THE EFFECT OF DRIVING SPEED ON SUBJECTIVE SAFETY EVALUATION

Lidia Żakowska

e-mail: lzakowsk@usk.pk.edu.pl
Cracow University of Technology, A-9
Warszawska st.24, 31-155 Cracow, Poland

Abstract

This research objective was to investigate the effect of the 3D/4D dynamic road environment on drivers' perception of road characteristics, in particular to evaluate the effect of driving speed on the perception of road parameters and road characteristics, in order to search for relationships between driving speed and the perception of road environment and subjectively perceived road safety. The laboratory experiment has been conducted to get a better insight into the speed effect on the perception of alternative road design. The results demonstrate that dynamic perception of road infrastructure has a very significant effect on the subjective safety assessment and on the choice of driving speed.

Introduction

The question *„What has to be considered in establishing modern highway geometric design guidelines ?"* is very tempting and exciting. While several important goals for highway geometric design (like capacity, function, economy, environmental protection) are regarded today in more or less satisfying way, great deficiencies still exist when analysing and evaluating the important goal ***safety***. Highway geometric design guidelines should guarantee the design and construction of safe roads. However, that dose not seem to be true. It is estimated, that about 50 % or more of the fatalities on the European roads can be attributed to two-lane roads outside of built areas, and at least half of these serious accidents occur on curved road sections.

The safe and efficient movement of traffic is greatly influenced by the geometric features of the highway. A review of accident spot maps shows that accidents tend to cluster on curves, particularly on very sharp curves (Lamm et al, 1994). Even though the design engineers possesses detailed information from standard values on driving through a curve, accident frequency often appear to not coincide with the actual driving behaviour.

How to design safer roads still remains the fundamental question that civil engineers, practitioners and researchers specialising in the field road design are trying to investigate. A number of unsolved problems exist in the field of road design, human behaviour and road safety. It is recommended (Wegman, 1996) that the production of best practice guidelines, incorporating all available knowledge with a sufficiently sound scientific basis is drawn up and periodically updated if necessary. It is advised that international research is carried out concerning road design, human behaviour and road safety, in which efforts must be done to develop a co-operative research community within Europe.
Numerous individual research are being carried out in most of European countries, discussing geometric road design problems related to driver's behaviour and perception. Numerous research methods are employed in these studies, presenting a wide range of traditional and modern approaches. One of the approach, presented in the paper, is based on the 3D and 4D visualisation of alternative road designs and road view perception studies.

Experimental design

The experimental research objective was to investigate the effect of dynamic road environment on the driver's perception of road characteristics, in particular: to evaluate the effect of driving speed on the perception of road parameters and road characteristics, to search for relationships between driving speed and the perception of road environment and subjectively perceived road safety and to search for relationships between subjective and objective information received from the observed, dynamic road view.
A multifactorial laboratory experiment was designed to test how the change of driving speed (decreasing 20% below or increasing 20% over the speed limit) affects the proper perception of the road view observed.

Method

Independent variables constructed an experimental driving speed (each experimental road section was recorded three times, namely while driven with the design speed, the designed speed increased at 20% and the designed speed limited at 20%), geometric road parameters (basic road curves design parameters as curve radius and deflection angle) and road environment characteristics.
To test driver's perception of road environment, subjective rating scales were used as the measures of dependent variables. The experimental dependent variables were the subjectively perceived road parameters and road view characteristics, such as road safety, road legibility, fluency, aesthetics, road environment and landscape attractiveness and choice of speed.

Rating scale

The same seven point graphical rating scale was used for six road view characteristics assessments, as in the previous authors studies [Żakowska (1994),(1995),(1996)]. The theory underlying the choice of this scales has well been documented by Heino et al.(1990). Figure 1 represents the scales incorporated in this research.

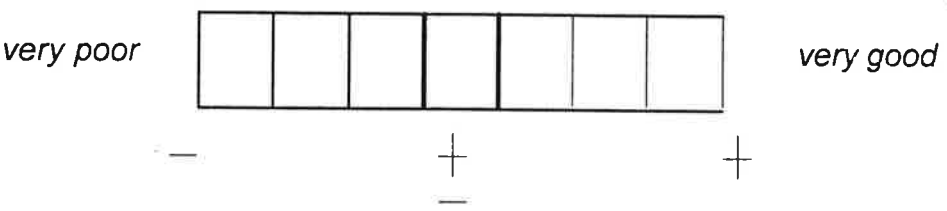

Figure 1. Rating scale used in the experiment

Stimuli

Two-lane rural highways in southern Poland were chosen as an experimental polygon. All stimuli were selected from the same category roads (the third technical class roads, designed at 80 km/h speed, with 70 km/h speed limit), that represents the majority of roads in the region. They varied in three groups of parameters, as shown in Table 1.

