A study of riding behavior changes through scoring and advice feedback for PTWs

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1 Background

Technology that visualizes skill for the purpose of improving motorcycle driving skill(1), as well as a smart riding application making use of that technology, have already been released(2). Other potential applications of that technology aimed at rider safety assist are also being assessed. In the meantime, systems and apps that promotes safe driving by feedback are of the gradual adoption for four-wheel vehicles. It makes accident prevention more effective by measuring everyday driving, and especially vehicle behavior, and providing feedback to the driver in various forms, including driving scores, driving logs, and advice.

Such effective improvements in safe driving based on feedback can undoubtedly also be applied to motorcycles. However, motorcycle behavior, driving characteristics, and different driving motivations, such as recreation, mean that the result of the feedback, as well as effective scoring and advice, remain vague.

This research uses a smartphone application that offers scoring and advice for motorcycle rider to examine how their behavior changes.

2 Objectives

This study set the following three objectives.

- Quantitatively investigate whether providing feedback after rides leads to changes in driving behavior.
- Qualitatively investigate whether riders are aware of changes in their behavior.
- Investigate how much time is required for changes in behavior to manifest.

3 Overview of the Experiment

Fifty riders who commute by motorcycle were asked to ride ten or more kilometers at least five times a week for two months. When they rode, they attached their own smartphone to the motorcycle using an off-the-shelf smartphone case, and used an internally built smartphone application to record driving data. The application uses internal sensors to measure the motorcycle behavior, and then provide feedback in the form of a score and advice tailored to the characteristics of the user after driving, as well as showing risky events* on a map.

* Risky events were defined as behavior with the potential to lead to an accident while driving. Sudden acceleration, sudden deceleration, sudden cornering and emergency evasion were detected from sensor data, and the time and location of the event was recorded. The threshold value of the event was set by ourselves.

In the first month, only measurements were taken to establish the rider's usual driving behavior as a baseline, and no feedback was shown after driving. In the second month, driving feedback was provided, and riders were asked to answer a survey after each ride. To maintain the motivation to change their behavior, the riders were informed that an extra reward based on driving score would be added to the standard reward prior to the experiment.

3.1 Test procedure

User testing followed the procedure below.

1. Riders attached the specified case themselves and installed the smartphone application.
2. Before a ride, they put the smartphone in the case, launched the application, tapped the start measurements button, and then started driving.
3. When the ride was over, they stopped the recording of measurements and removed the smartphone from the case.
4. Then then responded to an online survey.
5. The driving score and advice message was generated approximately 15 minutes after the ride finished (only during the second month).

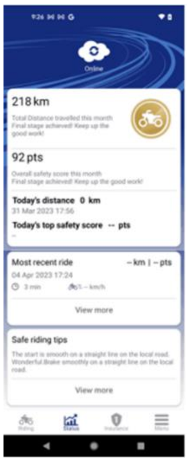
Steps 2 to 5 were repeated

3.2 Application specifications

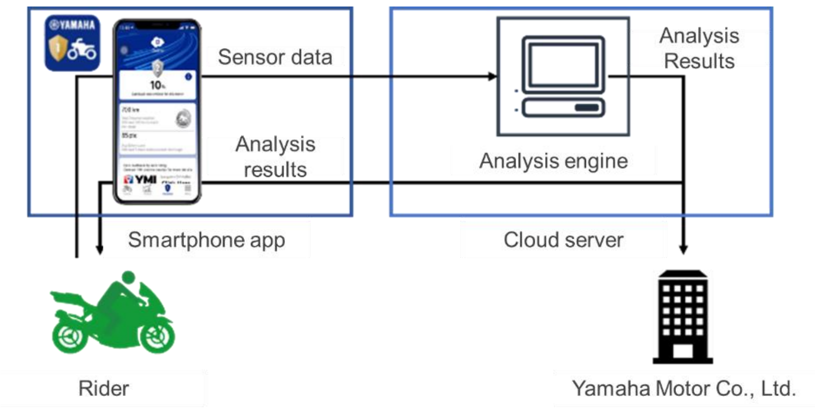
Native Android and iOS applications were created for this test to allow the subjects to use their own smartphones. The main screens are the **Home**, **Data Measurement**, and **Driving Results Feedback** screens. Data measurement is started and stopped manually, and the measured data is stored in a managed server. The score is calculated automatically.

