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Impact of Perceptual Countermeasures on Driving Behaviour at Curves Using Driving Simulator

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ABSTRACT

Objective: The probability of crash occurrence on horizontal curves is 1.5 to 4 times higher than tangent sections. Majority of these crashes are associated with human errors. Therefore, human behaviour at the curve needs to be corrected.

Methodology: In this study, two different road marking treatments, 1) optical circles and 2) herringbone pattern, were used to influence drivers' behaviour while entering the curve on a two-lane rural road section. A driving simulator is used to perform the experiment. The simulated road sections are replicas of two real road sections in Flanders.

Results: Both treatments were found to reduce speed before entering the curve. However, speed reduction was more gradual when optical circles were used. Herringbone pattern had more influence on lateral position than optical circles by forcing drivers to maintain a safe distance with the opposite traffic on the adjacent lane.

Conclusion: The study concluded that among other low-cost speed reducing methods, optical circles are effective tools to reduce speed and increase drivers' attention. Moreover, Herringbone pattern can be used to reduce crashes on the curves, mainly for head-on crashes where the main problem is inappropriate lateral position.

Keywords: Driving Simulator, Driving Behaviour, Herringbone Pattern, Horizontal Curves, Optical Circles, Road Marking

INTRODUCTION

One of the important factors which requires due attention of the designers while designing a road section is road safety, especially in case of rural roads. According to the NCHRP report (Torbic, Harwood, et al. 2004), approximately 75 percent of all fatal crashes occur in rural areas. On rural roads, certain behaviour is expected from the driver which is communicated through various clues. Knowledge of drivers' perception of these clues is important as failure to comprehend these will result in unsafe situations. Weller, Schlag, Friedel, Rammin (2008) concluded that drivers classify rural roads in three different categories which can be distinguished by few objective criteria. Application of these criteria can help us design rural roads on the self-explaining principle. A road design can be considered as self-explaining when it is able to evoke the required behaviour from the drivers without the help of road signs (Theeuwes, Godthelp 1995). With few additional road markings, a road can be made self-explanatory. Their role is to inform drivers about the behaviour needed to be adopted while driving through dangerous sections.

Previous research shows that probability of occurrence of a fatal crash in curves is 1.5 to 4 times higher than that for tangent sections (Alexei, Randy, Nicholas 2005) that makes safety a major concern in designing horizontal curves especially in rural areas. Radius of a curve is directly proportional to the design speed of the road (AASHTO 2011) and in some situations, it is required to be increased for enhancing road safety. Solutions other than changes in geometric design are required if geometry of the curves cannot be modified due to factors such as lack of available space etc. This is the case for the two selected locations in this study where altering geometric features of the curves was not feasible. According to Charlton (2007), driver's lack of attention, improper judgement of speed, poor lane positioning are major causes of driving errors that can result in crash occurrence implying the importance of appropriate curve design.

Several pavement markings at different road sections have been studied previously to make roads self-explaining (Charlton, Starkey, Malhotra 2018,Daniels, Vanrie, Dreesen, Brijs 2010,Retting, Farmer 1998). To ensure safe driving through the dangerous sections, speed reduction before entering the danger zones and maintaining the appropriate lane position is important. Charlton (2007) used various combinations of pavement markings and warning signs in a driving simulator study and found that herringbone pattern used with signboards increased the separation gap between the two opposing lanes of traffic and influences driver to follow the path that provides maximum available radius through the curve, which results in appropriate lateral position. Ariën, Brijs, et al. (2012) studied transverse rumble strips and herringbone pattern at curves on a two-way rural road in a driving simulator and found that transverse rumble strips were more effective than herringbone pattern in reducing speed. Kerman, McDonald, Mintsis (1982) proposed a reduction in approach speed to reduce speed at curves. This is because speed choice at curves is highly dependent on approach speed and geometry of the curve. Geem, Charman, et al. (2013) used this approach of reducing speed before the entrance of the curve in their driving simulator studies by applying different treatments (e.g. sign boards, surface treatments etc.), both individually and in combination. It was concluded that the application of treatments according to the severity of curves do result in speed reduction.

