# Stress Assessment of the Transport Handicapped Based on Biological Signals

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Presentation contents

# 1 Why stress assessment ?

Limit of conventional evaluation approaches

➡ **Changes in transport policy goals**

- Affordable, fast, safe, convenient + Comfortable and relax
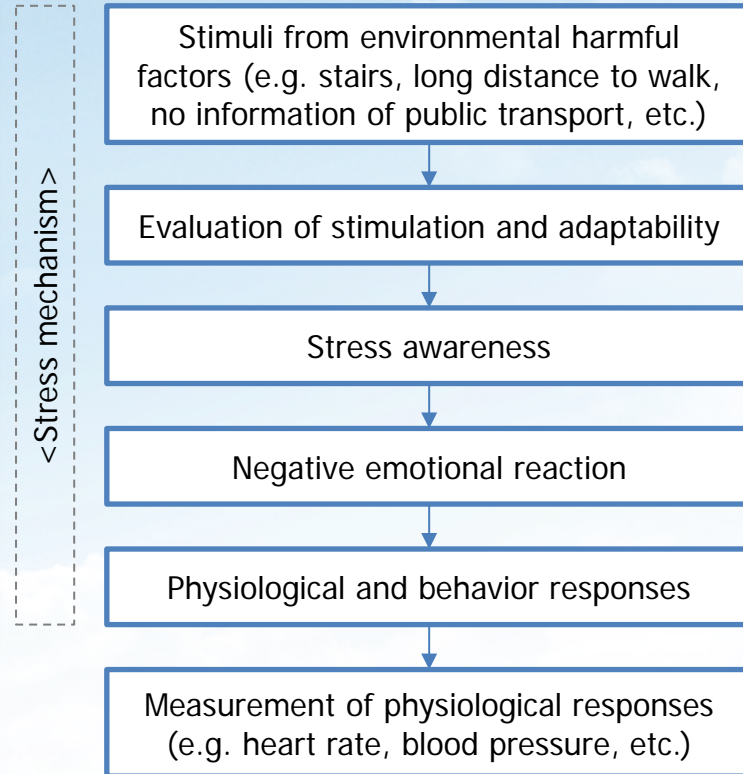- Maximum service supply + Minimum user disutility

➡ **Conventional evaluation methods**

- Environmental evaluation
    - Indicators : environmental situation (i.e. distance by type, time)
    - Objective value and easy to understand qualitative aspects
    - Limit to understand the load experienced by users (i.e. how difficult for the transport handicapped to walk for 10 minutes)
- Psychology and cognitive evaluation
    - Indicators : subjective satisfaction using the Likert Scale
    - East to survey and good for qualitative evaluation
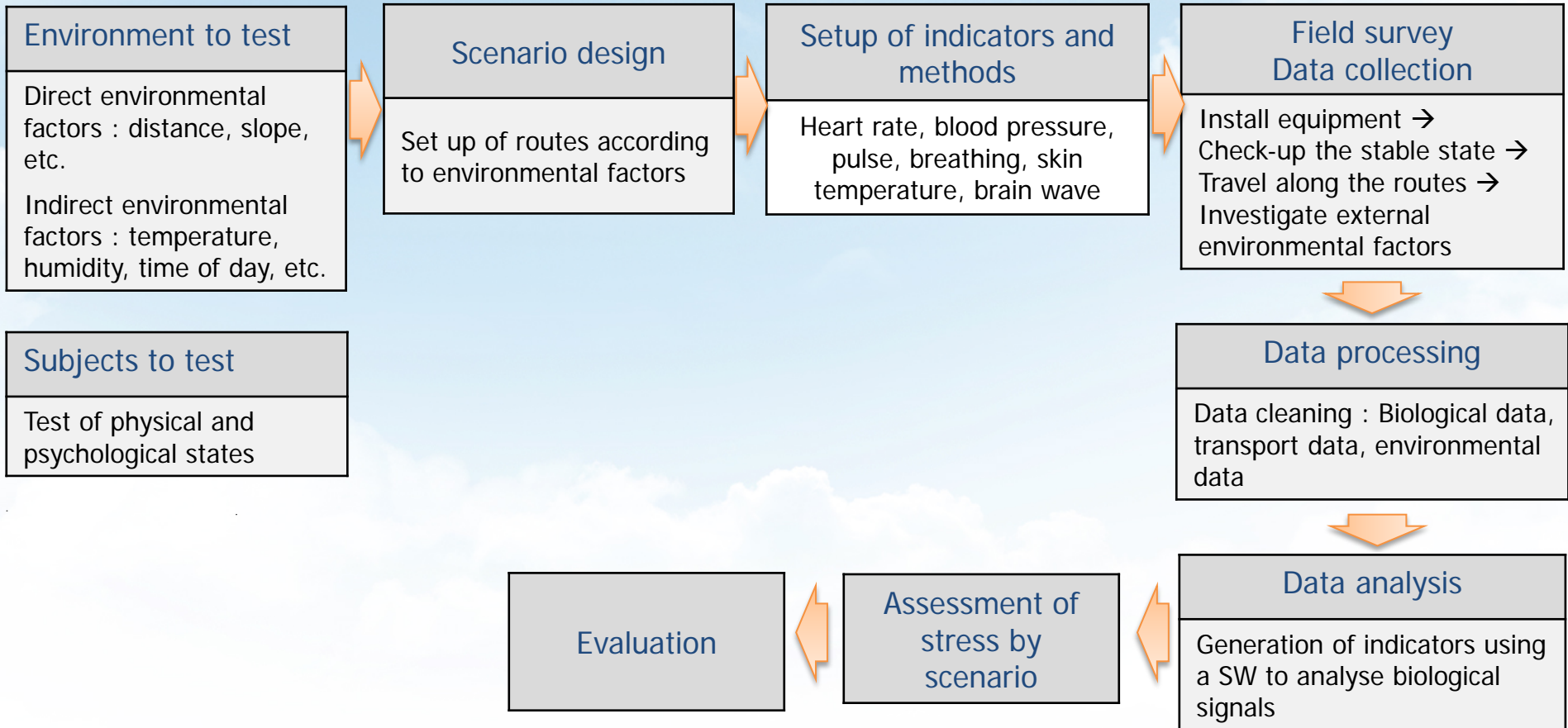    - Limit in quantitative and objective assessment, different results depending on the survey group