Home

Measurement in progress



Results feedback



Overview of the Measurement Application System

3.3 Details of feedback.

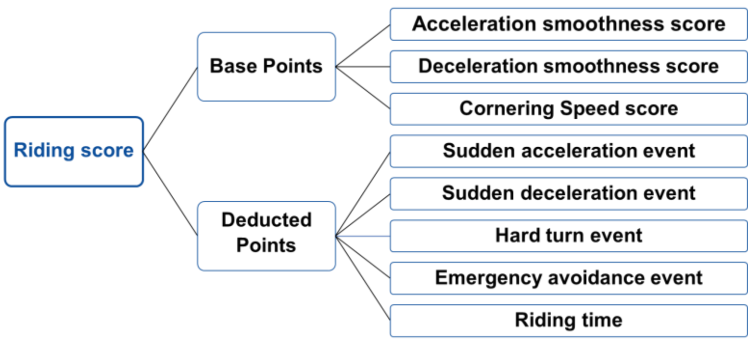
3.3.1 Driving score

After each trip, the extent to which the rider drove safely was visualized with a score between 0 and 100. The scores were defined by combining information such as motorcycle driving instructor guidelines, and actual accident data providing a variety of motorcycle behavior indices. The system only calculated scores for data representing three or more continuous minutes of driving to the scoring is more stable.

Base score: Points are added based on acceleration, deceleration, and cornering speed.

Deduction factors: Points are deducted according to the number of times events marked as "sudden" (e.g., sudden acceleration or sudden cornering) occur.

The sample driving data obtained in advance for score assessment purposes had a distribution with a median of approximately 80 points.



Riding score structure

3.3.2 Driving advice

The driving behavior of each individual trip is combined with rider driving characteristics to formulate and send advice to achieve safer driving.

As with the score, the advice relies on vehicle operation items obtained from the smartphone data as well as from driving scenarios. Approximately 60 items were defined, and advice covering the four respective cases of straight line driving, cornering, high score vehicle operation items, and low score vehicle operation items was generated. The advice and items to extract were, like the scores, defined based on the advice of motorcycle driving instructors.

Smooth and wonderful braking. However, the acceleration is a slightly harsh. Be aware of other vehicles on road and ride with the flow of traffic.

You are performing great and stable at all speed ranges.

The bike is stable when braking on a straight line on the local road. Wonderful.

It is important to grip the bike tightly with your knees so that the bike does not sway, when turning on the corner on the local road.

Example of an advice sentence

3.3.3 Acceleration and cornering stability distribution

The application presents a graph showing how the rider compares to the average of riders as well as a chronology of each trip.

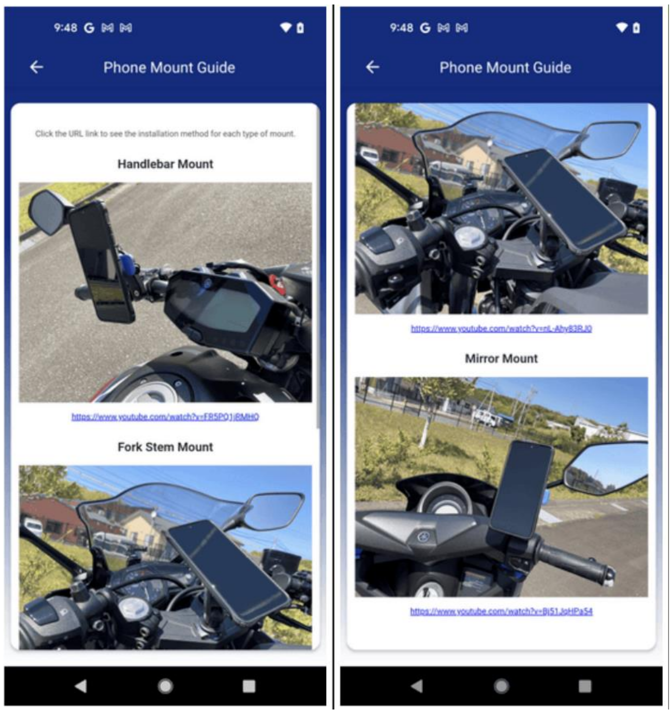
3.4 Data collection

Driving data:
During driving, the GNSS mounted on the smartphone collected position and other sensor data. All of the data was transmitted to a server, which then calculated the number of risky events and the driving score, and generated the advice. The results were displayed on the user's smartphone as soon as the calculations are finished.

