A Method for Analyzing Improper Driving Using Passenger's Danger Perceptions

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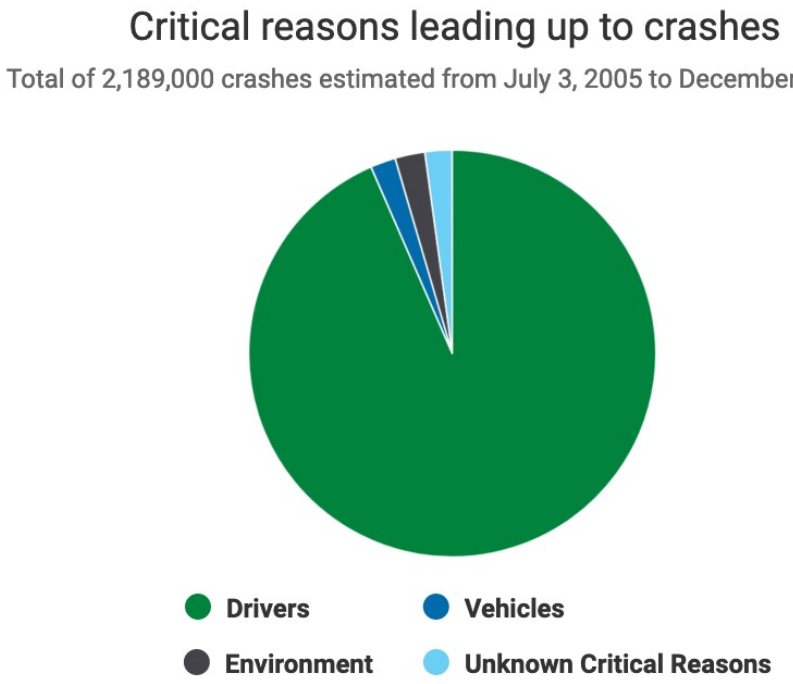
Research Background and Objectives

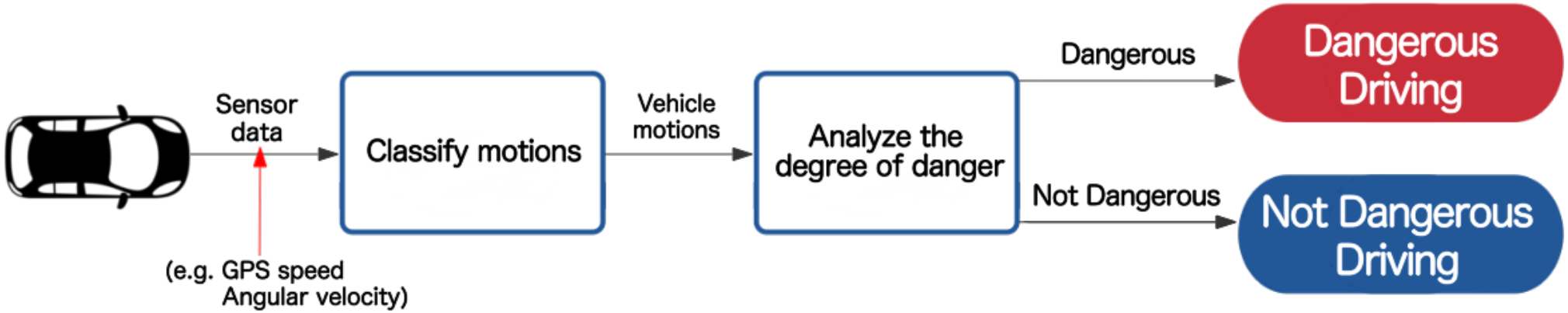
One of the major causes of traffic accidents is the **driver's improper driving**



To prevent traffic accidents, a support system that points out the **occurrence of improper driving** and provides **advice for improvement** will be useful for the driver.

Existing method 1 : Driving behavior analysis (DBA)

DBA is to detect dangerous driving patterns by collecting and analyzing sensor data on vehicle motions while driving.