➡ ## Improvement of conventional evaluation methods

- Corresponding to the paradigm change of policy and evaluation

- Enabling to understand the level of load experienced using a quantitative and objective indicators

- Enabling to understanding the relationship of cause and effect of stress

- Useful for ex-post evaluation

- Including more personalised characteristics

<Stress mechanism>

Stimuli from environmental harmful factors (e.g. stairs, long distance to walk, no information of public transport, etc.)

↓

Evaluation of stimulation and adaptability

↓

Stress awareness

↓

Negative emotional reaction

↓

Physiological and behavior responses

↓

Measurement of physiological responses (e.g. heart rate, blood pressure, etc.)

# 2 Method of stress assessment

## Environment to test

Direct environmental factors : distance, slope, etc.

Indirect environmental factors : temperature, humidity, time of day, etc.

## Scenario design

Set up of routes according to environmental factors

## Setup of indicators and methods

Heart rate, blood pressure, pulse, breathing, skin temperature, brain wave

## Field survey Data collection

Install equipment → Check-up the stable state → Travel along the routes → Investigate external environmental factors

## Subjects to test

Test of physical and psychological states

## Data processing

Data cleaning : Biological data, transport data, environmental data

## Evaluation

## Assessment of stress by scenario

## Data analysis

Generation of indicators using a SW to analyse biological signals

# 2.2 Equipment to measure biological signals

## ➡ Electrocardiogram(ECG)

• Autonomic nervous system activity → Electrical activity of hearts



<Position of ECG electrode>
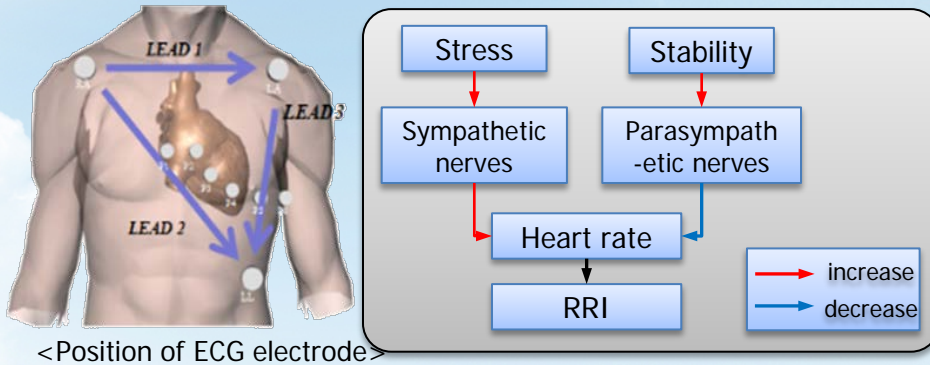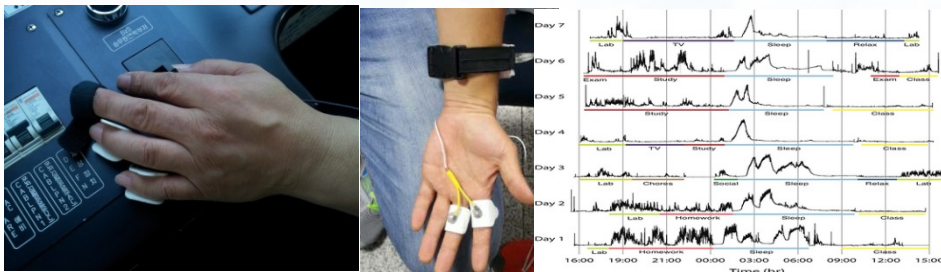
## ➡ 3-axis acceleration sensor