Table 1. Design and environmental characteristics of the experimental road sections

SECT. NR	DESIGN SPEED [km/h]	DRIVING SPEED	CURVE PARAMETERS Rh [m]	*fi* [deg]	direction	ROAD ENVIRONMENT greenery	traffic	pedestrians
1	80	90	500	20	R	-	+	+
2	80	90	500	32	R	+	-	+
3	80	90	300	56	L	+	-	-
4	80	70	1000	20	R	-	-	+
5	80	70	500	32	L	+	-	-
6	80	70	300	56	L	+	-	+
7	80	70	500	20	L	-	+	-
8	80	70	500	20	R	+	+	-
9	80	70	500	32	R	-	+	-
10	80	70	1000	20	L	-	-	+
11	80	50	1000	20	R	-	-	+
12	80	50	500	32	R	+	+	-
13	80	50	300	56	L	+	-	+
14	80	50	500	20	R	+	+	-
15	80	50	500	20	L	-	+	-
16	80	50	500	32	L	+	+	-

For each segment a video of the dynamic view was recorded from the driver's point of view, whilst driving with the speed presented in Table 1, respectively. Each stimulus was approximately 60 second long and covered the uniform characteristics for the road segment represented. To eliminate the influence of non manipulated external factors, all sites were filmed in summer driving conditions, good light and weather and none or limited traffic on the road.

Subjects

21 subjects took part in the experiment. They were all licensed drivers of different driving experience-from very experienced, (over 200 thousands km driven and in possession of a driving licence for over 10 years), through experienced drivers (50-100 thousand km driven), to inexperienced, novice drivers 1-3 thousands km driven and possessing a driving licence for no more than 2 years). Subjects were not paid for their participation in the experiment.

Procedure

Unlike in former experiments [Żakowska (1994), (1995)] the motion road views were presented with use of a video projector on a large screen, (2m x 3m) in a laboratory environment, giving the subjects a closer simulation of the real driving environment. Subjects were tested in groups of 4 - 6. The laboratory conditions were the same as during the former *road category experiment* described in Żakowska (1996). A pre-recorded tape of experimental instructions and a practice film were presented as a training at the start of the session. then the sequences of 16 film-clips were presented, with 30 seconds of blank film between each clip, when subjects made their assessments on the response booklet provided beforehand. The experiment consisted of five sessions.

Results

Individual ratings were preorganised and selected with the help of the EXCEL program, and statistically analysed using STATGRAFICS end EXCEL programs. For each dependant variable a separate analysis was performed, based on descriptive methods and one-way ANOVA. The most significant results are presented below.

Speed effect on subjective road parameters and characteristics perception

The effect of speed manipulation on subjective assessment of six characteristics, namely: (1) the subjective estimate of the chosen speed, (2) road safety, (3) attractiveness of road environment, (4) road aesthetics, (5) road legibility and (6) road fluency, are presented in Figure 3.

The comparison of subjective mean assessments of the above characteristics (Fig.3) have revealed that:

- road safety, legibility (readability), and fluency assessments increase with the lover driving speed and these characteristics are well correlated,
- road aesthetics and road environment attractiveness assessments decrease only with an increase of driving speed above speed limit, lover driving speeds than the design speed do not effect the driver's perception of road attractiveness and aesthetics,

- speed choice mean assessments tend to be overestimated, increasing with the decrease of actual driving speed.

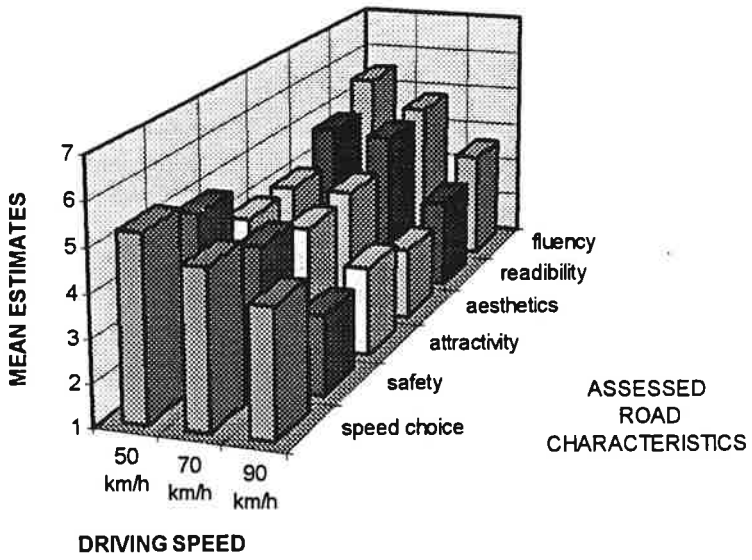

Figure 3. The effect of driving speed on subjective estimates of road characteristics.

