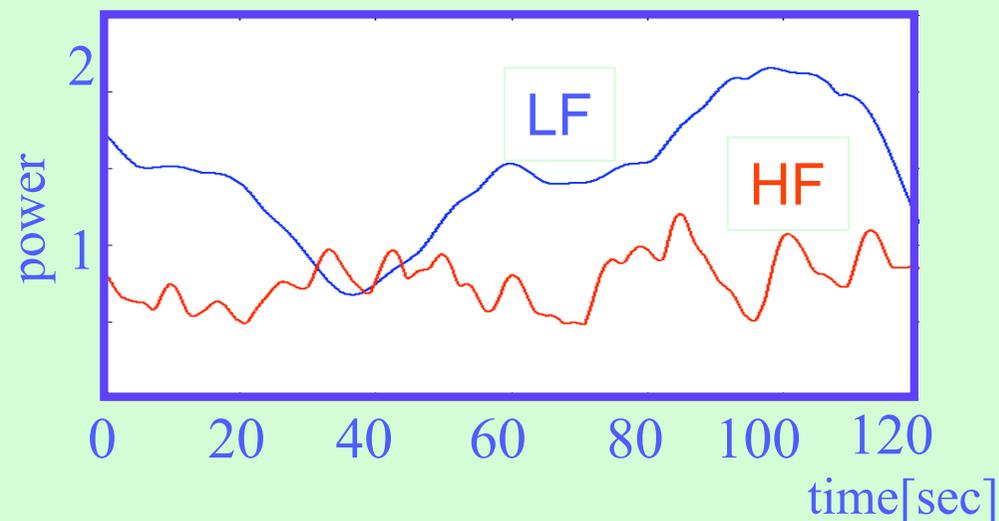
Correlation between Pan and Right/Left



Info. on Autonomic Nervous Activity

R-R interval

time-frequency
representation



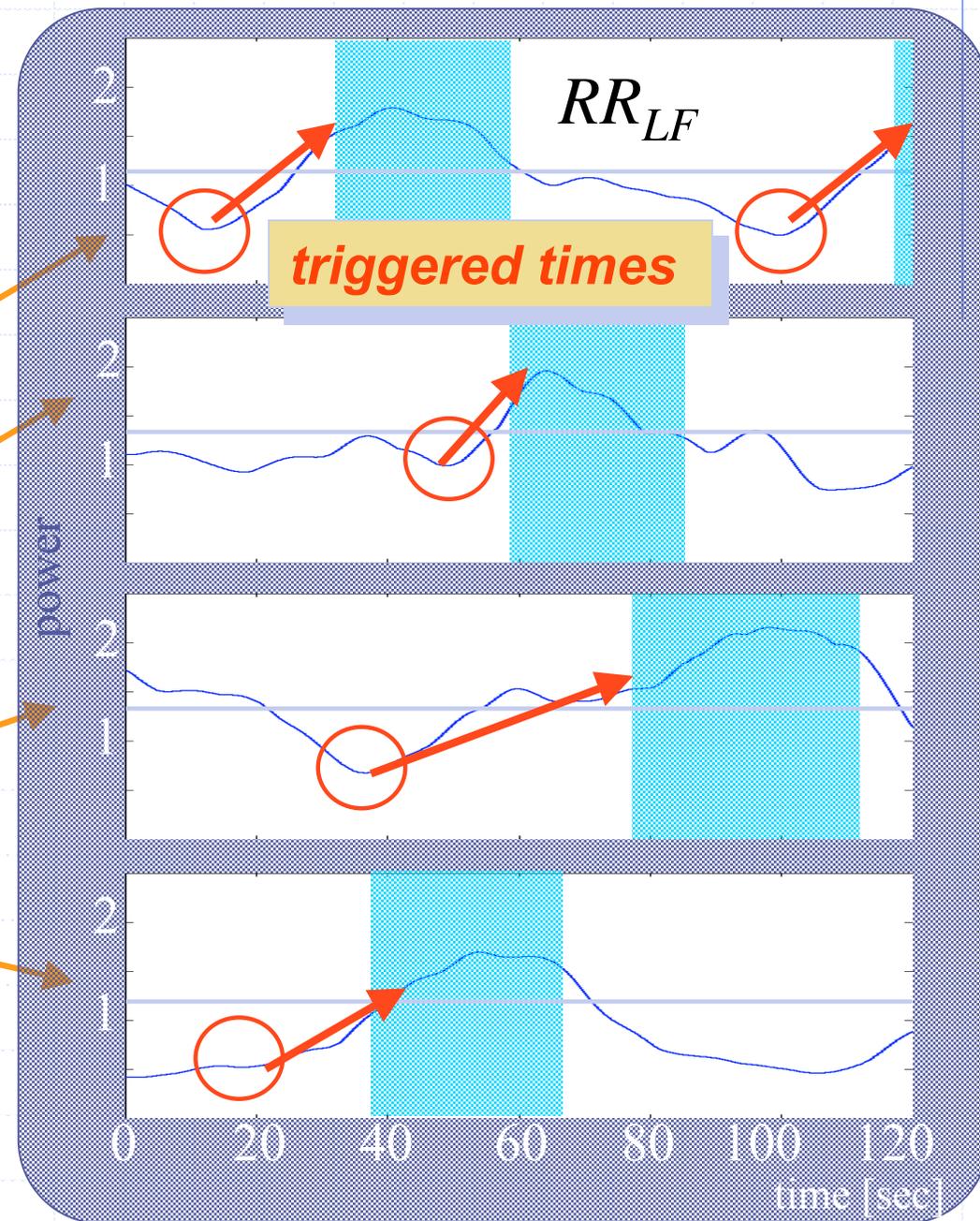