• Measurement of vertical and horizontal movement → Understanding of walking patterns
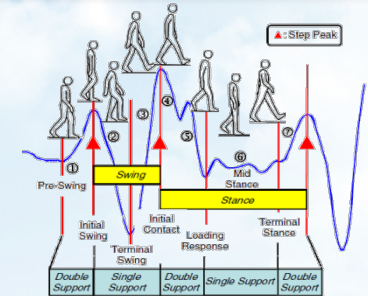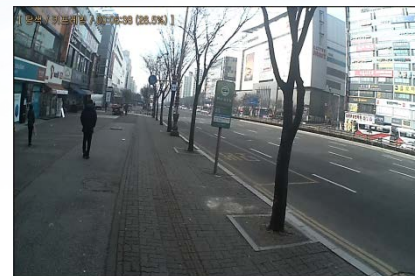


<Walking pattern from the vector sum of the movement

## ➡ Electrodermal activity(EDA)

• Increase in secretion of sweat → Increase in EDA peak in times and magnitude



## ➡ Goggle-type CCD camera

• Look-ahead situation, visual direction, duration, etc. → Survey environment(stress factors) and changes

# 2.3 | ECG signal analysis

## ➡ Analysis of Heart Rate Variability

• Configuration in RR intervals(RRI) which indicate time difference between heart rates
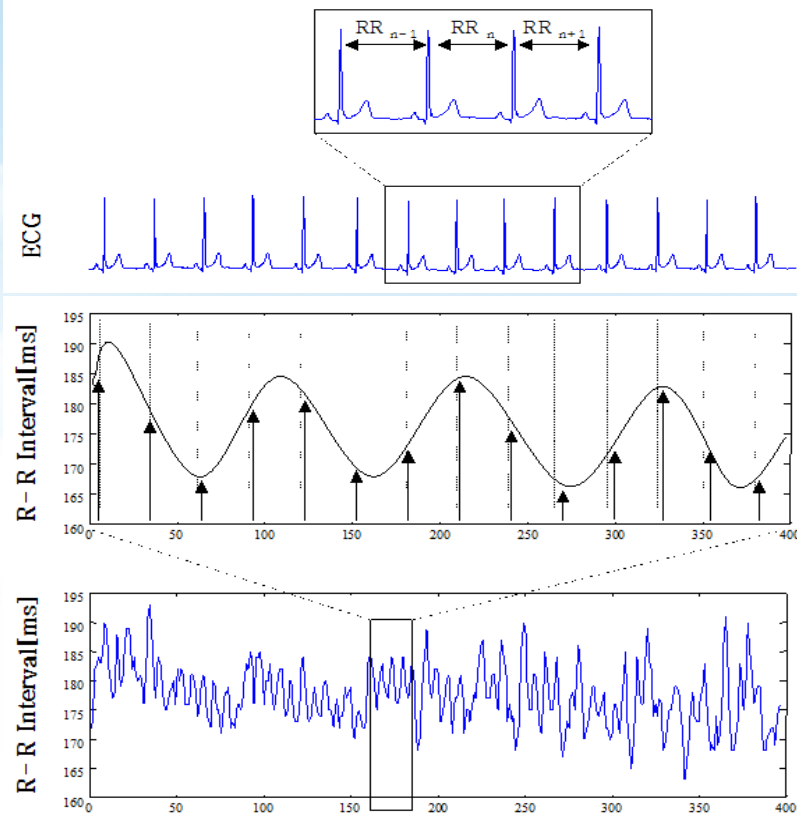


## ➡ Indicators using RRI

| Indicators | | Meaning |
|---|---|---|
| Time Domain | mean RRI (msec) | • Hear rate interval<br>• Average strength of the load caused by stress factors<br>• Lower mean RRI at the nervous state |
| | mean BPM (number) | • Heart rate per minute<br>• Higher BPM at the nervous state |
| | stdev RRI (msec) | • Degree to which RRI dispersed in average<br>• Too low stdev RRI is used as indicator for high mortality rate |
| | RMSSD | • Changes in the adjacent heart rate |
| Frequency domain | Low frequency (LF) / High frequency (HF) | • The frequency analysis enables one to understand the equilibrium state of sympathetic and parasympathetic nerves<br>• LF(0.04~0.15 Hz) related to sympathetic nerves → high at nervous or agitated states<br>• HF(0.15~0.4Hz) related to parasympathetic nerves → low at furious states<br>• High LF/HF ratio indicates stress caused by psychological factors |
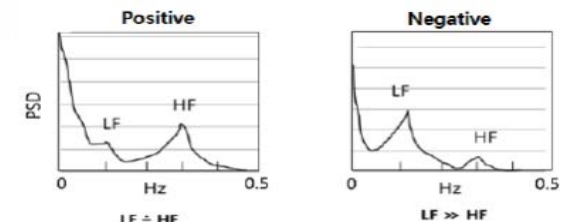
# 3 Case studies