Some configurations of pavement markings are presumed to manipulate speed perception of the drivers by creating an illusion of high speed, commonly called perceptual pavement markings(Rosey, Auberlet, Bertrand, Plainchault 2008,Ding, Zhao, Rong, Ma 2013,Meyer). Godley (1999) used optical transverse bars which gradually increased in length and width making drivers to get a feeling of increased speed while driving over them, which resulted in speed reduction. Kitamura, Yotsutsuji (2015) studied the effects of sequential transverse and lateral markings on perceived speed on a single-lane straight road using driving simulator. Different configurations of transverse markings along with roadside poles were created in which spacing between transverse markings and poles was decreasing gradually. Results indicated that the perceived speed was higher than the actual vehicle speeds. Montella et al. (2015) studied effects of transverse rumble strips, coloured strips, dragon teeth, and a coloured median along with other traffic control devices (signboards) in a driving simulator. Perceptual markings (i.e. dragon teeth, coloured strips and median) were found to have significant effect on driving behaviour both in the approach tangent and inside the curve. However, dragon teeth markings were applied in combination with the transverse rumble strips. Based on the concept of self-explaining roads and in relation to the optical markings, optical bars and dragon teeth have already been studied. However, it is required to study more innovative markings in order to develop better standards for optical markings for different scenarios such as curve section, transit areas (i.e. between rural and urban settings), danger zone etc. To augment the already existing knowledge on the effect of optical markings on driving behaviour, this study presents a novel optical marking (i.e. optical circle) to be used before horizontal curves We hypothesize that the use of optical circles can increase drivers' vigilance and make them reduce their speed.

Previous studies mentioned above show that driving simulator is an effective tool to understand driving behaviour and study effects of other factors on it. Various other studies also used driving simulator addressing various behavioural and design related issues (Bella 2014,Bella, Calvi 2013,Antonson, Ahlström, Wiklund, Blomqvist, Mårdh 2013,Bartolozzi, Frendo 2014,Helland, Jenssen, et al. 2016,Oron-Gilad, Ronen 2007,Papantoniou 2017). In our study, driving simulator is used to create two horizontal curves selected from real world and optical circles (created on the same principle as of optical bars) and herringbone pattern (used by Charlton (2007)) are applied using the similar methodology as explained in Ariën, Brijs, et al. (2017). The following section contains an overview of the methodology adopted for this study. This is followed by the section where obtained results are analysed and presented. These results are then discussed in detail followed by the conclusions section.

METHODOLOGY

The driving simulator at the Transportation Research Institute (IMOB) of Hasselt University, is a fixed base medium fidelity simulator consisting of a mock up car (Ford Mondeo) with a seamless, curved screen placed at front of the vehicle. A synchronized image of 4200 by 1050 pixels quality is presented by three projectors at 60Hz refresh rate with 180^0 wide vision. Steering wheel, speed meter, brake, clutch and accelerator pedals and mechanisms are replaced by the digital counterparts for data collection. Vehicle sounds (simulator and traffic) were also presented. Data from the driving simulator was collected at the frame rate. Previously, several road design and road marking studies (Arien, Jongen, et al. 2013,Ariën, Brijs, et al. 2014) have been conducted using the same driving simulator and its validity has been verified in Ariën, Brijs, Vanroelen, Ceulemans, Jongen, Daniels, Brijs, Wets (2017).

Two horizontal curves (named as Hoogstraat and Masseik in this paper) selected from Belgian road network on a two-way rural road were created in STISIM Drive Version 3. Lane width on the Hoogstraat and Masseik was 3.2m and 2.8m respectively. Both of these were transitional curves and their lengths and radii are given in Table

1. Pavement markings i.e. optical circles and herringbone pattern were placed on both of these curves. Effects of these markings were studied by comparing both curves with a control scenario in which no treatment was applied. As a result, six road sections (three sections for each curve) were created. Length of these road sections for both curves was three kilometres and they were arranged in a randomized order to make two 18km long scenarios. The entire driving duration for both test scenarios was approximately 30 minutes.