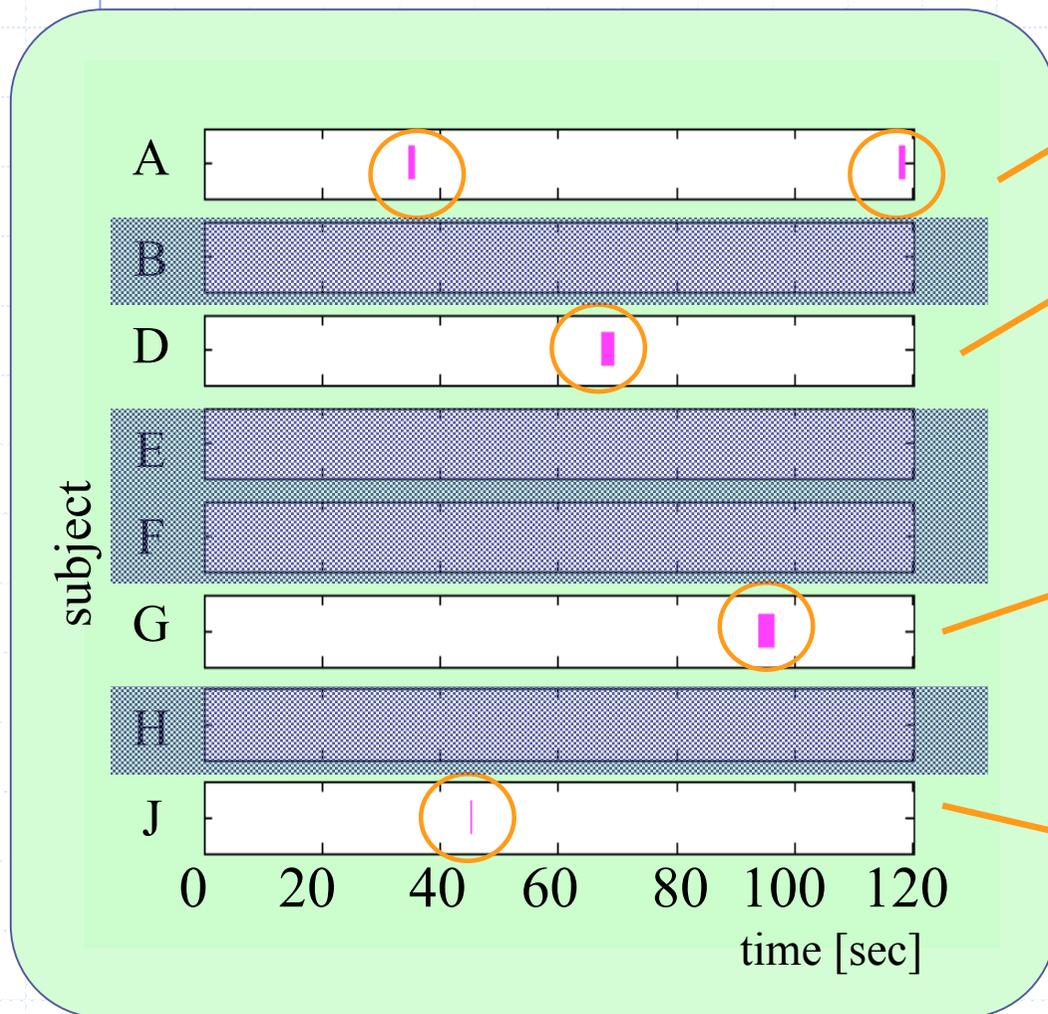
- LF component (0.04-0.15[Hz]): Mayer Wave related band
- HF component (0.15-0.45[Hz]): Respiratory Sinus Arrhythmia related band