Stress measurement of the disabled in airport terminals

➡ **Purpose**

> To understand the factors that affect mobile load of airport terminal users with disability
> → Improvement of airport terminal facilities applying the concept of universal design
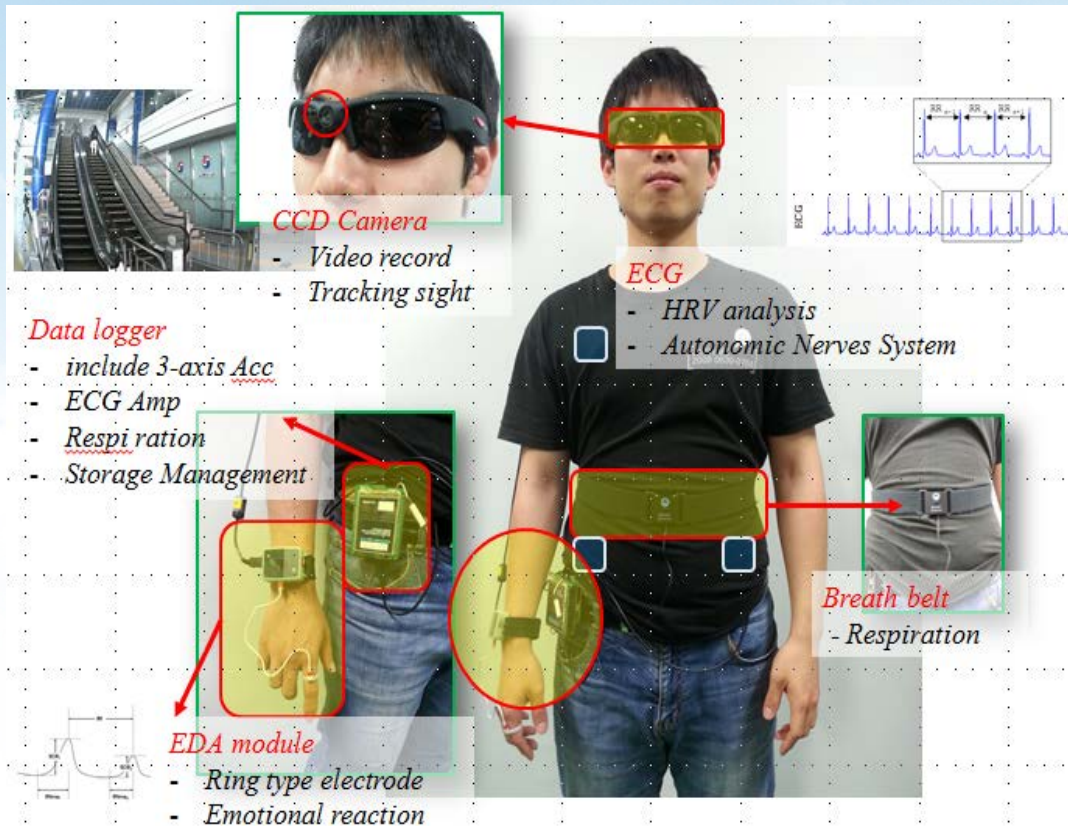
➡ **Subject : Wheelchair users, the visual impaired and general users**

➡ **Scenarios**

| # | Characteristics | Travel environment | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| S1 | General user | Waiting at entrance | Stairs | Ticketing | Shopping | Security | Toilet | Waiting for boarding |
| S2 | General user | | Elevator | | | | | |
| S3 | General user | | Escalator | | | | | |
| S4 | Wheelchair user with help | | Elevator | | | | | |
| S5 | The visual impaired without help | | Escalator | | | | | |
| S6 | The visual impaired with help | | Elevator | | | | | |