Optical circles segment was 90 meters long with a centre-to-centre distance of 10 meters between circles. The diameter of circles increased gradually from 1.4m to 2.3m with an increment of 0.1m. Top view of optical circles in the driving simulator is presented in Figure 1 (a). The illusion of increased speed is created by the concept of forced perspective illusion according to which relation between viewing angle and distance can make objects to appear larger or smaller than their actual size (Endler, Endler, Doerr 2010). This optical circle segment ended 91 and 107 meters before the start of the curve for the case of Masseik and Hoogstraat respectively. Optical circles in this study are designed on the similar principal of previous studies in which transverse optical bars with gradually increasing width and decreasing distance between the markings were used to increase the perceptual speed of the drivers (Galante, Mauriello, et al. 2010,Godley, Triggs, Fildes 2000,Montella, Aria, et al. 2011). Reason to choose circles over square and eclipse is that circles require less area than squares and eclipse will become longer if placed along its major axes in the direction of travel and might not create illusion of increased speed, or they can cover considerable portion of the lane width if placed along their major axes perpendicular to the direction of travel (Hussain, 2017). Triangular road markings have been already used for various purposes such as warning signs, shark/dragon teeth markings for priority, and to keep safe distance on highways. It is assumed that it might be confusing for the drivers to understand the intended purpose of the markings if triangular markings are used in the manner similar to the previous ones. According to Dewar & Olson (2007), road markings might have negative impact on various other aspects of the road structure such as drainage, surface friction etc. Hence, the proposed treatment with circular shape is the most feasible due to their less surface area.

Herringbone pattern used by Charlton (2007) is given for 3.5m lane width. Width for the drivers to drive on both road sections was kept 2.5 meters at the start of the curve. This width gradually increases to the maximum lane width in the middle of the curve and then starts to reduce again. In this study, length of herringbone section was kept 196m for both curves. For Hoogstraat, herringbone section started 38 meters before the start of the curve and lasted 28m after the curve. For Masseik, this section started 50 meters before the start of the curve and ended 30 meters after the curve. The inclination of herringbone strips was kept along the direction of the travel. Top view of herringbone pattern is shown in Figure 1 (b).

49 participants volunteered in this study with age range between 19-54 years with mean age of 26.08 years. 28 % of the participants were female and remaining 72 % were male. Participants were invited through personal contacts of the researchers. They were given a brief introduction to the driving simulator and the study. After this, a warmup drive of approximately five minutes was conducted by each participant to make themselves familiar with the simulator before they drove the two scenarios of 18Km length.

Data was collected through the entire drive for both 18Km long scenarios. However, for data analysis, data from the second run was considered as we presume that the data for the second run describes more realistic driving behaviour due to the novelty effects of the first run and the potential learning effects. After detecting outliers, data for 43 participants were considered in the analysis. Driving behaviour parameters considered in this study are longitudinal speed, mean acceleration/deceleration and mean lateral position. Effects of pavement markings are computed and compared for both curves on 11 points (along the longitudinal axis) selected for the analysis. Description of these points is provided in Figure 2d. For lateral position values obtained from the driving simulator, the central median was considered as benchmark. Positive values indicate that driver is on the right side of the median.

RESULTS

Due to the difference in lane width of the two roads, both curves are analysed individually by applying MANOVA statistical test to study overall effects of independent variables (i.e. road marking, points, two-way interaction between road marking and points) on dependent variables (i.e. speed, acceleration and lateral position) and repeated measures ANOVA to study the with-in subject effect of independent variables on each dependent variable individually. Repeated measure ANOVA was applied due to the reason that each participant drove through all treatment conditions. Results are provided in the following paragraphs of this section. Table 2 and Table 3 present the analysis results for Hoogstraat and Masseik respectively. Road markings and points were found to have overall significant effect including the two – way interaction between them (Wilks' Lambda $p < 0.05$). This means that each road marking has significantly different values on each of the 11 points. Effects of markings are explained on all three dependent variables in this section.

Mean Speed

Figure 2a and 3a show three speed profiles across the 11 points for all three conditions for the curves Hoogstraat and Masseik respectively. For both curves, there is a difference between speed profiles of three different road treatments at various points. For Hoogstraat, independent variables such as points and the two-way interaction were found significant (*p*-value<0.05, Table 2) whereas road markings turned out to be insignificant for speed (*p*-value=0.815, Table 2). Post-hoc analysis for the curve Hoogstraat shows that significant difference in mean speed was observed between the control scenario and scenarios with road markings (*p*-values <0.05 Table 4). However, difference was not significant among the two road markings (i.e. herringbones and optical circles with *p*-value > 0.05). For Masseik, all three independent variables had significant effect on speed (p-value<0.05, Table 3). Post-hoc analysis shows that for the curve Masseik, mean speed was significantly different among three scenarios (*p*-value < 0.05). These results show that road markings significantly reduced mean speeds before and in the curve. Drivers started to reduce their speed from the point 500 meters before the curve (500MBC) for all three conditions for both curves. The reason for this is that the curve was made visible approx. 500 meters upstream and a warning sign was placed 500m before the curve. At the Hoogstraat curve, for both treatments mean speed was decreasing until the start-of-the-curve point, however, in control condition speed kept decreasing till the middle-of-the-curve. At the Masseik curve, decrease was noted for all three conditions, and it was maximum for optical circles at the end-of-treatment point. This was expected as the objective of surface treatments is to reduce the speed of the driver before entering the curve.

