A Study on a Method to Call Drivers' Attention to Hazard

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Abstract. This paper presents a new warning method for increasing drivers' sensitivity for recognizing hazardous factors in the driving environment. The method is based on a subliminal effect. The results of many experiments performed with six subjects show that the response time for detecting a flashing mark tended to decrease when a subliminal mark was shown in advance. This paper also proposes a scenario for implementing this method in real vehicles.

Keywords: Driving Assistant System, Subliminal Information, Attention.

1 Introduction

Driver-assistance systems are being put on the market in conjunction with ongoing research concerning Intelligent Transport Systems (ITS). Driver-assistance systems reduce a driver's workload for executing operations to make a vehicle go, turn and stop, representing the basic dynamic behavior of vehicles. Adaptive cruise control (ACC)[1] and lane-keeping support systems[2] are typical examples of such systems that are designed to lighten drivers' workload. In addition to mechanical intervention, other conceivable forms of driver assistance include support for the tasks of perception, cognition and judgment. For example, a navigation system[3] that can detect a distant pedestrian and display the information on a dashboard monitor can reduce drivers' perception workload by aiding their ability to perceive the outside world. From this perspective, this study focused on a system for assisting drivers' situational awareness.

There are many instances where the discrepancy between a driver's situational awareness and the actual situation can lead to a serious accident. However, it is not easy to assist drivers in perceiving their surrounding circumstances in diverse driving situations. In general, the direct presentation of information to a driver about the driving environment can be considered as a means of making the person aware of a potentially critical situation. A typical example here is a following distance warning system.[4] However, there are times when the provision of such information by a system can interfere with a driver's cognition of some other aspect of the driving environment. For example, warning a driver about the presence of a forward object might

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reduce the attention resources allocated to other aspects.[5] There are also problems related to the accuracy (certainty) of the sensed information provided. If the sensed information is 100% accurate, providing it to a driver can be expected to have some effect in assisting driving operations. However, if the information presented contains uncertainties, the provision of uncertain sensed information to a driver, even though it might happen very infrequently, could cause confusion and induce a phenomenon known as risk homeostasis.[6] So long as remote sensing is used to detect the information that is the target of a driver-assistance system, it is necessary to construct cognitive support systems that tolerate uncertain information within given limits.

For example, consider a situation where many vehicles are stopped due to congestion in the oncoming traffic lane of a two-lane road with two-way traffic. For the drivers of vehicles traveling in the opposite lane that is not congested, there is the uncertain possibility that someone might suddenly dash out from behind one of the stopped vehicles in the congested oncoming traffic lane. There are people who exercise vigilance against such a possibility and drive very cautiously.[7] On the other hand, there are others who are completely indifferent to it. If the latter drivers be could be alerted that the situation requires caution, it could heighten their awareness of and attention to the uncertain possibility of an accident occurring because of someone suddenly dashing out in front of their vehicle. That could quicken their response time in the event such a situation should actually occur. In fact, the importance of training in risk prediction is recognized at driver education schools. It is expected that such prediction training will improve drivers' attention and sensitivity to the driving environment.

Against this backdrop, this study focused on a method of improving drivers' risk sensitivity and prediction in relation to unsafe factors of an uncertain nature that might occur at anytime, which are referred to here as hazardous factors. Focusing on the subliminal consciousness that acts on human latent consciousness, a study was made of the possibility of using subliminal warnings to increase drivers' awareness of and attention to their surrounding circumstances. Section 2 discusses subliminal consciousness and section 3 explains the basic experiments that were conducted. Section 4 discusses the experimental results and section 5 summarizes the findings of this study.

2 Warning Action

2.1 Previous Studies on Subliminal Consciousness

The term subliminal combines the prefix sub, meaning below, and the Latin word limen, meaning threshold or boundary. A threshold is a value that marks the dividing line between whether a presented stimulus can be consciously perceived or not. A stimulus which does not reach that level is subliminal. The quantity of visual information humans can perceive is reported to be 10 Mbit/s,[8] which is equivalent to the number of characters on approximately 53 newspaper pages. Of that amount, it is said that humans can consciously perceive an information flow of 40 bit/s, which means cognition of 2.5 characters per second. Subtracting 40 bit/s from 10 Mbit/s gives the quantity of information that is not consciously perceived and is processed as subliminal information.