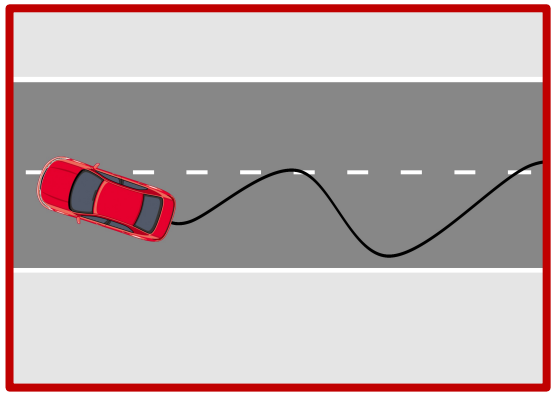


Vehicle motions		Dangerous driving patterns
・Going straight ahead	→	・sudden braking
		・sudden acceleration
・Turn right	→	・sudden steering
・Turn left		
・Stop		
etc.	→	・unsteady handing

Problems with DBA

Some dangerous driving patterns detected by DBA are not actually dangerous because DBA does not take the surrounding traffic conditions into account.

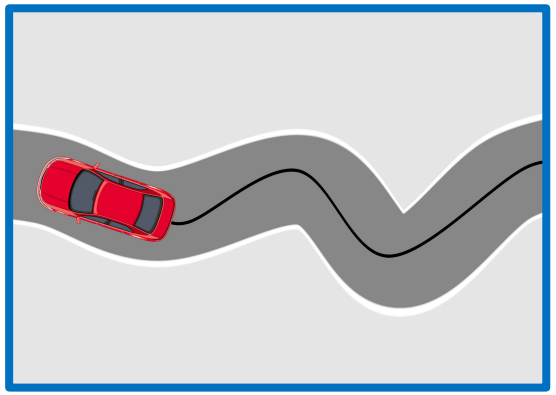
Unsteady handing



Dangerous Driving

or

The road itself is crooked.



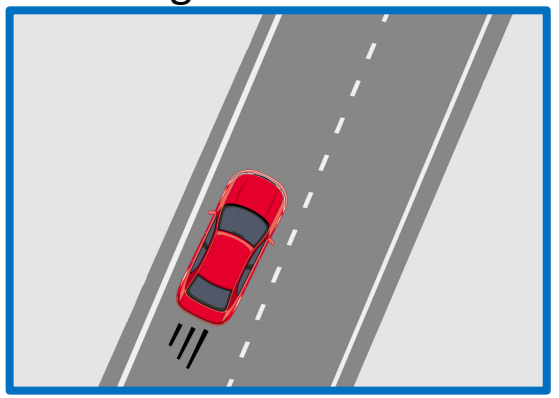
Not Dangerous Driving

Driving on roads
with many pedestrians

Dangerous Driving

or

Driving on wide roads

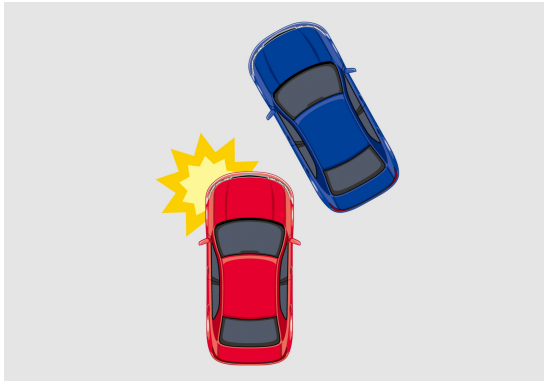


Not Dangerous Driving

Existing method 2 : Driver's danger perception

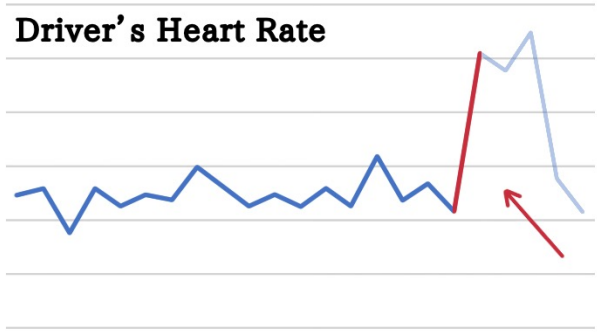
Driver's danger perception is a method to detect external dangers, such as unexpected events or unsafe situations, based on Driver's abnormal heart rate patterns.

e.g.)