➡ Evaluation indicators : movement, energy consumption(kcal), heart rate(Mean RRI and LH/HF)
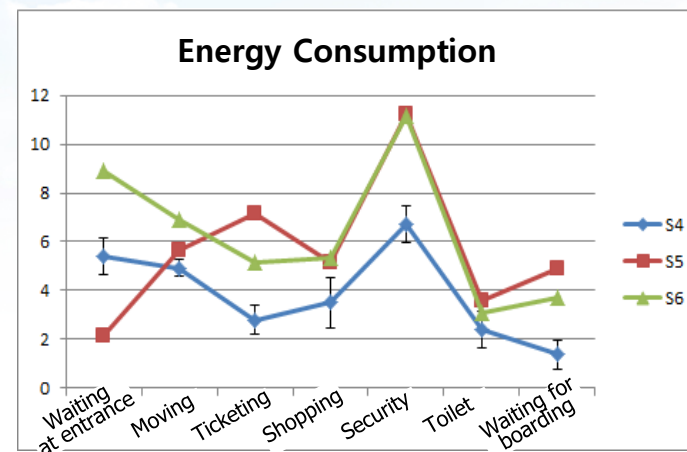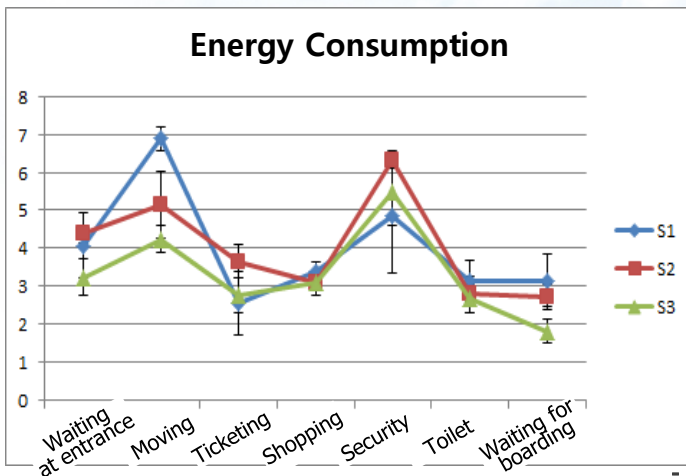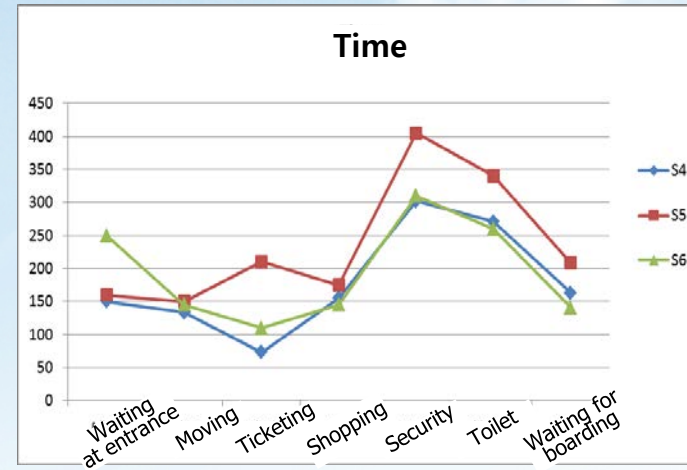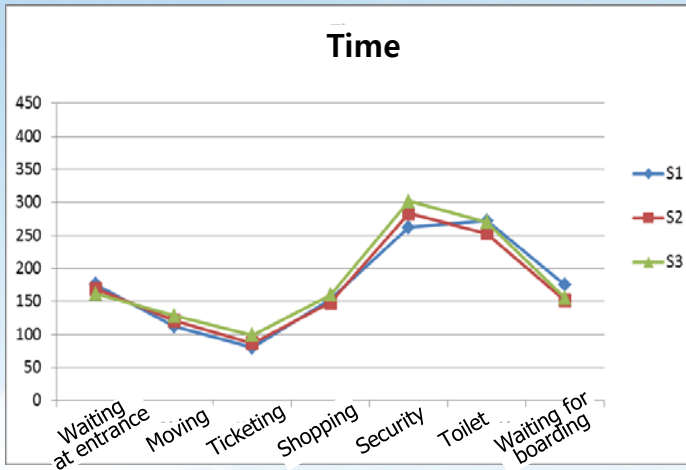
➡ Movement data and biological data collection



<Wheelchair user>



<Measurement equipment>



<The visual impaired>

## Results

① Time and energy consumption

② Stress indicators : mean RRI, LF/HF ratio
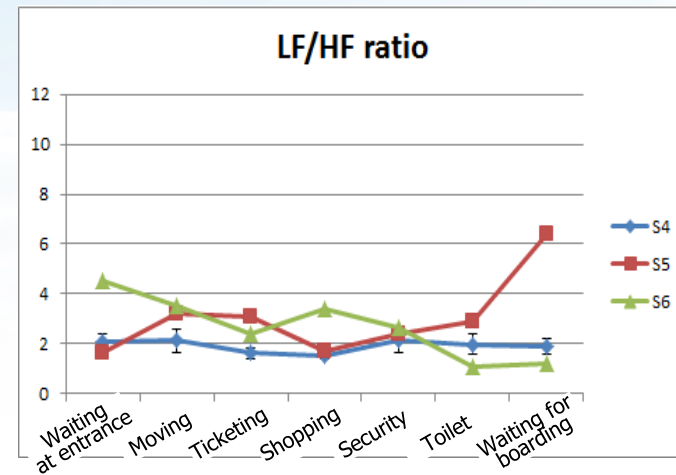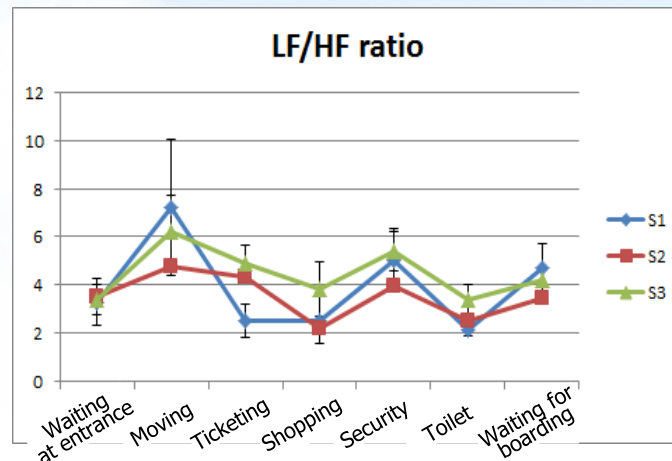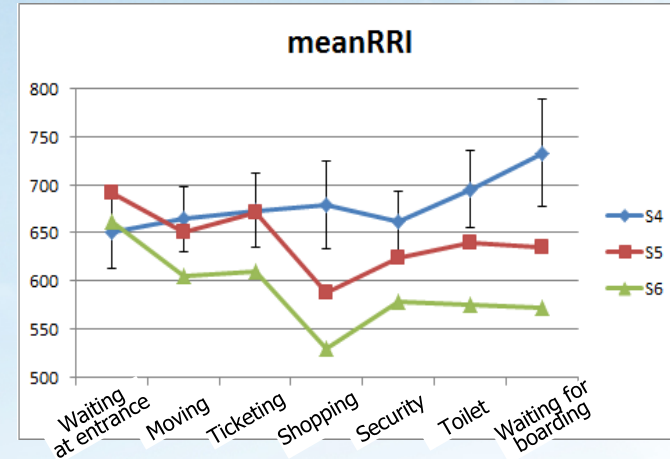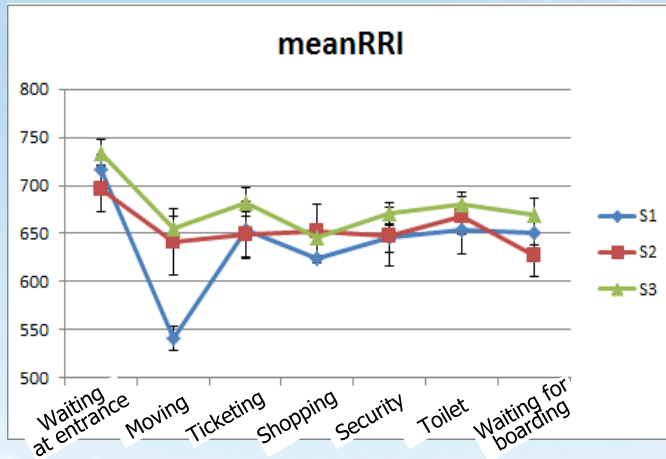
# 3.2 | Stress measurement of the elderly in public transport use