1. Estimating the averages of LF and HF components under a target image for each subject.
2. Determination of the intervals for sickness.

$$(\overline{RR}_{LF120\%} < RR_{LF}) \wedge (\overline{RR}_{HF80\%} > RR_{HF})$$

Specification of Trigger Points

$$(\overline{RR}_{LF120\%} < RR_{LF}) \wedge (\overline{RR}_{HF80\%} > RR_{HF})$$



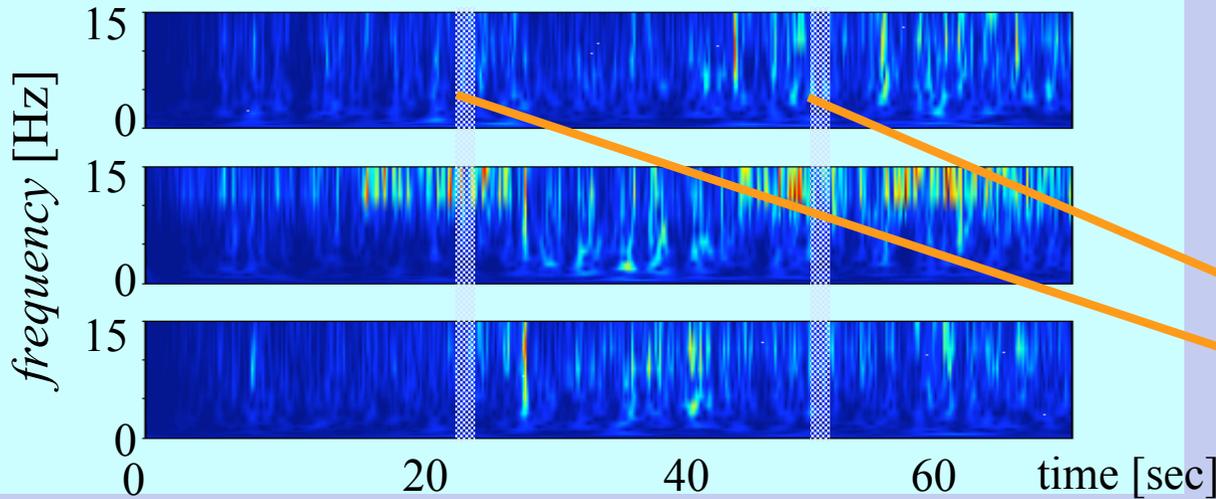