Survey data:
Surveys were collected before and after the test started, as well as after each trip.
The purpose of the surveys taken before and after the test started was to look into factors such as self-awareness of changes in driving behavior resulting from driving style or the use of the application. The purpose of the surveys after each trip was to determine whether there were any near misses and to identify discrepancies between the score and how riders actually perceived their driving.

3.5 Attaching the smartphone

Riders were provided with a specific case for the smartphone and asked to attach it as shown in the picture to ensure the accurate recording of vehicle behavior. The mounting location was chosen from the handlebars, mirror mount, or fork stem, as appropriate to the motorcycle model. An auto-calibration functionality was implemented to eliminate differences due to the mounting angle.

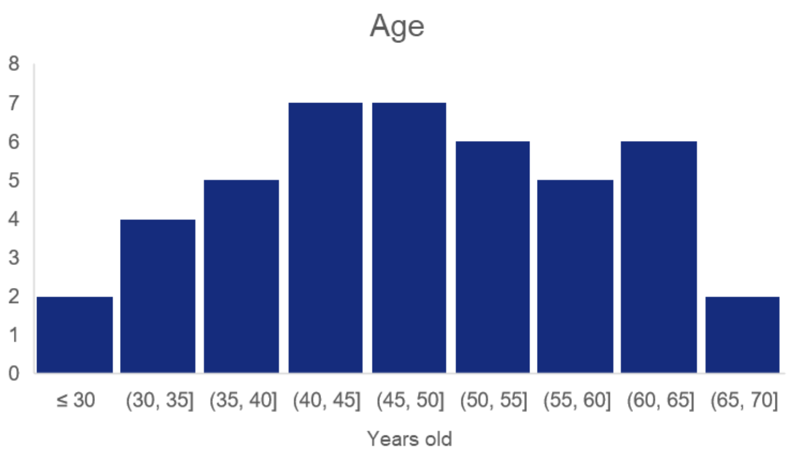


3.6 Overview of test subject attributes

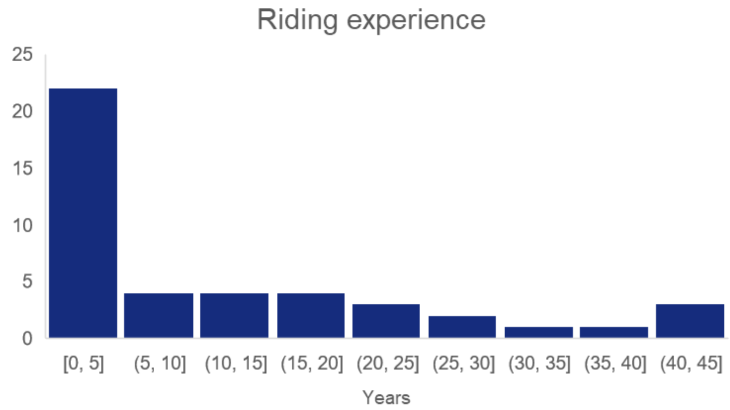
The eligibility criteria were set as follows:

- Someone who usually rides a motorcycle
- Someone who uses a smartphone

Fifty-eight Australian riders applied to take part in the experiment.
Actual valid data covering the required driving distance for the study was obtained from 45 riders.
There were 754 trips during the period without feedback: 16,072 km
There were 856 trips during the period with feedback: 18,150 km
The age distribution of the riders is shown below.



The riding experience of the riders is shown below.



4 Evaluation Indices

The types of behavior changes that occurred with and without feedback were compared according to the points (indices) below.

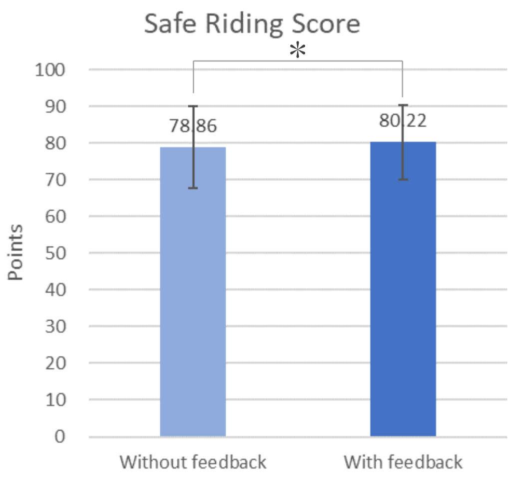
- Change in driving score:
  Average safe driving score (total of driving scores during the period/number of trips)
- Change in risky event frequency:
  Number of risky events per unit kilometer per trip
  Risky events were defined as behavior with the potential to lead to an accident while driving. Sudden acceleration, sudden deceleration, sudden cornering and emergency evasion were detected from sensor data, and the time and location of the event was recorded. The threshold value of the event was set by ourselves.
- Change in the riders' subjective perception of the number of near misses
  The number of "Yes" answers to the "Was there any situation that could have led to an accident?" survey question after each trip.
- Ratio of self-awareness of changes in driving behavior
  Proportion of answers indicating a change in awareness from the no feedback period to the feedback period.