Occurrence of external danger

causes →



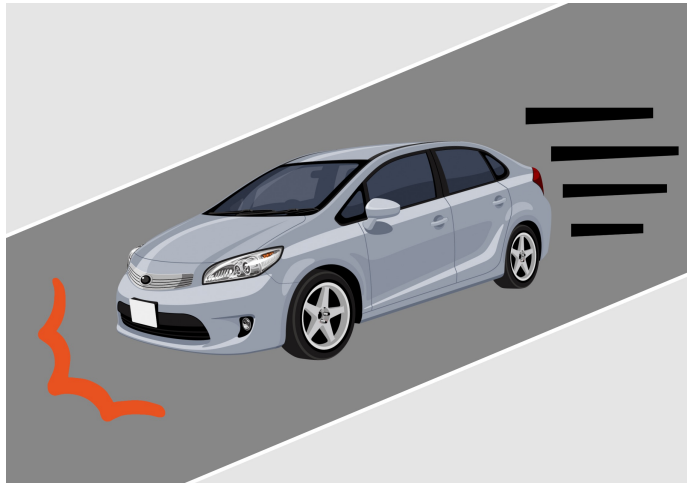
Rapid increase in heart rate

Driver's danger perception can detect dangers mainly caused by the surrounding traffic conditions, which DBA can not detect.

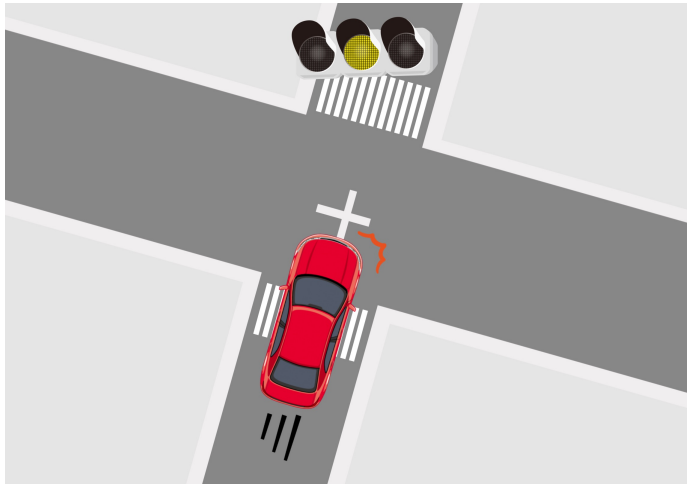
Problems with Driver’s danger perception

Driver’s danger perception misses not a few dangers because the driver recognizes the situation subjectively.

Slightly abrupt braking



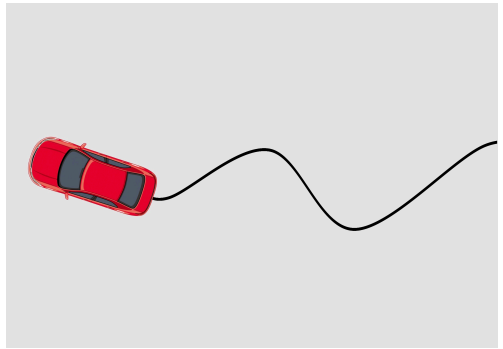
Driving too hard at a yellow light



Problem Solving (1) Matching DBA and Danger perception.