An example of an early study of subliminal consciousness is the experiment conducted by James Vicary, a marketing researcher, at a movie theater in Fort Lee, New Jersey in 1957. During the showing of the movie Picnic, he flashed two different messages (Eat Popcorn and Drink Coca-Cola) on the screen repeatedly every five seconds and measured the impact on sales. The frames containing the messages were displayed for such a brief duration that they were not consciously perceivable by the viewers. The experiments conducted by William Kunst-Wilson and Robert Zajonc can be cited as another example. Not all of the scientific experiments dealing with subliminal consciousness have shown that there is an effect on conscious perceptibility[9]. An effect has been reported in some studies but not in others depending on the conditions. It is not scientifically known at this point under what type of conditions the effect becomes stronger.

2.2 Application of Subliminal Warnings to Driver Awareness Assistance

Assuming that a driver-assistance system is capable of detecting a potentially hazardous situation, there is the issue of how that information should be conveyed to the driver. The information can be presented visually by using dashboard warning lamps, HUD images or other visual means. The driver can also be warned of the situation by issuing audible or haptic alerts. Guiding the driver's line of sight for an extended period of time is not deemed to be a very suitable means of providing information for predicting potential risk when the occurrence of the event is uncertain. Audible or haptic alerts cannot not easily present information on spatial positions, and drivers might sometimes feel such alerts themselves are annoying. From these perspectives, we think that the presentation of a hazard warning by a technique that operates on the subliminal consciousness is a method of conveying information that is worthy of examination.

This study investigated a method of presenting a warning to a driver in a situation where a potential hazard has been detected in the driving environment. Hazard detection, which is the precondition for issuing a warning, is accomplished by means of a hazard estimation model [10] that we constructed previously using a neural network and fuzzy logic rules.

3 Basic Experiments

The experiments examined how long attention was improved by the presentation of information at the subliminal consciousness level. The experiments also examined the relationship between the timing for presenting subliminal information and the effect on improving attention. A concrete explanation of the experimental procedure is given below.

Fig. 1. Example of presented image (1)

Fig. 2. Example of presented image with predictor mark (2)

Several different types of images to be presented to the subjects were prepared in advance. The images included moving images and still images containing disturbance elements such as the direction and speed of a moving object. First, a still image like that shown in Fig. 1 was presented for over ten seconds. Then, an image like that in Fig. 2 was interposed for 0.02 s, after which the display returned to the image in Fig. 1 again. The interposed image in Fig. 2 corresponded to a visual stimulus that acted on the subliminal consciousness. The exclamation mark (referred to here as a predictor) in the figure was highlighted in the image, but the mark was actually difficult to perceive unless one looked closely.

After the displayed image was changed from that in Fig. 2 back to the image in Fig. 1, an interval of 1, 3, 5, 7, 9 or 10 s was provided and then the image in Fig. 3 was presented. The subjects were asked to press a button as soon as they recognized some change in the image, as shown in Fig. 3. The interval from the presentation of the image in Fig. 3 until the subjects pressed the button was measured. The star in the image in Fig. 3 was located in the same position as the predictor mark, for stimulating

Fig. 3. Example of presented image with final mark (3)

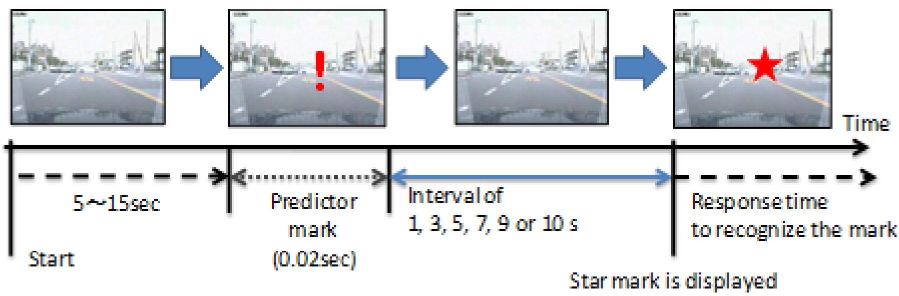

Fig. 4. Time chart for presenting images

the subliminal consciousness, in the image in Fig. 2. It was thought that the subjects should immediately perceive the appearance of the star in Fig. 3, if they were cognizant of the predictor mark in Fig. 2.