Mean Acceleration

Table 2 and 3 show that all three independent variables were significant for acceleration at both curves (*p*-value<0.05). Figure 2b and 3b show the plots of mean acceleration values for all three treatment conditions across the 11 points. Difference between acceleration values among all three conditions at both curves can be seen. The post-hoc test showed that for the curve Hoogstraat, mean acceleration was significantly different among the control and the two road markings and also between the two road markings themselves (*p*-values < 0.05 Table 4). For the curve Masseik, in the post-hoc analysis, mean acceleration was found significantly different between the control scenario and the two road markings (*p*-value < 0.05). However, mean acceleration was not found to be significantly different between the two road markings. This shows that both road markings increased vigilance of the drivers by compelling them to decelerate well before the start of the curve. In case of Hoogstraat, the acceleration in the optical circles case drops from '500MBC' to the minimum value at start of optical circles (SOOC). The decrease in the acceleration was gradual, which also correspond to a second order (much smoother) change in speed for optical circles case compared herringbone and control cases. For herringbones, the decrease in acceleration was constant from '500MBC' till 'SOOC'. This is because the herringbone markings were visible before the start of the curve. Thus, drivers reacted to those markings by decreasing their speed before the start of the curve. However, minimum acceleration values at the point end of optical circles (EOOC) imply that the drivers applied brakes over the course of 100 meters between SOOC and EOOC. In control case, acceleration values suggest that the drivers started to decelerate from the point 'SOOC' and kept on decelerating till they reached the point 'first quartile of the curve' (FQOC).

For Masseik, acceleration for optical circles was minimum at 'SOOC' point. For herringbone and control conditions, minimum acceleration values were found at the point start of the curve (SOC). Acceleration value for herringbone was smaller compared to control condition which implies drivers are braking suddenly. However, increase in acceleration through the curve was largest for the herringbone treatment. This is because, for the herringbone treatment, drivers did not have to focus on correcting their lateral position, they only required to take care of speed and acceleration. From this, we can assume that optical circles had a positive influence on speed and acceleration as they were able to reduce speed gradually. The speed did reduce for control and herringbone pattern but acceleration values suggest that speed before entering the curve was not decreased gradually rather abruptly.

Mean Lateral Position

Table 2 shows that for Hoogstraat, lateral position of the drivers are significantly different (p-value < 0.05) for points and the two-way interaction between points and road marking. The significance of the two-way interaction factor shows that values changed significantly for each road marking treatment among 11 points. This is also visible in Figure 3c and 4c. Table 3 shows that for Masseik, lateral position is significantly different for all three independent variables (p-value < 0.05). Lateral position values for Masseik were found to be lower than Hoogstraat. This was because of the narrower lane width of Masseik than Hoogstraat (2.8 for Masseik and 3.2 for Hoogstraat). Table 4 shows the post-hoc results for lateral position among the three scenarios. For both curves, significant difference in lateral position was found between herringbone and the other two scenarios (*p*-value < 0.05). However, lateral position was insignificantly different between the optical circles and the control scenario (*p*-value > 0.05). This indicates that only herringbone pattern significantly influenced the lateral position of the drivers in the curves. This is a rather predictable situation since the optical circle markings did not continue into the curve and were intended to reduce speed with no impact on lateral position. For both curves, drivers started to adjust their lateral position from the 'SOOC' point, which is approximately 300 meters before the start of the curve, by shifting towards the right edge of the lane when herringbones were applied. Drivers adjusted their lane position by driving closer to the left side of the lane between points 'SOC' and 'FQOC' in case of Hoogstraat. For Masseik, the lateral position for all three treatments were found to be approx. similar at the 'SOC' point. In case of herringbone marking, drivers lateral position were approximately around the middle of the lane, however, for optical circles and control condition case, drivers were found to drive more towards the left edge of the lane through the curve. This might be considered unsafe as this can increase the risk of head-on collision with the traffic on the opposing lane.