5 Results

This section presents the collated results for the indices described above.

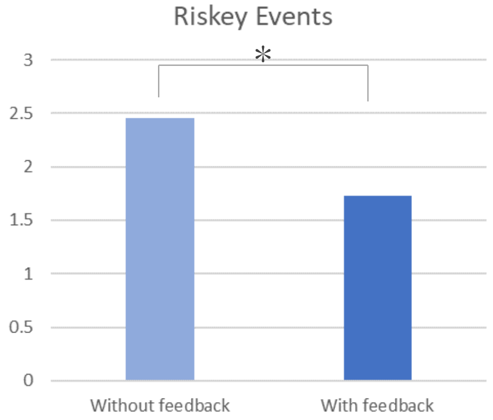
5.1 Change in driving score

Average safe driving score (without feedback): 78.86
Average safe driving score (with feedback): 80.22
The change amounted to a 1.72 point increase, which is statistically significant (p 0.05).



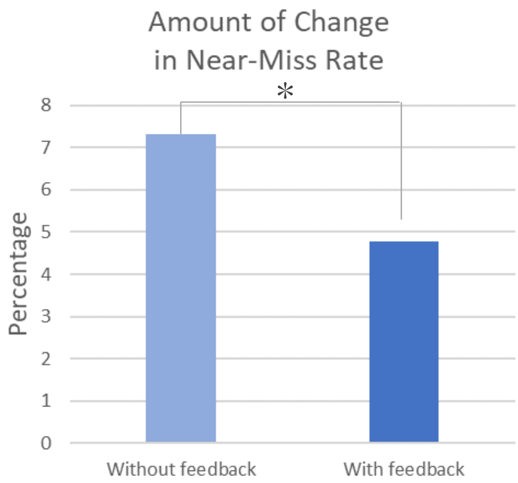
5.2 Change in risky event frequency

Period without feedback: 2.4 times per 100 km driven
Period with feedback: 1.7 times per 100 km driven
This represents a decrease of 29% between the period without feedback and the period with feedback.



5.3 Subjective perception of the number of near misses

There was a significant 34% decrease in the period with feedback compared to the period without feedback.



6 Observations

The observations were made while keeping in mind that the scores are not based on the number of accidents, but rather determined by assigning points based on both quantitative and subjective results from accident surveys and discussions with driving instructors.

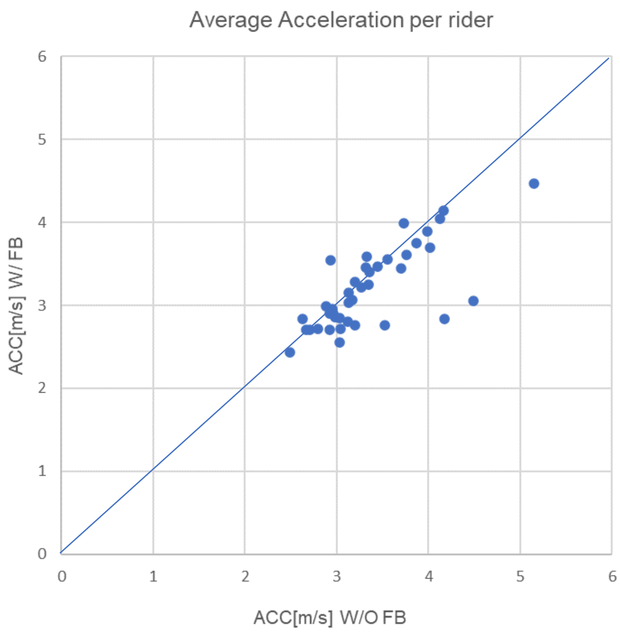
Changes in actual vehicle behavior:

The increase in driving score being limited to a mere 1.72 points is attributed to two factors.