A time chart for the presentation of the images is shown in Fig. 4. The subjects were not told about the presence of the predictor and only knew that their task was to press the button as soon as they recognized a change in the image in Fig. 3. The attributes of the subjects are shown in Table 1, and the computer environment used in the experiments is described in Table 2. A typical example of another image used is shown in Fig. 5. This image represents a driving scene on an expressway.

The subjects were shown experimental samples of the presented images in advance so that they would clearly understand the experimental procedure. These samples were newly created for this specific purpose and none of the images used in the experiments were presented at this time. After the subjects understood the procedure, they were shown the images in turn, using different image combinations that had been prepared in advance. Six sets of images were created at random, including one set that did not contain the predictor mark. One set of images was randomly selected for use in each experiment. The order in which the images were presented was entirely

Table 1. Attributes of test subjects

	Gender	Age
Subject A	Male	23
Subject B	Male	23
Subject C	Male	22
Subject D	Male	50
Subject E	Male	37
Subject F	Male	44

Table 2. Computer environment used for presenting images

OS	Windows Vista™ Home Premium
CPU	Intel® Core™2 CPU6600@2.4GHz
RAM	2030MB
Image creation software	Ulead Video Studio® 11
Image playback software	APlayer

Fig. 5. Example of presented image

random for all of the subjects. Because the limit of human reaction speed is reported to be 0.1 s, any data for less than 0.1 s were excluded from the data collected before switching to the final image during the experiment. In addition, data were also excluded that deviated greatly from the standard deviation of 1 s after the presentation of the final image. Approximately 250 data samples were thus collected that represent the experimental results described in the following section.

4 Result and Discussion

4.1 Experimental Results

The mean and standard deviation of the response time data obtained from all of the subjects are shown in Fig. 6. The vertical axis indicates the measured response time, and the horizontal axis shows the interval between the presentation of the predictor (exclamation mark) and the presentation of the final mark (star). The results in the graph indicate that the response time tended to be shorter when the predictor mark, which presumably acted on the subliminal consciousness, was presented, compared with the condition when it was not shown. In addition, the mean response time became faster as the interval between the presentation of the predictor mark and the presentation of the final mark was gradually lengthened from 1 s to 3 s to 5 s. Among all the intervals, the greatest effect on improving the response time was seen for an interval of 5 s, after which the response time became slower again. The results of a test for a statistically significant difference indicated that there was a significant difference, with a 95% confidence interval, for the patterns where the images were changed after intervals of 7, 9 and 10 s, compared with the condition without the predictor mark.