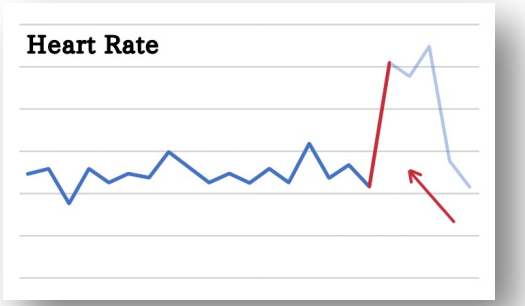
- DBA does not take the surrounding traffic conditions into account.
  - ➢ By matching DBA and Danger Perception, it is possible to detect improper driving based on traffic conditions.

e.g.）Driving behavior analysis



Detects unsteady handing

Danger perception



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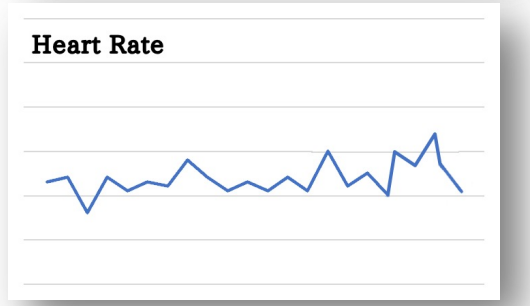

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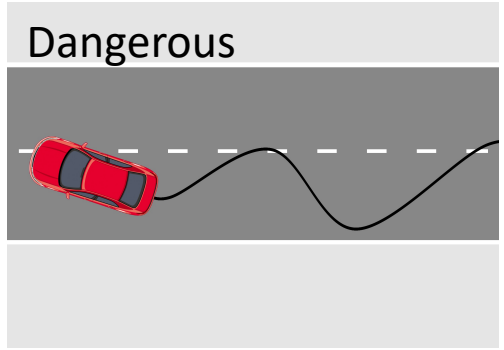
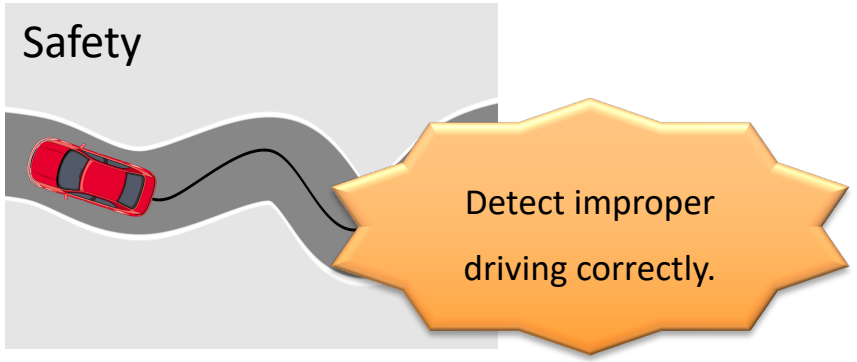
Judgment

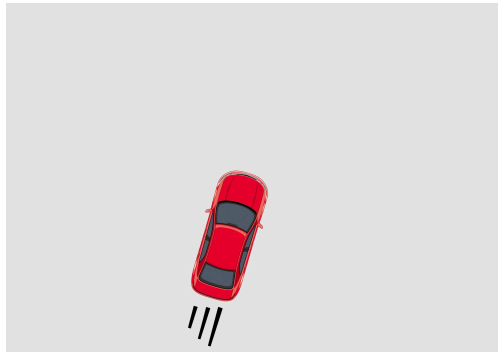




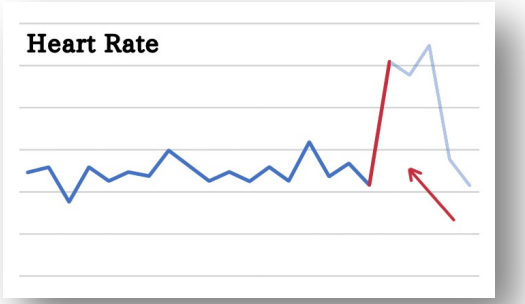
Problem Solving (2) Use the passenger's heart rate.