Interestingly, there is stronger relationship (fig.3) between speed choice and the perceived road fluency, than between speed choice and the subjectively perceived safety. The more fluent drivers perceive the road the higher speed they would choose while driving at speed limit as well as slower or faster than speed limit.

Road design parameters effect

The effect of road curve design parameters on subjective safety perception were studied during former experiments conducted on the static stimuli by the author and well documented (Zakowska 1995). Three different experimental speeds were incorporated into the research now in order to investigate the composed effect of road geometric parameters and driving speed on subjective choice of speed (Figure 4), subjectively perceived safety (Figure 5) and subjective assessment of road curvature and road curve deflection angle (Figure 6 & 7).

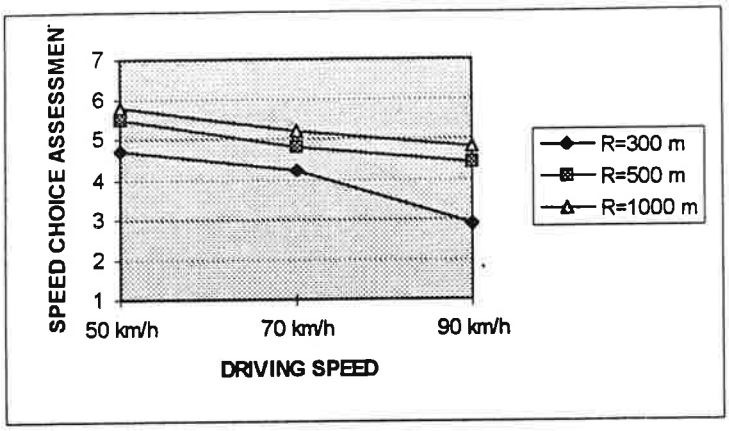

Figure 4. The effect of road curve design parameters on the subjective choice of speed assessment, at different driving speeds.

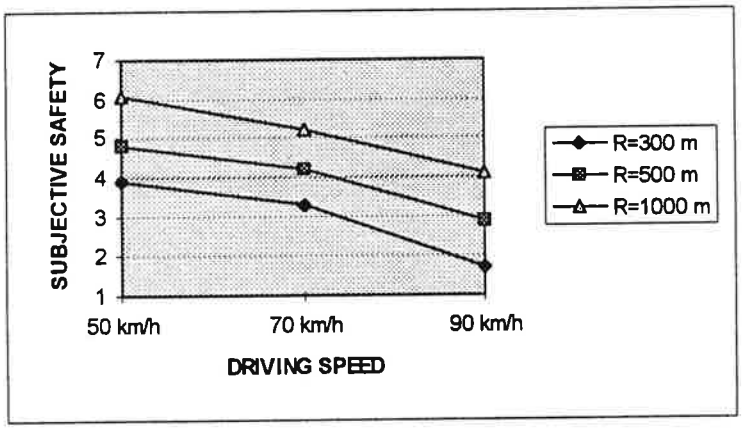

Figure 5. The effect of road curve design parameters on the subjective safety assessment, at different driving speeds.

It has been shown (Fig.5), that subjective safety increases with decrease of driving speed for each curve radius tested in the experiment. Moreover, the results demonstrate that subjective safety assessment increases with an increase of the road curve radius, while driven with the same speed along the road of variable geometry. This results supports the former findings (Zakowska,1995 and Theeuwes, 1995), that road behaviour is related to road design.

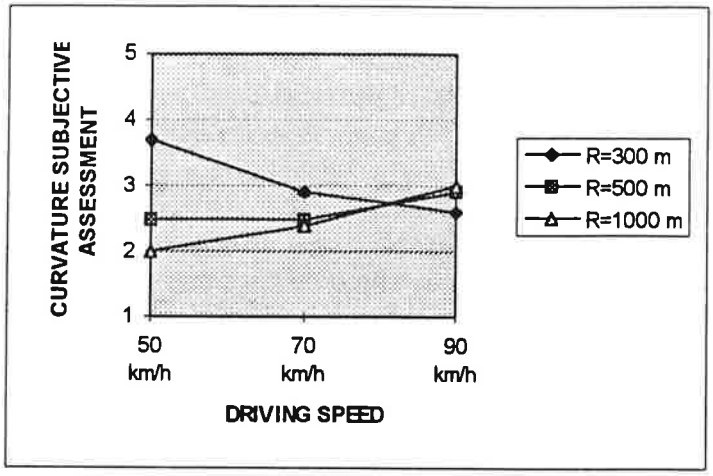

Figure 6. The relationship between objective and subjective curvature of the road driven at different speeds.