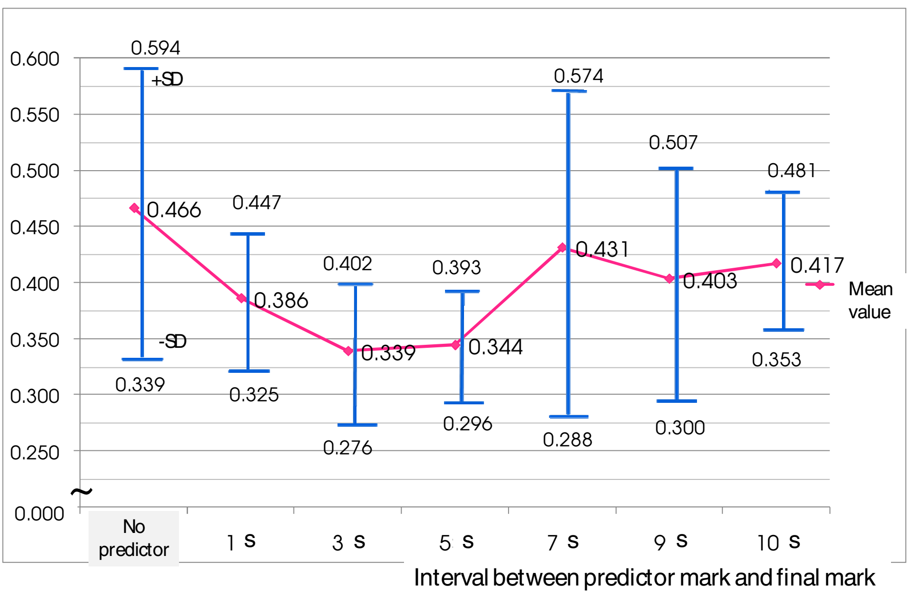

Fig. 6. Relationship between presentation of predictor mark and response time

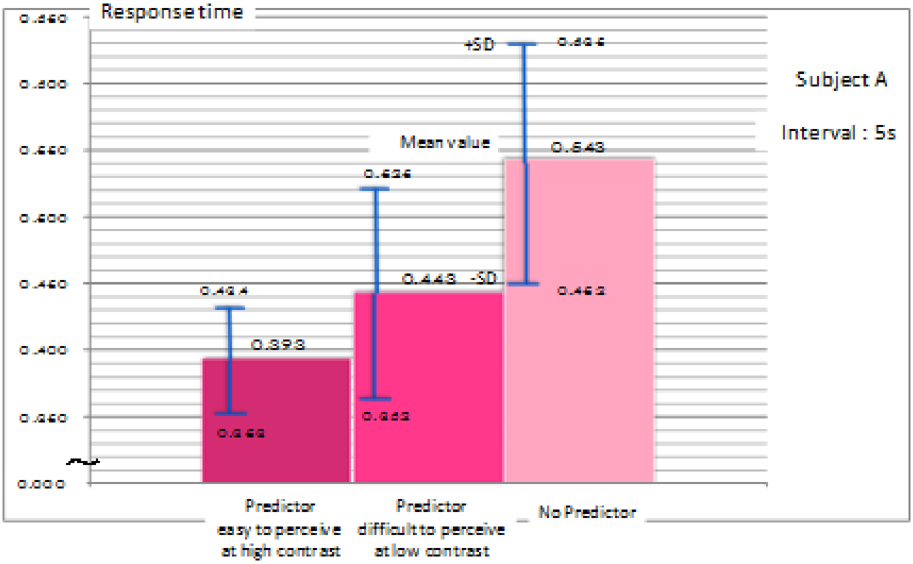

Fig. 7. Relationship between predictor mark visibility and response time

The following experiment was conducted to verify the reliability of the measured data. The continuity of the measured data was examined to see if there was any difference ascribable to the ease of perceiving the predictor mark. The response time was investigated for the pattern where the presented images were changed after 5 s, which was the interval that showed the fastest response time overall. Three types of images were used in this experiment: one without a predictor mark, one with a difficult-to-perceive predictor mark and one with an easy-to-perceive predictor mark. The results in Fig. 7 are for a 5-s interval between the presentation of the predictor mark and the presentation of the final mark. The vertical axis shows the measured response time and the horizontal axis shows the interval in seconds between the presentation of the predictor mark and the changing of the images to the final one. The results in the graph clearly indicate that the response time was faster for the images with the predictor mark compared with the response time without it. The response time continuously became faster in the order of no predictor mark, difficult-to-perceive predictor mark and easy-to-perceive predictor mark. The continuity of the effect on the response time attributable to the difficulty in perceiving the presented information can be seen from the results.

4.2 Application to an Actual System

A preliminary study was made of the effectiveness of presenting subliminal information that acts on the subliminal consciousness of drivers. This section discusses how such information might be used as a warning. As mentioned earlier, the authors have previously proposed a method of predicting the location and position of hazards in the driving environment [10]. This method uses a camera to observe the forward direction and a neural network to estimate the location and position of hazards that typically

Fig. 8. Concrete example of operation of in-vehicle system

draw the attention of experienced drivers. The neural network has been taught the typical points that experienced drivers are generally vigilant of. While the general applicability of this method requires further detailed discussion, it is thought that the configuration of the system at least provides a mechanism for arousing the attention of drivers. As illustrated in Fig. 8, that can be accomplished by briefly projecting a light on the places in the forward view wherever and whenever hazards are detected with this method, so as to act on the driver's subliminal consciousness and encourage the devotion of attention to those locations.

5 Conclusion

This paper has proposed the use of subliminal warnings as a new way of presenting warning information to drivers and described the results of a preliminary study of its effectiveness. It was found that the presentation of subliminal warnings to six subjects significantly increased their awareness of a change in the images of the driving scenes presented. In future work, it is planned to investigate the effectiveness of the proposed method for various presentation times, specific presentation modes and other factors in order to examine its applicability in the field of vehicle safety under more diverse levels of subliminal consciousness.

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