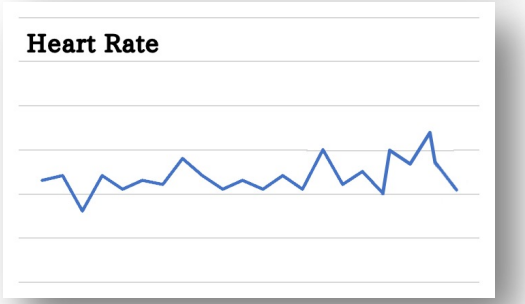
- Driver recognizes the situation subjectively.
  - ➢ We adopt an approach to use the passenger's danger perception, which considered is more objective than that the driver's one.

e.g.）Driving behavior analysis　　Passenger's danger perception　　Judgment



40km/h　going straight ahead





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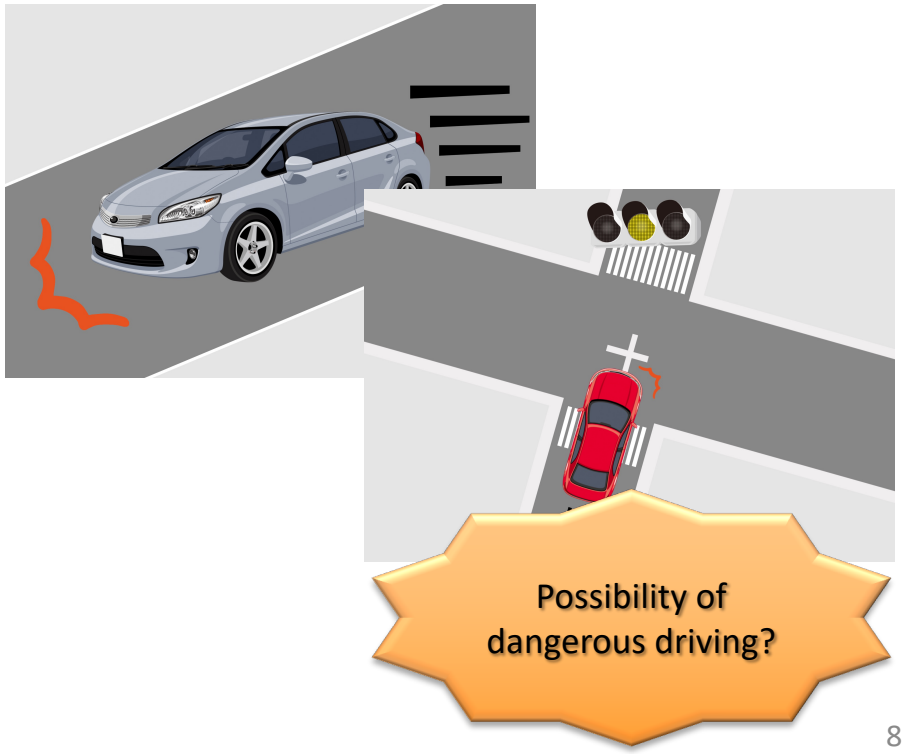


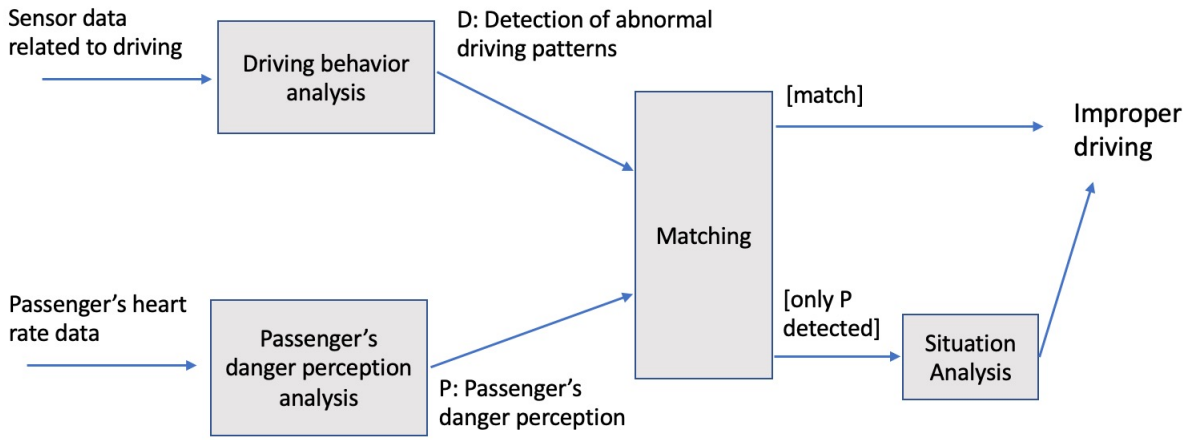
Proposed method

We proposed a method for detecting improper driving using driving behavior analysis(DBA), combined with the passenger's danger perception.