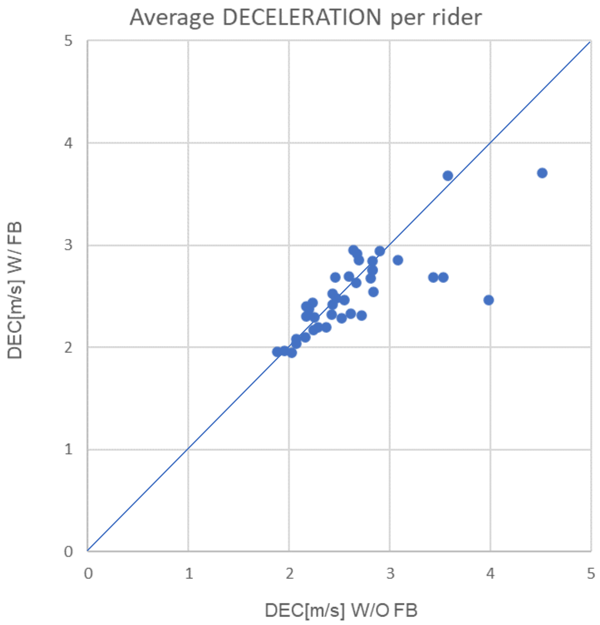
1. The scores exhibited little sensitivity to changes in driver behavior (due to insufficient validation of the scoring algorithm).
2. There was no change in driver behavior.

The risky event and driving behavior constituent elements of the score were analyzed separately to isolate the causes with respect to the actual driving behavior.

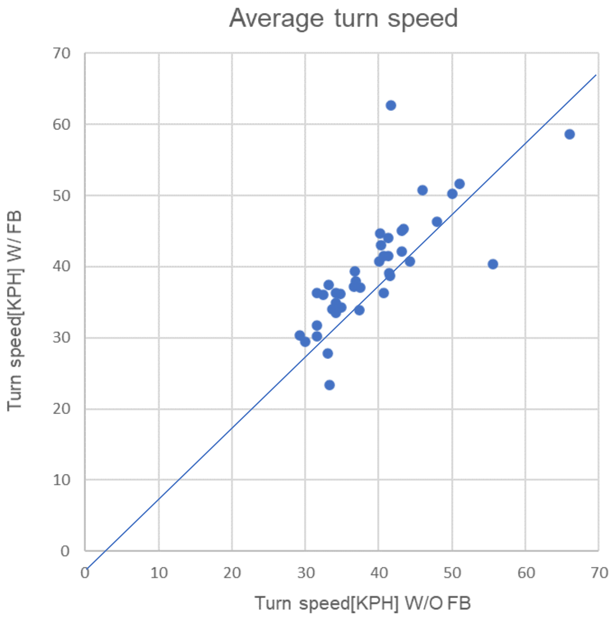
For each trip, the mean acceleration, the mean deceleration and the mean cornering speed were compared by “Without feedback” and “With feadback”. The horizontal axis shows the evaluation values for each item with no feedback, and the vertical axis shows the evaluation values with feedback. The area above the reference line indicates that the evaluation value has increased, and the area below the reference line indicates that the evaluation value has decreased. It can be seen that there are several riders whose acceleration and deceleration values have decreased drastically. This is particularly seen for riders with large values for each indicator. However, it seems there is no trend about turning speed.



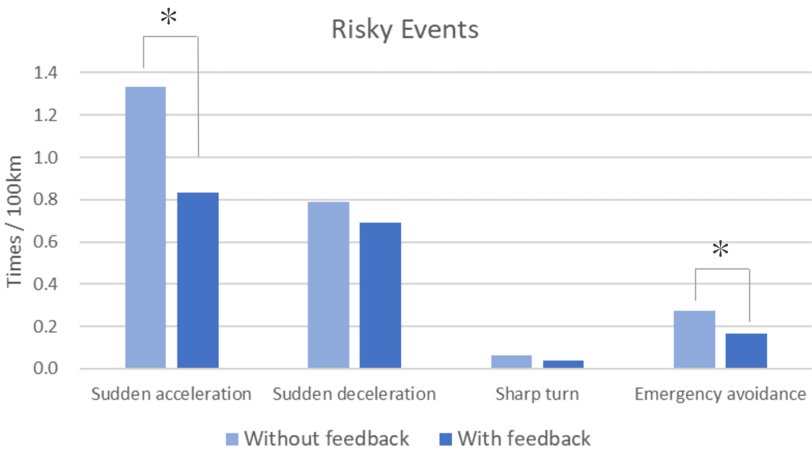
Average Acceleration per rider
ACC[m/s] W/ FB
ACC[m/s] W/O FB
0
1
2
3
4
5
6



Average DECELERATION per rider
DEC[m/s] W/ FB
DEC[m/s] W/O FB
0
1
2
3
4
5



The shift in the number of cases for each type of risky event is presented below.