Time-Frequency Representation of GMVs

bobsleigh

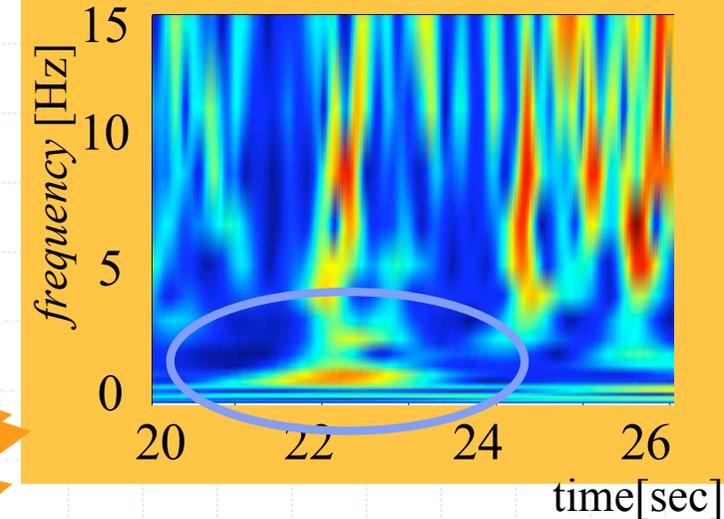
zoom

pan

tilt



zoom

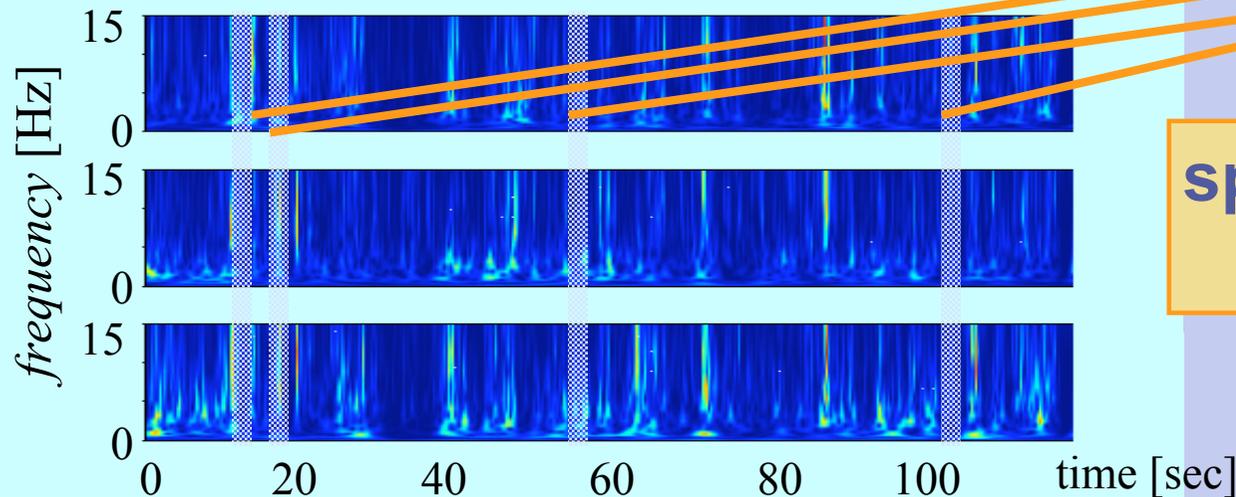


mountain-bike

zoom

pan

tilt



specific frequency band:
0.1-3.0 [Hz]

Cases for Random Dot Patterns

task 1		task 2		task 3		task 4		task 5		task 6		task 7	
S	S	PT	S	ZPT	S	ZT	S	ZPT	S	ZP	S	ZPT	S