### ➡ Purpose

- Pilot study to confirm where stress in travelling can be measured using biological signals
- To check difference of the level of stress that the elderly experience in  public transport use
- To formulate a guideline of public transport facilities to improve accessibility of the elderly

### ➡ Survey environment

- Time of day : 10 am ~ 4 pm (non-peak time)
- Subjects
  - 1st survey : elderly 3 people(male), non-elderly 3 people
  - 2nd survey(3/1) : elderly 3 people(female), non-elderly 3 people

### ➡ Scenarios

| Section | Mode | Expected Time | Routes |
|---|---|---|---|
| A place near Youngtong station | | |  |
| Youngtong station → Jungja station | Subway(Bundang line) | 30 min. | |
| Jungja station | Walk (transfer) | - | |
| Jungja station → Gangnam station | Subway(New Bundang line) | 20 min. | |
| Gangnam station | Walk (transfer) | - | |
| Highway from Gangnam to Youngtong | Bus (no. 5100) | 45 min. | |

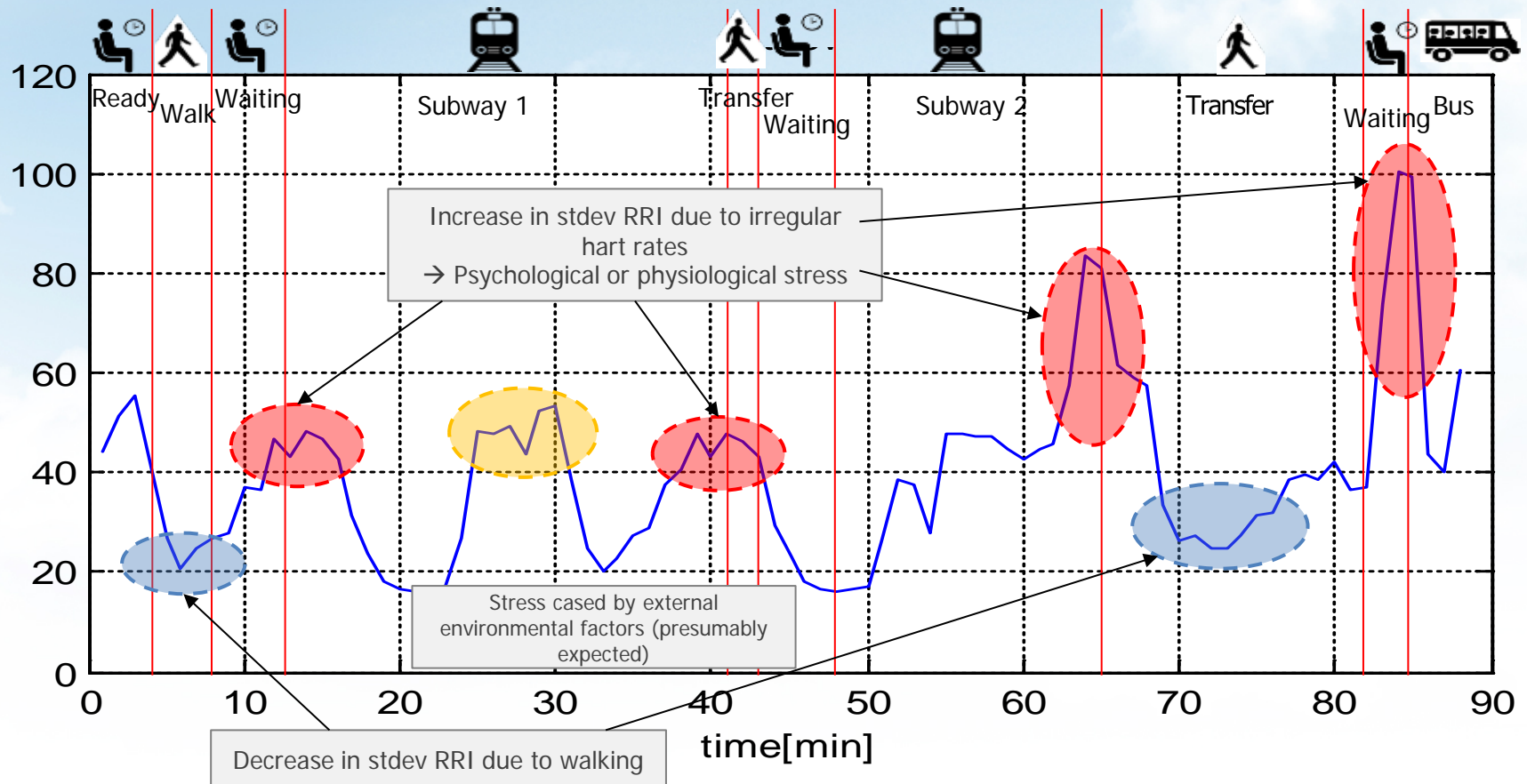# 3.2 Stress measurement of the elderly in public transport use

➡ BPM
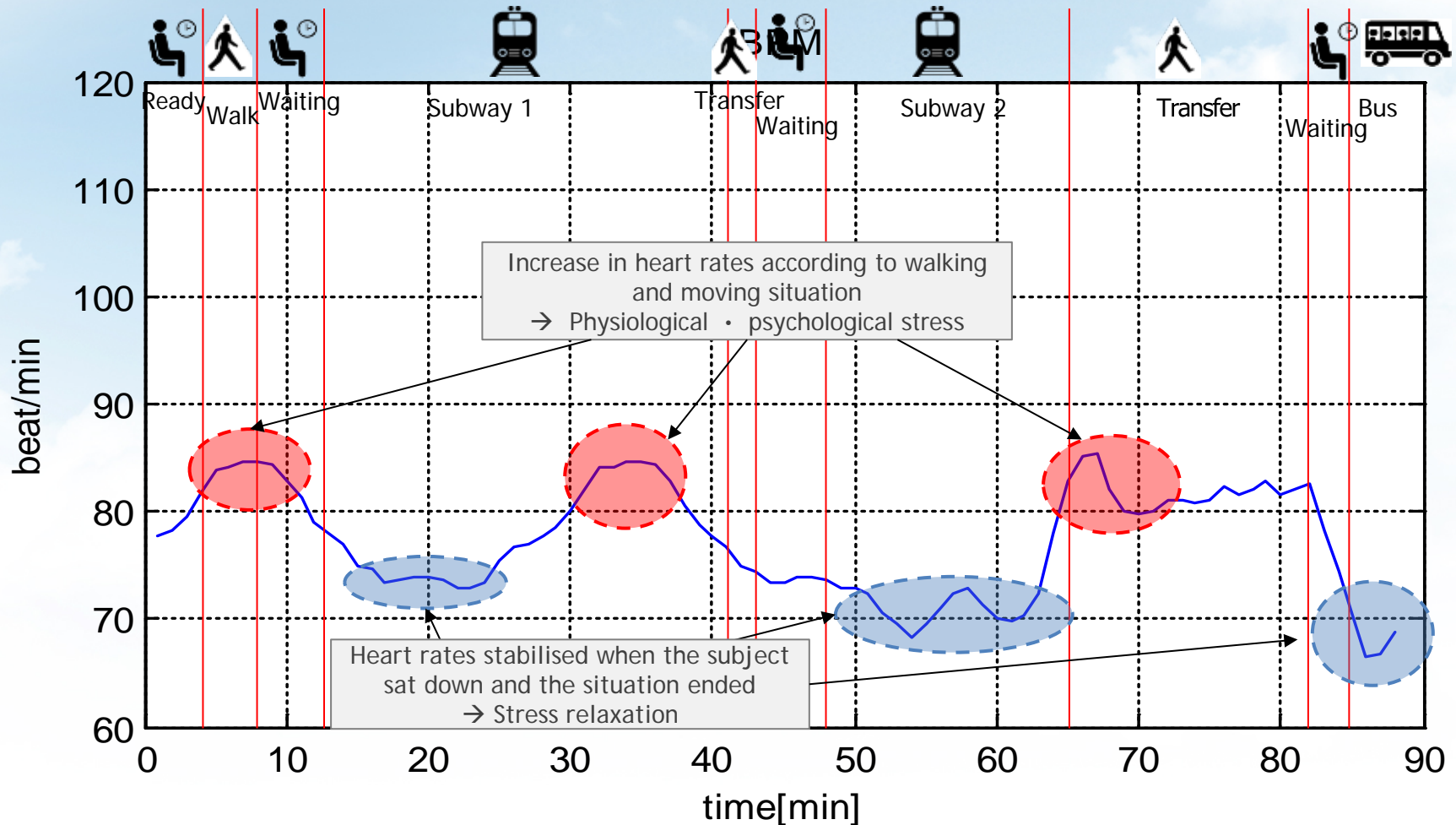
# 3.2 Stress measurement of the elderly in public transport use