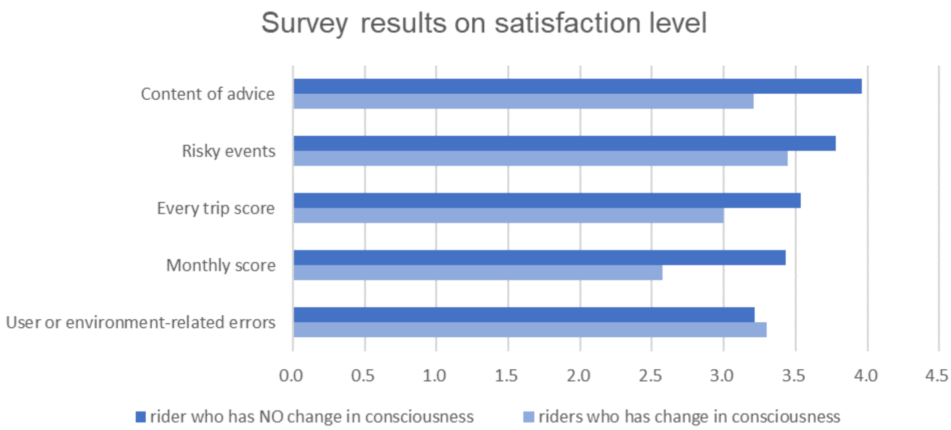
The results demonstrate that the frequency of occurrence decreased for all events, with some exhibiting a statistically significant difference. The data demonstrates that the driving feedback causes a change in behavior that mitigates risky driving.

Consequently, it seems logical to deduce that the algorithm and scoring proposed in this study were not sufficiently sensitive to changes in driving behavior. However, the test was only conducted for one month, and a longer term survey will be required to determine whether use over more than one month can produce changes in behavior.

Changes in rider mentality

After the two-month test, 39 riders responded to the survey. Of those, 25, or 64%, reported a change in awareness from May to June, and within that group, twelve riders noted attempting to increase their driving score as the reason for the change. It is believed that visualizing driving through a score and the incentive of raising that score provided motivation to try to improve.

The responses of riders who, conversely, did not perceive any change in their awareness were also examined. Given that riders base their driving on the basic behavioral principle of not wanting to cause an accident or get injured in the first place, it is expected that the lack of change was caused by some degree of unconscious objection during the test. The results of the survey collected after the test concerning whether the riders agreed with the test contents indicate that the group with no self-recognition of a change in behavior had low levels of acceptance concerning the driving scores for each month. It seems likely that those riders felt they had made an effort, but determined that their behavior had not changed since they did not see any improvement in their scores. Similarly, compared to the group that perceived a change in their behavior, the group that did not perceive a behavior change had lower levels of acceptance of the advice.



Increasing self-recognition of a change in behavior will require carefully defining the point distribution in the scores and cautiously determining how to present explanations and advice.

For reference, of the 58 entrants, 45 participated in the test on a constant basis and provided valid data. The remaining riders did not drive the required number of kilometers. The cumbersome process of having to attach the smartphone and manually start measurements for every trip stood out among the various reasons given for not driving a sufficient number of kilometers. There appears to be a need to find the proper balance between incentivizing even safer driving and how cumbersome the process is.

7 Conclusion

Motorcycle riders were attributed a score reflecting how (safely) they drove and provided advice for each trip they made for one month.

During the feedback period, behavioral changes that mitigated risky driving were observed. However, the score increase was slight, indicating a need to review both the algorithm and the coefficients assigned to each evaluation item.

Nevertheless, 60% of riders recognized a change in their own driving behavior resulting from the use of the system. This study has made it clear that an appropriate change in scores and advice that riders can accept are important to encouraging changes in behavior through the feedback system.

References

1) Keisuke Morishima, Hiroshi Daimoto, “Fundamental Study on the Quantification of the Riding Skills of Motorcycle Riders”, Yamaha Motor technical review, 2012-12 No.48, 71-80
2) Yamaha Motor Co., Ltd., “Yamaha Smart Riding app”, https://www.yamaha-motor.co.jp/mc/life/apps/smartriding/