S: still, Z: zoom, P: pan, T: tilt

task 3	subject	G	F	C	D	C	I	B	G
	time [sec]	11.7	47.8	66.9	92.7	104.0	106.7	114.3	115.3
task 5	subject	C	B	I	J	H	E	C	
	time [sec]	14.7	54.2	57.8	90.2	103.3	110.4	118.8	
task 7	subject	J	B	G	D	F	C	G	
	time [sec]	7.1	17.5	66.4	78.4	85.1	86.9	106.2	

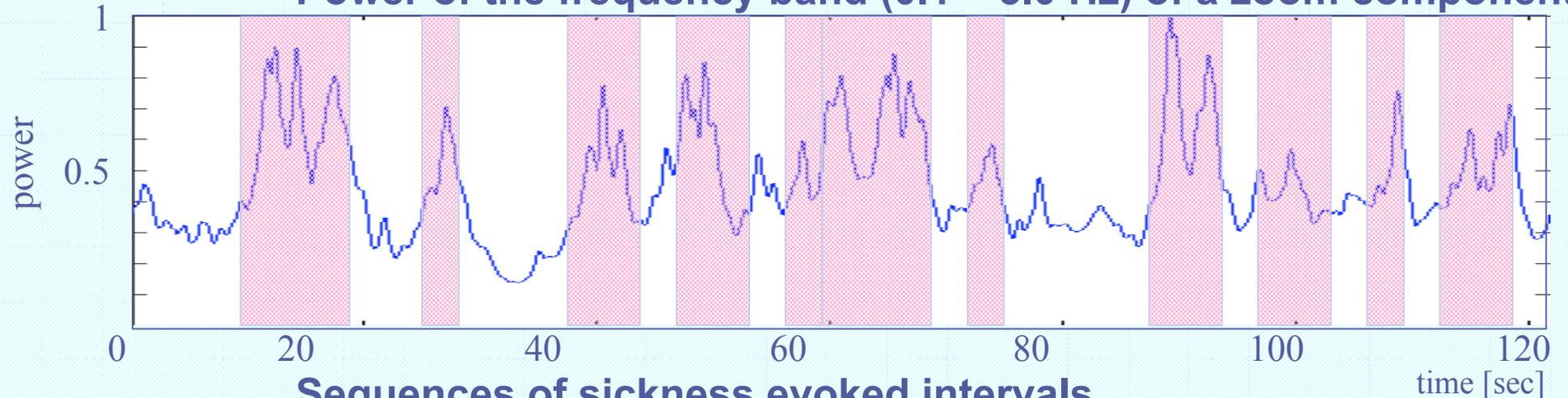
- Sickness was evoked for 22 epochs for 9 subjects.
- 14 of 22 epochs showed the same time-frequency representation of motion vector for real images