The method consists of the following step:

1. Using DBA to detect dangerous driving patterns.

2. Using Passenger's danger perception to detect external dangers, which depend on the surrounding traffic conditions.



3. If the timings of dangerous driving patterns and the external dangers are matched, these can be determined to be improper driving.
   Even if there is no match, some of the dangers which only passenger's danger perception detect can be improper driving by analyzing the situation in more detail.

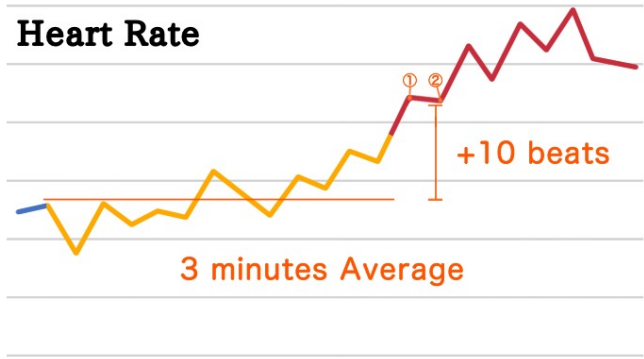
Implementation of Danger perception analysis

Danger perception analysis detects dangers using abnormal heart rate patterns.

We defined two types of patterns based on experiments.

- Rapid increase in heart rate [beats/min]
  - ➢ when heart rate increases more than 10 beats for 5 seconds.

- High heart rate state
  - ➢ when the heart rate keep 10 beats higher than the average rate for 10 seconds.
  - ➢ The average rate is determined based on the measurement for the last 3 minutes, in order to compensate individual differences.



Experiment Summary (1) -Experimental methods

- Driving behavior and the heart rate of the passenger are measured and analyzed.
  - The vehicle's speed and angular velocity are measured using the smartphone's sensors.
  - The passenger's heart rate is measured using the Apple Watch's optical heart rate sensor.
- The experiment consist of 50 sessions. One session is about one-hour driving.