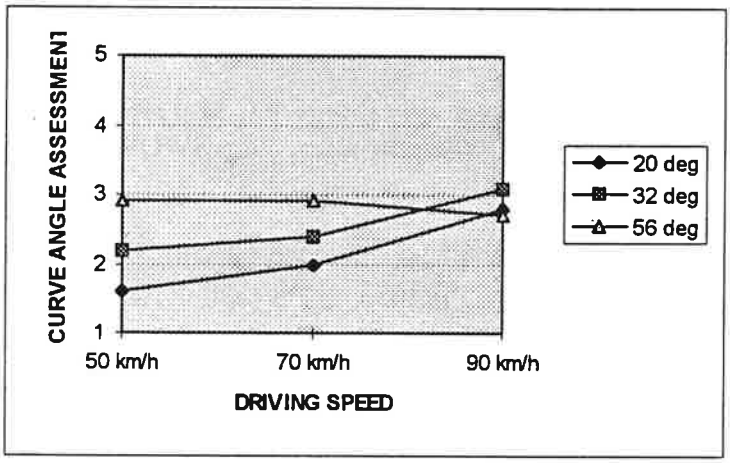

Figure 7. The relationship between objective and subjective curve deflection angle estimated at different speeds.

Conclusions

Earlier road perception studies in this series, conducted by the author, (Zakowska 1994, 1995, 1996), were directed at the lower road categories driven at the designed speed, while here, special attention was paid to the III-rd class roads (with 80 km/h design speed), but driven at three experimental speeds. This study demonstrates that dynamic perception of road infrastructure has a very significant effect on the subjective safety assessment and on the choice of driving speed. Such a road view elements as side lines painted, gentle curves and good preview, or high quality of the pavement, result in higher assessment of road

aesthetics. Especially for higher driving speeds, choice of speed is well correlated with the proper perception of the road characteristics. The higher speed of driving, though, the more attention should be put on the road fluency and road aesthetics, realised in a total care for the proper road view perception. This study supports the general finding of Tenking and Horst (1991) and Theeuwes (1994), that road behaviour is related to road design. This study furthermore demonstrated, that driving speed is strongly related to the way road users perceive road environment. To achieve safe traffic behaviour, drivers expectations, that the road environment elicits, must be in line with how road users should behave on these road. If this is realised, than one can speak of a genuine self-explaining road environment.

References:

HEINO A., MOLEN, van der, H.H. & WILDE, G.J. (1990). Risk-Homeostatic Process in Car Following Behaviour, Report VK 90-22, VSC Traffic Research Centre, RUG Haren.

LAMM R., PSARIANOS B. & GUENTHER A.K. (1994). Interrelationships between Three Safety Criteria, Modern Highway Geometric Design, as well as High Risc Target Locations and Groups. Proceedings of The Third International Conference on Safety and the Environment in the 21th Century, November 1994, Tel-Aviv, Israel, pp.439 - 449.

RUYTERS H.G.J.C.M., SLOP M. & WEGMAN F.C.M. (1994). Safety Effects of Road Design Standards, Report R-94-7, Leidschendam, NL: SWOV Institute for Road Safety Research.

TENKING, E. and HORST, A.R.A. van der (1991). Effects of road width and curve characteristics on driving speed. TNO Institute fir Perception Report No. IZF-C-26.

THEEUWES J. (1994). Self-Explaining Roads: an Exploratory Study, Report TNO-TM 1994 B-18, Soeterberg, NL: Human Factors Research.

THEEUWES J. & DIKS G. (1995). Subjective Road Categorisation and Speed Choice, Report TNO-TM 1995, B-16, Soesterberg.

WEGMAN, F. (1996). Road Design, Human Behaviour and Road Accidents: towards a 'learning design community'. International Conference "Road Safety in Europe" Proceedings, Birmingham, SWOV Report D-96-6.

ŻAKOWSKA L. (1994). Road Curve Evaluation on the Basis of Road View Perception Studies, Doctoral Thesis (unpublished), Cracow University of Technology, Civil Engineering Department, Poland.

ŻAKOWSKA L. (1995). The Effect of Environmental and Design Parameters on Subjective Road Safety - a Case Study in Poland, *Safety Science Journal* No.19, Elsevier Science

ŻAKOWSKA L. (1996). Dynamic Road View Research for Road Safety and Aesthetics Evaluation. The 7th ICECGDG Proceedings., Kraków, Fotobit Poland, Vol.I, 276-279.