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Dynamic Road View Research for Road Safety and Aesthetics Evaluation

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Abstract. The dynamic road view perception study was designed and conducted in order to get a better insight into the safety and speed effects of alternative road design. The laboratory experiment was designed, primarily, to test the effect of road category, geometric road design and road environment elements, as well as driving speed, on subjective assessment of road characteristics and drivers speed choice. The dynamic road visualisation method applied has been tested for practical use in computer aided 3D road design evaluation.

Key Words: Geometric road design, visualisation, perception, aesthetics, safety.

1 Introduction

Safety is one of the main problems of road traffic. Drivers' behaviour is highly dependent on the way he perceives the road environment, so driving is mainly a visual task. It is estimated [5] that 90% of accidents are due to human error. These errors are often caused by inadequate road design and can only marginally be changed by information, rules or sanctions [3]. As a means to a safer road design, the concept of self explaining roads (SER) has been developed. In an SER environment, drivers know how to proceed safely on the basis of the road design [4], i.e. of the road view observed. The experiment presented here[1] concerns a real-time dynamic road visualisation study of subjective safety evaluation. The validation studies of laboratory experiments in comparison to the field studies have been well documented by Denton in [1] and by Watts in [6] and [7].

2 Experimental design

The experimental research objective was to investigate the effect of the dynamic road view on the driver's perception of road characteristics and in particular to:

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- evaluate the effect of the road category on the perception of road parameters and on the choice of speed,
- search for relationships between driving speed and the perception of geometric and environmental road parameters, road safety and the subjective road and road environment aesthetics,
- describe relationships between subjective and objective information that the driver receives from the moving road view.

2.1 Method

Independent variables were the constructed geometric road parameters and road environment characteristics, as well as an experimental driving speed. The experimental dependent variables were the subjectively perceived road parameters and road view characteristics, such as road legibility, fluency, safety, aesthetics, road environment and landscape attractiveness and choice of speed.

2.2 Rating scale

The same seven point graphical rating scale was used for six road view characteristics assessments, as in the previous authors studies (Żakowska [8] & [9]). The theory underlying the choice of this scales has well been documented by Heino et al. in [2]. Fig. 1 represents the scales incorporated in this research.

						the same speed				
3. `I would drive this road section`	−	1	2	3	4	5	6	7	+
	much slower				±				*much faster*
4. `the road safety`	−	1	2	3	4	5	6	7	+
	very poor				±				*very good*
5. `the road aesthetics`	−	1	2	3	4	5	6	7	+
	very poor				±				*very good*

Figure 1: Rating scale used in the experiment

2.3 Stimuli

Eighteen road segments were selected in southern Poland from different category roads (from I-st class freeways to V-th technical class minor roads) and represented all official road categories. They varied in four groups of parameters, as shown in Table 1.

For each segment a video of the dynamic view was recorded from the driver's point of view, while driving with the design speed. Each stimulus was approximately 60 sec. long and covered the uniform characteristics for the road category represented. The pictures below (Fig. 2 and Fig. 3) are a static representation of the III-rd class road environment used as stimulus material in an experiment.

Road Typ tech. class	Speed limit (km/h)	Design Characteristics		
		emergency lane	side markings	lane width /number
I	120	+	+	3.5 / 4
II	90	–	+	3.25 / 4
III	70	–	+	3.25 / 2
IV	50	–	–	3.0 / 2
V	40	–	–	2.75 / 2

Table 1: The five categories of roads outside the built-up area in Poland and their characteristics

Figure 2:

Figure 3:

Figure 4: The laboratory environment of the experiment

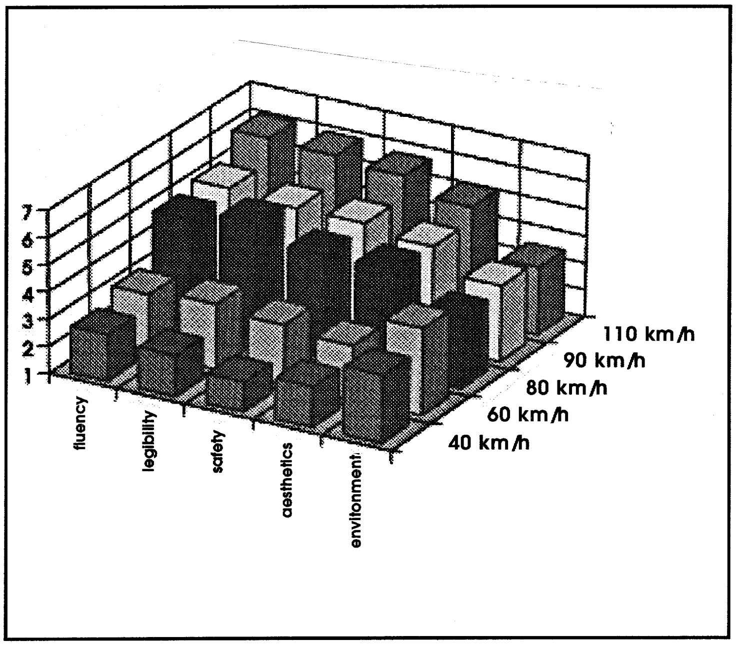

Figure 5: Mean estimates of road characteristics for each road category

2.4 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.

2.5 Procedure

Unlike in former experiments (Żakowska [8]) the motion road views were presented with use of a video projector on a large screen (2m × 3m) in a laboratory environment, giving the subjects a closer simulation of the real driving environment. Subjects were tested in groups of four to six. Fig. 4 shows the laboratory environment during the experimental session.

3 Analysis of results

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

3.1 Road category effect

The effect of road category on subjective assessment of six characteristics, namely: (I) road fluency, (II) road legibility, (III) road safety, (IV) road aesthetics, (V) attractiveness of road environment and (VI) speed choice are presented in Fig. 5. The comparison of subjective mean assessments of the above characteristics has revealed that:

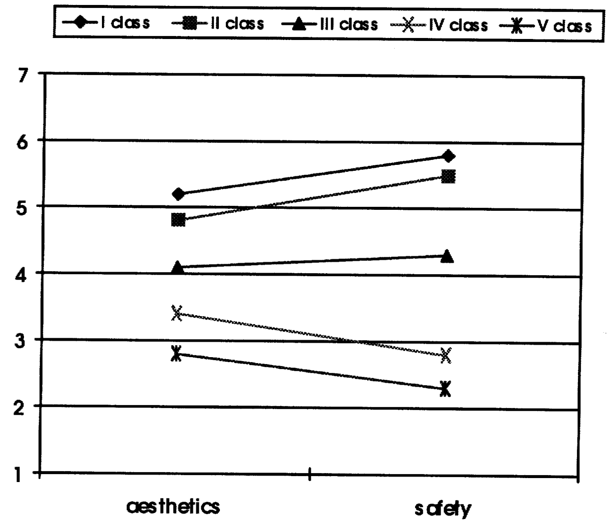

Figure 6: The relationship between subjective road aesthetics and subjective road safety for different road categories