smartphone

Apple watch

Record video

Take memo

Experiment Summary (2) –Subjects' driving experience

Driving frequency of Passengers in the experiment

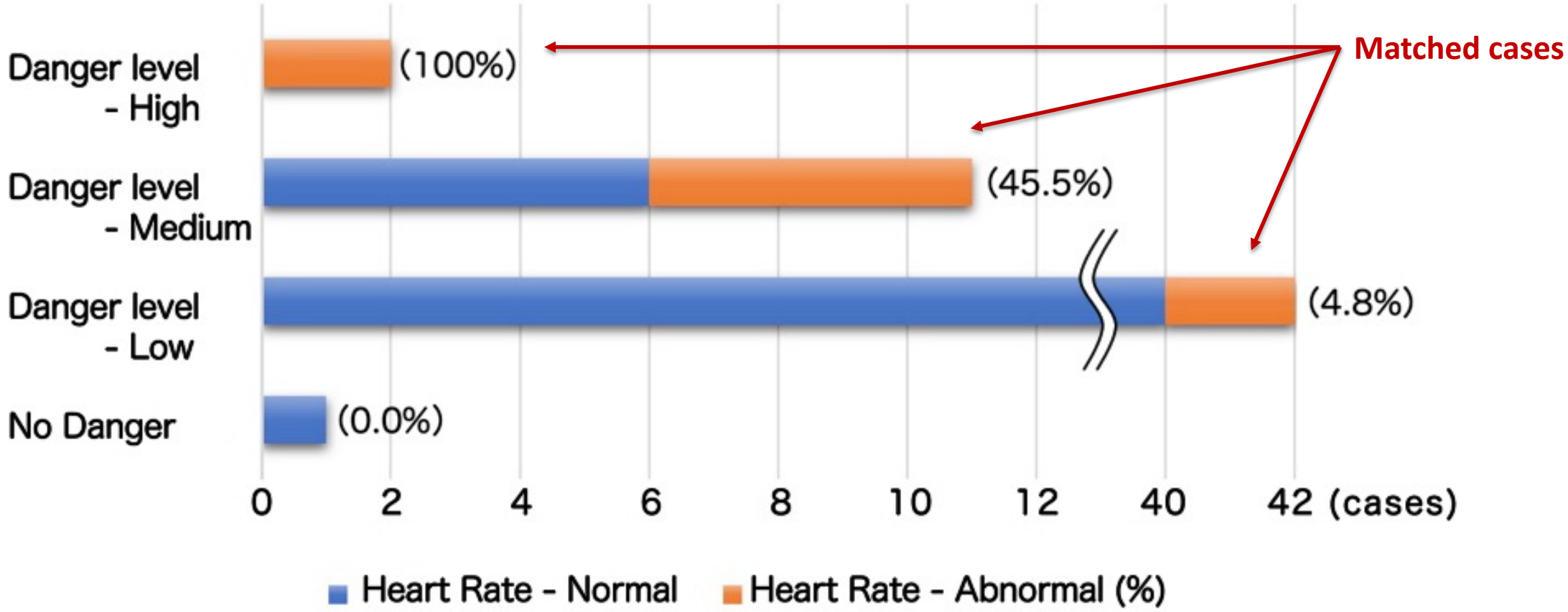
Passengers' driving frequency	Number of people	Number of experiments
Drive on a daily basis	5 people	12 sets
Sometimes drive	4 people	10 sets
Don't usually drive	4 people	13 sets
No driver's license	4 people	15 sets
Total	17 people	50 sets

Combination of drivers and passengers in the experiment

Driver's driving frequency	Passengers' driving frequency	Number of experiments
Drive on a daily basis	Drive on a daily basis	7 sets
	Sometimes drive	1 set
	Don't usually drive	8 sets
	No driver's license	4 sets
Sometimes drive	Drive on a daily basis	5 sets
	Sometimes drive	9 sets
	Don't usually drive	5 sets
	No driver's license	11 sets
Total		50 sets

Results of experiments (1)

- **56 abnormal driving patterns** are detected by the DBA in total.
  - ➢ We classify the patterns into 4 danger levels by the review using video and memo.



Analysis (1)

Driving behavior analysis and Passenger's danger perceptions are:

- Matched when the danger level is high, and
- Not matched in most situations where the danger level is low or no.

Use of passenger's danger perception analysis **can reduce the number of incorrect "improper driving patterns"** detected by DBA.

Results of experiments (2)

- 142 cases are detected with **passenger's danger perceptions only**, whose reasons are analyzed:

1. Dangerous driving: 18 cases
   - Anxiety or fear felt about the driver's dangerous driving
2. Threats in the surrounding traffic conditions : 43 cases
   - Perceived danger due to external factors, such as interruptions by other vehicles or pedestrians jumping out
   - Anxiety caused by environmental factors, such as narrowness of the road and poor visibility

Danger related

3. Non-danger : 62 cases
   - Excitement or surprise during conversation
   - Drowsiness and fatigue
4. Reason unknown: 19 cases

Analysis (2)

Passenger's danger perceptions can **cover most of improper driving** that DBA cannot detect.

Can detect improper driving comprehensively.

- However, the cases passenger's danger perception detects also include non-danger cases. A method to extract only improper driving from the detected cases is needed.

Conclusion and Future tasks

- We proposed a method for detecting improper driving using driving behavior analysis(DBA), combined with the passenger's danger perception.
- The driving experiments were conducted, which show that:
  - Use of passenger's danger perception analysis can reduce the number of incorrect "improper driving patterns" detected by DBA.
  - Passenger's danger perceptions can detect improper driving comprehensively.

- Future tasks
  - To use passenger's danger perception, a method to extract only improper driving from the detected cases is needed.
  - We need to prove that the passenger's heart rate abnormalities are better than the driver's ones to capture the objective danger perception.