Validation of Sickness Evoked Intervals

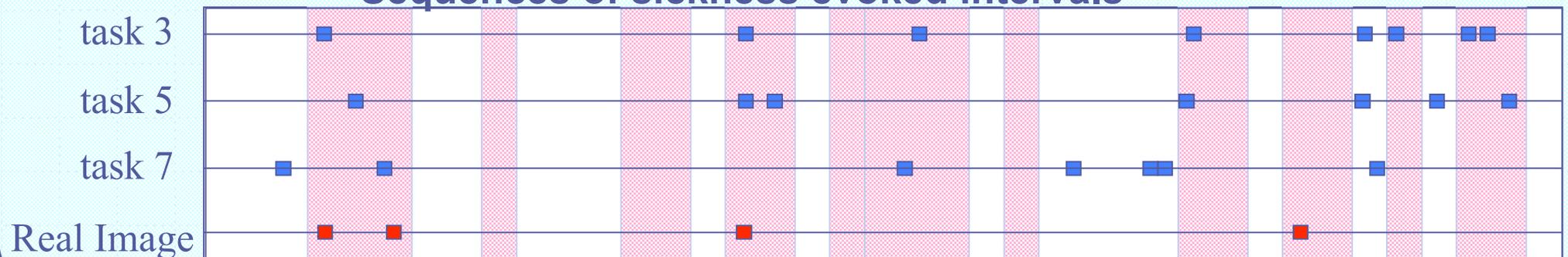


S: still, Z: zoom, P: pan, T: tilt

Power of the frequency band (0.1 – 3.0 Hz) of a zoom component



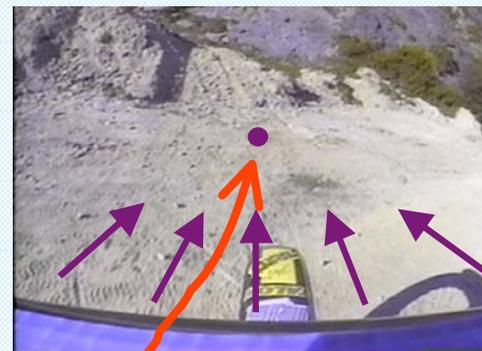
Sequences of sickness evoked intervals



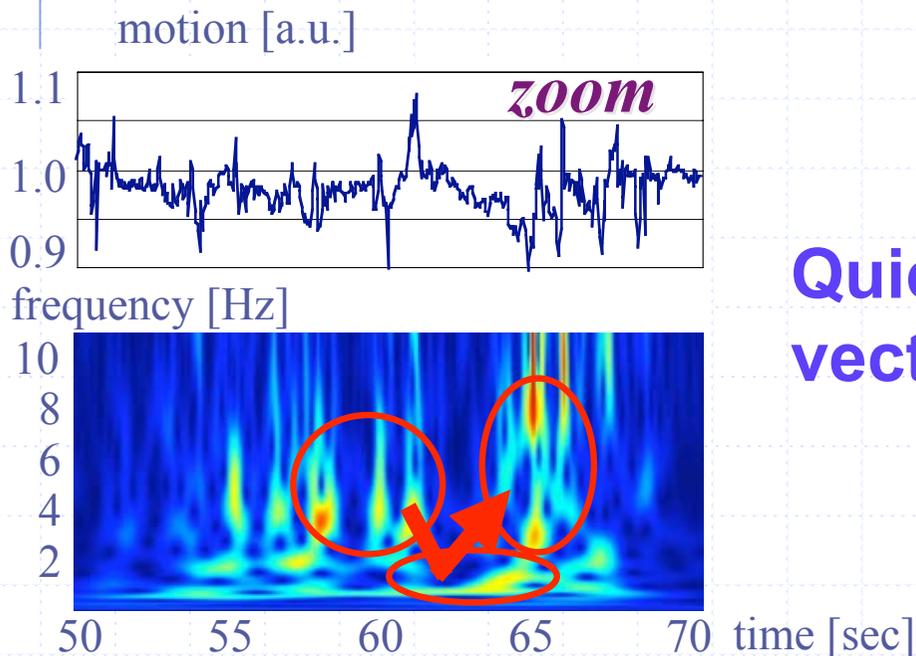
Discussion

– prediction of traveling direction by motion vectors –

zoom component affected on autonomic regulation, referring to the experimental results.