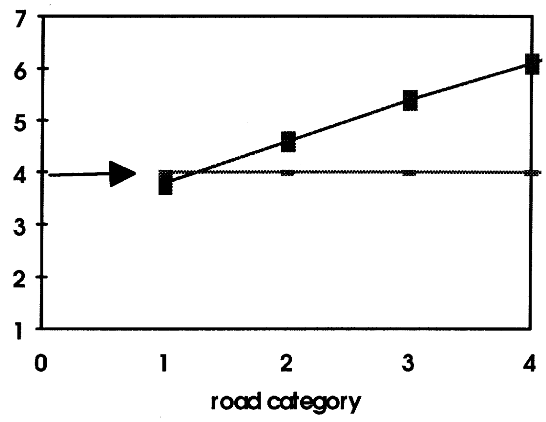

Figure 7: The effect of road category on driver's choice of speed

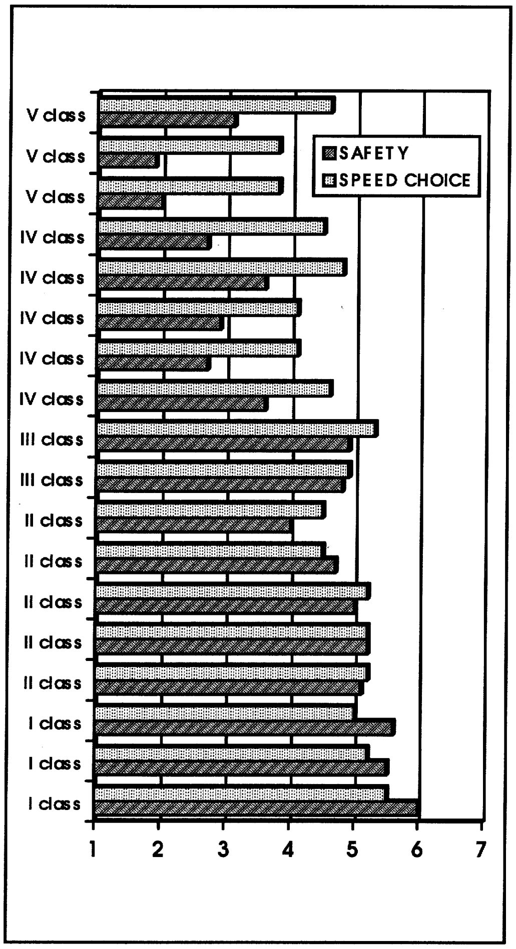

Figure 8: Safety and speed choice subjective assessments for tested segments of all road classes

- road safety, legibility and fluency assessments increase with higher road category and these characteristics are well correlated,
- road aesthetics assessments slightly increase with an increase of road category,
- road environment attractiveness assessment does not relate to road category,
- speed choice is well correlated with road safety assessment only for higher road categories (I-st and II-nd class roads); for lower road categories speed choice is in contradiction to the subjective safety and is highly overestimated.

Interestingly, there is a relationship between road safety and road aesthetics, although these characteristics are objectively not dependent.

Fig. 6 presents the effect of road category on subjective road safety and road aesthetics. As shown in Fig. 6, the IV-th and the V-th class roads were perceived as unsafe, while their aesthetics were assessed more highly, which is probably related to the road environment factors. This is in correspondence to the results revealed for higher road categories, where better infrastructure effected a higher level of safety and aesthetics evaluation.

3.2 The effect of choice of speed

Road behaviour, in particular the choice of speed, is closely related to road design. The way in which choice of speed is related to road characteristics, such as design speed and official road categorisation, is shown in Fig. 7. The higher the road category, the faster subjects would drive, in relation to the design speed of each road category.

This effect does not always correspond to the subjective road safety, which is documented in Fig. 8. For speed choice assessment, score 4 means keeping the same speed (speed limit for each road category), score 1 means dramatic speed limitation, and respectively, score 7 means a high increase of driving speed in relation to design speed. Despite the poor safety assessment of the V-th class roads, speed choice more or less corresponds to design speed. The IV-th class roads, however, although perceived as rather unsafe, unexpectedly highly scored for the speed chosen for driving (the most dramatic variation between safety and speed choice assessment exceeds two points in the seven points scale). This may explain the low level of safety at this road category, documented in a large number of accidents.

The results (Fig. 8) show stabilisation for higher road categories. III-rd class roads are perceived as rather safe and speed choice scores present only a slight increase in driving speed over the designed speed. For II-nd class roads, mean speed and safety estimates are highly correlated, although scores are not the same for each road segment. This result is in in correspondence to the earlier findings of Theeuwes [5] in the speed choice experiment based on static stimuli, where it was claimed, that driving speed is related to elements of the environment. The important elements in determining the speed here, were pavement characteristics, side markings, presence of side-roads, houses, trees, the overview etc. Surprisingly, for I-st class roads, safety assessments exceed the speed assessment scores. Drivers perceive highways as very safe roads and would decide on increasing the driving speed above the speed limit, but no higher than the safety scores.

4 Discussion and Conclusions

The present study indicates that road users are able, based on dynamic road-like stimuli, to discriminate between the basic road characteristics in most road categories. Earlier road perception studies in this series, conducted by the author ([8], [9]) were directed at the lower road categories, while here, special attention was paid to the I-st and II-nd class roads (with 120 and 90 km/h design speed). 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. Road view elements, such as painted side lines, gentle curves and good preview, or high quality of the pavement, improve the aesthetic quality of the road. Especially in high road categories, choice of speed is well correlated with the proper perception of the road characteristics. The higher the road category (and therefore the driving speed), the more attention should be put on the road aesthetics, achieved through total care for the proper road view perception. This study supports the Theeuwes' [5] findings, that road behavior is related to road design. This study furthermore demonstrated, that driving speed is strongly related to the way road users perceive the road environment. To achieve safe traffic behavior, the expectations of the driver, elicitted by the road environment, must be in line with how road users should behave on these roads. If this is achieved, then one can speak of a genuine self-explaining road environment.

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