➡ Mean RRI
- Close to zero when one has heart disease
- Increase at a stressful state when one does low-intensity activities
- Decrease as RRI become constant when one does high-intensity activities

➡ LF/HF ratio

- When one get stressed, sympathetic nerves are activated and the hear rate increase

- Once sympathetic nerves are activated, parasympathetic nerves decrease,
  → Lf/HF ration increase
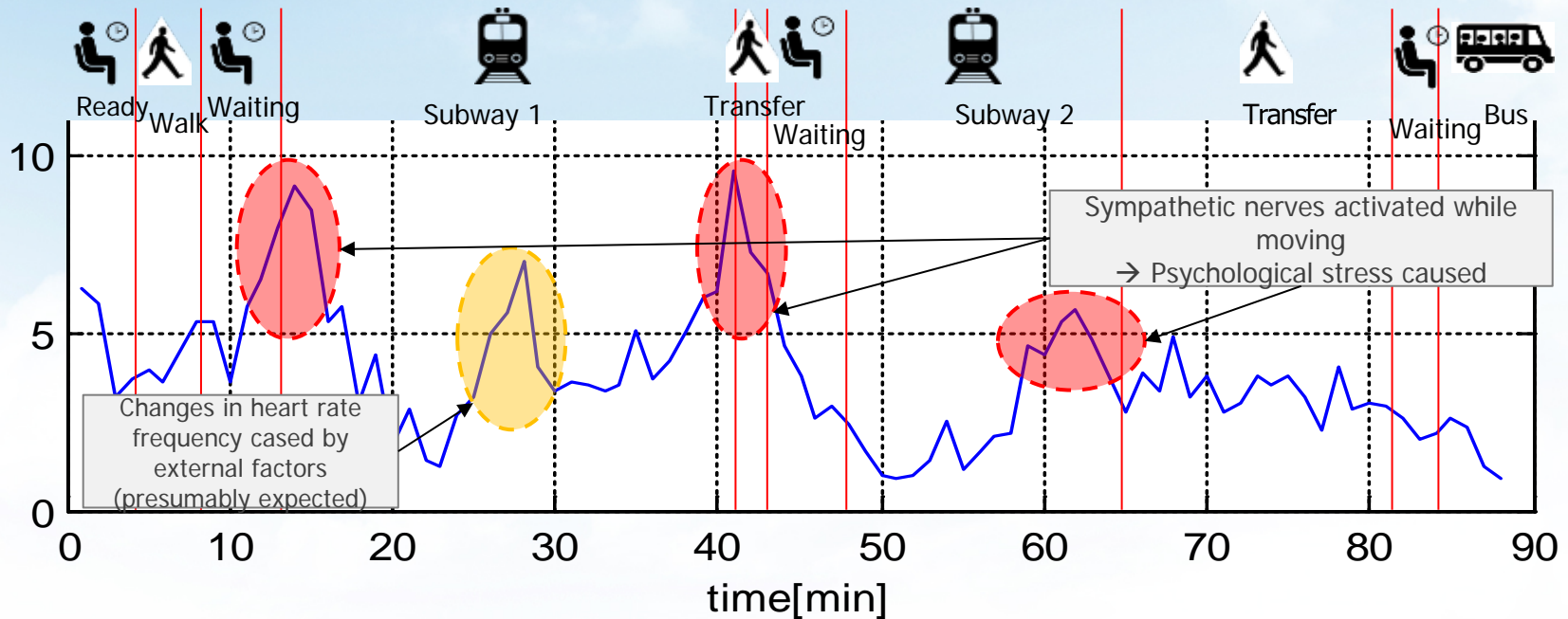
# 3.3 | Lessons and future tasks

➡ Lessons

- Stress assessment method can be an alternative to evaluate transport policy
- Stress can be an indicators to show physiological and psychological changes in making use of transport facilities
- Stress indicators can provide more objective and personalised results

➡ Future tasks

- Development of stress measurement technology suitable for moving situation
- Development of comprehensive indicators using various types of stress indicators
- Data Processing techniques to deal with outliers that cannot be reasonably explained
- Determination of the acceptable level of stress in moving situation

Thank you

Thank you for listening.