DISCUSSION

The main objective of this study was to investigate the effects of two road markings i.e. optical circles and herringbone applied before and in the curve on driving behaviour parameters using a driving simulator. In order to ensure safe driving through the curve, speed reduction should take place before drivers enter the curve as speed reduction in the curve can cause skidding of the vehicle which increases the probability of crash occurrence. Speed difference between the points 'EOOC' and 'SOC' for control condition was found to be minimum (5.33km/hr) than for herringbone and optical circles (12.23 and 8.51km/hr respectively) for Hoogstraat curve. Whereas in case of Masseik, the difference for control condition was found to be 9.07km/hr and for herringbone and optical circles, it was 8.87km/hr and 7.84km/hr respectively. This shows that both road marking treatments were able to reduce the speed of the drivers before entering the curve. Based on the concept of relative validity of the driving simulators, it can be assumed that the magnitude of the change in speed might be different in reality if same treatments are applied before and at the curve but the direction of changes would be similar (i.e. speed will decrease). For optical circles, acceleration values decreased uniformly because the optical circles were applied 100m before the curve. Acceleration values for herringbone and control condition decreased sharply before the point 'SOC'. This shows that optical circles were effective in safe reduction of speed before entering the curve. Though mean acceleration magnitude for all conditions was less than the recommended rate of -0.85m/s2 (Lamm, Choueiri 1987), it can be assumed that variations can be expected in real life, however, it cannot be said with certainty that low values of deceleration was caused due to release of the gas pedal by drivers or with the use of brake pedals. Our study also did not observe this behaviour. For herringbone pattern, acceleration values started to increase after the point 'SOC'. This is because drivers' lateral position was controlled by the herringbone markings. As a result, drivers were comfortable to drive at higher speeds through the curve. For the lateral position, herringbones pattern's influence was significant in the curve for both Hoogstraat and Masseik. The reason for that is the path that drivers have to follow along the herringbone pattern is created in a way that the radius of the driver's trajectory is increased.

As mentioned in the literature that crash rate on curves is almost 1.5 to 4 times higher than on the straight sections and 60 to 70% of all the fatal crashes on curves are caused by single vehicle runoff (due to inappropriate speed and lateral position) (Calvi 2015). The results of our study show that by decreasing speed and modifying lateral position of the drivers, drivers' vehicle control is increased which might lead to decrease in crash rate on curves.

Ariën, Brijs, Vanroelen, Ceulemans, Jongen, Daniels, Brijs, Wets (2017) found that for speed reduction, transverse rumble strips were more effective than the reverse herringbone pattern. In our study speed reduced for both treatments but acceleration values suggest that optical circles will cause a safe reduction in speed before the curve. For lateral position, Ariën's study did not find any significant effect of both transverse rumble strips and reverse herringbone pattern treatments before or through the curve. In our study, herringbone pattern was found to influence the lateral position of the drivers before and through the curve. This may be due to the appropriate design of the herringbone strips followed in our study. In Ariën study, herringbone strips were always having the constant length and strip inclination was also in the opposite direction of traffic flow.

Effects of optical circles on the speed reduction at curves have not been investigated previously. However, different studies did investigate the effects of optical bars on speed reduction on a straight road. In one such study, various methods to reduce speed before approaching an intersection were compared in which optical bars were compared with simple rumble strips (Montella, Aria, D'Ambrosio, Galante, Mauriello, Pernetti 2011). Both were found to significantly reduce the speed. Another study was conducted at the Hasselt University (IMOB) in which speed reduction at rural-urban transition due to optical bars and optical circles were studied and optical circles turned out to reduce speed more than optical bars (Hussain 2017). Results of our study give a similar outcome that optical circles are able to reduce speed safely before entering curves as compared to the herringbone pattern. A study by Montella et al. (2015), where the impact of dragon teeth were investigated on two-lane rural highways indicated that optical markings are more effective compared to other combination of road markings to reduce speed at the curve entry. They noted reduction of 12 km/hr at the curve entrance in comparison with do nothing case (the mean speed of drivers before the curve section was 110 km/hr). In our study, although the optical circle marking are found effective and significant reductions of speed were noted, the results cannot be directly compared with this study since in our case the design speed before the curve is 70 km/hr. At the entry of the curves reductions of 3-4 km/hr are noted compared with control scenario. Our study further strengthen the case for the use of optical marking as it influence the operating speed on the curves.