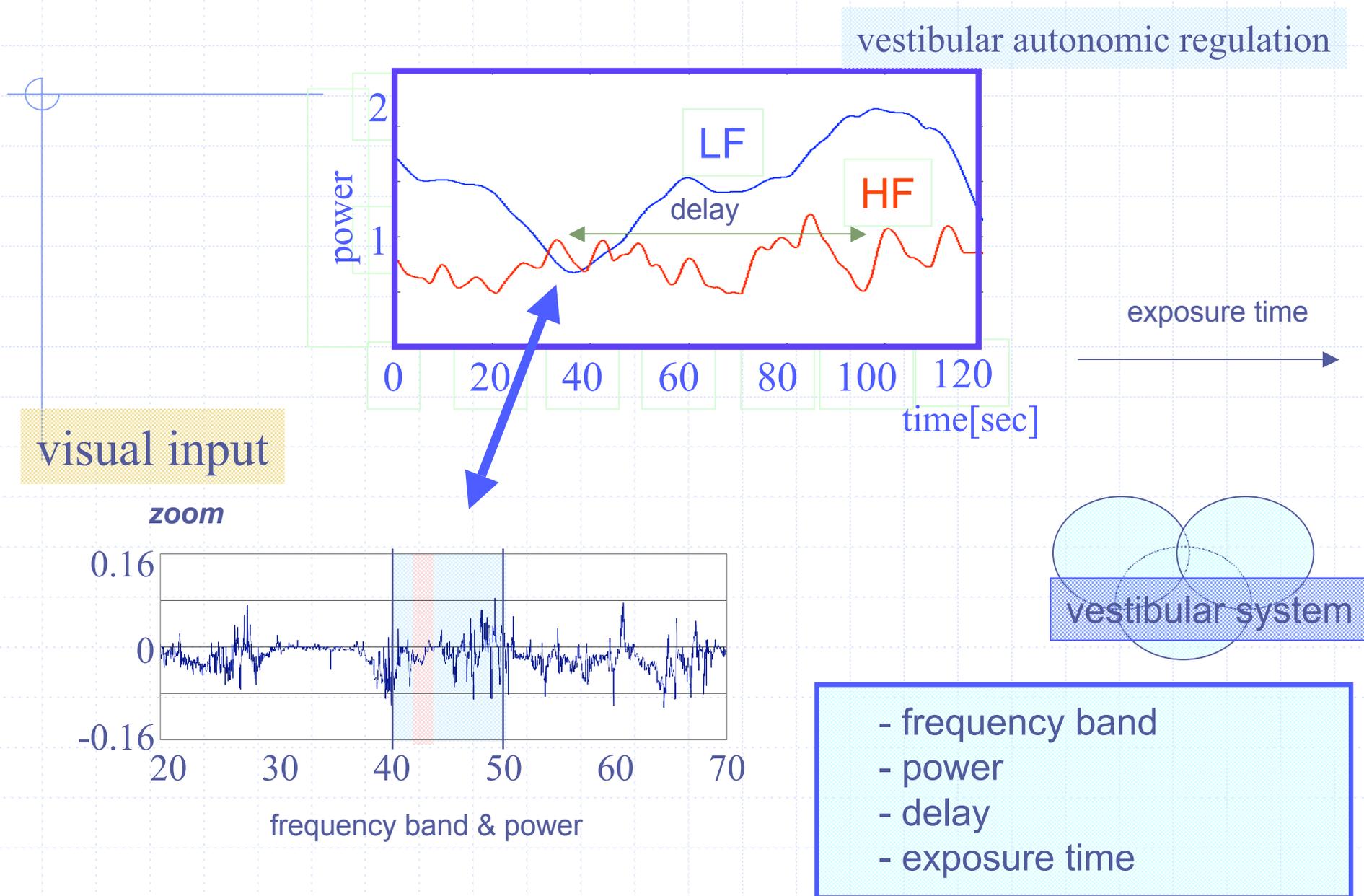


zoom component might be used for prediction of traveling direction



Quick vibration appeared in motion vector could disturb prediction

Process of Cybersickness



Conclusion

-We studied influences of vection-induced images in the relationships between autonomic nervous activity related indices and motion vectors of images.

-Autonomic nervous activity was evaluated from R-R interval, blood pressure, and respiration. The motion vectors including global and local motion vectors were estimated by the data compression technique.

-According to the time-varying behavior of motion vectors, the specific frequency band (0.1 – 3.0 Hz) of a zoom component possibly caused cybersickness.

- However, we have not yet concluded whether the unpleasant feeling was caused by the content of the vection-induced image or the structure of the image scene (the frame rate, the vibration of objects, etc).

- Moreover conditions of subjects should be evaluated at each experiment.