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Accident-preventive Measure Selection Method Based on the Speed Cognition of Lead-vehicle Driver in Curved Roadway

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Abstract

To select appropriate traffic safety measures in curved roadways, we focus on the structure of drivers' cognitions of lead-vehicle speeds in curves. The purpose of this study is to propose an accident-preventive measure selection method based on the speed-cognition structure of the lead-vehicle driver in a curved roadway. In order to test the hypothetical structure of the speed cognitions, we use path-analysis approach and employ a driving simulator. And in our hypotheses about the speed-cognition structure and the curve cognition process of the driver, we focus on the relationship among a target-setting error due to the maximum safety speed (TSE), a subjective-adjustment error due to perceived speed (SAE), an "objective-adjustment error due to perceived speed (OAE) a speed-perception error due to actual speed (SPE), and a maximum-safety error due to actual speed (MSE)". In the results of our driving-simulator experiment, in the case of left-hand curves, the measures that have drivers perceive the perceived speed low during passing through the curve are effective for diminishing the actual vehicle speed. In the case of right-hand curves, on the other hand, the measures that have drivers target the target speed low before proceeding into the curve are effective for diminishing the actual vehicle speed. In the class of sharp curves, drastic measures such as improvements to the working of the curve are better than measures such as the impact on the perceived speed. In the class of gentle curves, on the other hand, even though in the same class, the measures should be handled sensitively before proceeding into the curve or while passing through the curve, depending on the degree of the change of curvature.

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Keywords: Speed cognition ; Driving simulator ; Maximum safety speed ; Target speed ; Perceived speed

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1. Introduction

Single-vehicle drivers tend to underestimate the speed in roadways (Yotsutsuji and Kita, 2010). Underestimation of speed in curved roadways may be a contributing factor necessitating speed adjustment and thus causing fatal and serious injury accidents in curves (Milosevic and Milic, 1990; Cameron and Elvik, 2010; Elvik, 2013). As the result of approaching sharp curves without realizing that current speed is dangerous to passing through the curve, when driver fails to decelerate while just realizing that, the driver feels a tense moment and traffic incidents may occur. Hence in order to prevent drivers' misperception of speed from traffic incidents in curves, it is necessary to select accident-preventive measures which reflect speed-cognition structures of the drivers toward/into the curves, in keeping with the characteristics of curves.

Studies on speed-cognition structures of drivers toward/into a curve still have unclear points. This study conducts an in-house experiment employing a driving simulator, not an in-vehicle experiment, in order to replicate driving situations toward/into curves at the risk of accidents. Targeting curved sections in a non-urban two-lane roadway, it is assumed that information by road signage is not provided to drivers before approaching the curves and each driver does not take a glance at the speedometer while looking at the curves. Under the assumption, focusing on speed cognition according to the characteristics of curves, this study examines the selection method of various preventive measures handling errors involved in the speed-cognition structure.

This study focuses on the structure of drivers' cognitions of lead-vehicle speeds in curved roadways. The purpose of this study is to propose an accident-preventive measure selection method based on the speed-cognition structure of the lead-vehicle driver in a curved roadway, while using path analysis technique to analyze data from a driving-simulator experiment. With respect to the curve-cognition process and speed-cognition structure of lead-vehicle driver, this study generates hypotheses as discussed in detail in chapter 3.

2. Relevant Studies

Vision psychology explains that motion perception in the human visual system is affected by the contrast and special frequency of a moving brightness. As for moving patterns of the black and white lines in order (i.e. moving patterns of brightness), humans are known to perceive the high contrast and high special frequency patterns faster than physical speeds of the patterns, otherwise, the low contrast and low special frequency patterns slower than physical speeds of the patterns (Weiss, Simoncelli and Adelson, 2002). Such discrepancy between perceived speeds and physical speeds are modeled by the Bayesian model (Weiss, Simoncelli and Adelson, 2002; Hurlimann, Kiper and Carandini, 2002), the ratio model (Hammet, Champion, Morland and Thompson, 2005), and the power model (Yotsutsuji and Kita, 2010). This study focuses on cognitive factors influencing the discrepancy between perceived speeds and physical speeds.

It is important for driver performance and speed adjustment in curves to estimate vehicle speed as accurately as possible. In traffic engineering, however, it is empirically known that drivers underestimate vehicle speed after deceleration (Milosevic and Milic, 1990), and is quantitatively known that underestimation of vehicle speed bears relevance to a number of accidents in curves (Cameron and Elvik, 2010; Elvik, 2013).

In Japan, Oumi et al. (2002) analyzed driver's cognition process regarding the direction of bentness and the change of curvature, and also studied how effective road signage should be in the curve detection point, while conducting an in-vehicle experiment in several curve sections of a non-urban two-lane roadway. As the result of classification of curves with respect to each impression to the change of curvature, such as "sharp" with a strong need for decelerating, "normal" with a weak need for decelerating, "gentle" with no need for decelerating, they point out that the strength of the impressions has a discrepancy between approaching to and passing through the curve and a gap between these impressions and actual driving behaviors carries latent accident risks.

3. Hypotheses

3.1. Curve cognition process