Road markings can be considered as relatively low-cost alternatives than other speed perceptual treatments such as road-side fence and gantry treatments to create road narrowing effect and increase drivers attention. However, according to Dewar, Olson (2007), such road markings/treatments can have drawbacks like lower drainage, lower tire to road surface friction, noise etc. Similar drawbacks can be anticipated for optical circles when implemented in real life. Hence in order to use optical circles at curves, proper engineering considerations and selection of suitable material to install optical circles can reduce such negative impacts. Herringbone pattern used in this study was found to have a significant effect on the lateral position. However, herringbone pattern used in combination with other speed reducing treatment might result in speed reduction together with better lateral position along the curve.

CONCLUSION AND FUTURE RESEARCH

Results obtained for driving behaviour parameters show that both optical circles and herringbones have positive effects on driving behaviour. The optical circles caused safe speed reduction before entering the curve which makes them a more suitable option than herringbone pattern. However, for lateral position, herringbone pattern made drivers follow a safe path along the curve. This shows that herringbone pattern can significantly reduce the number of head-on crashes on the curves where crashes occur mostly due to faulty lateral position of the drivers. Hence, it can be concluded that at curve sections where speed reduction is required, optical circles are better option whereas herringbone pattern is more useful when inappropriate lateral position is the known cause of crash occurrence.

Real world implementation of both treatments with before and after studies can allow policy makers to study the long term effects of both treatments. Moreover, comparison of other perceptual treatments and their combination (e.g. combination of herringbone pattern and optical circles) using a driving simulator may also be investigated in future.

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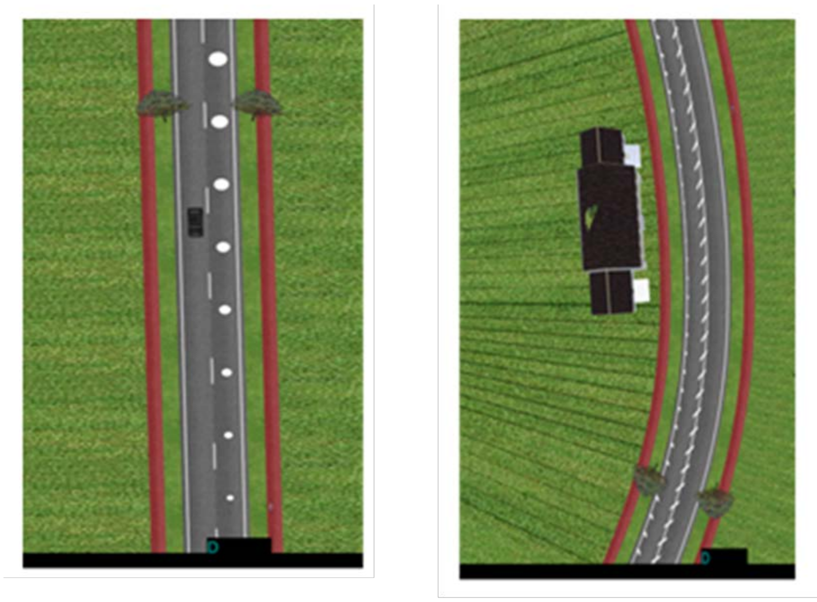
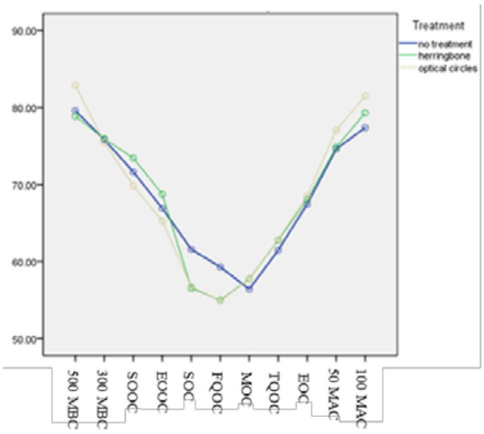
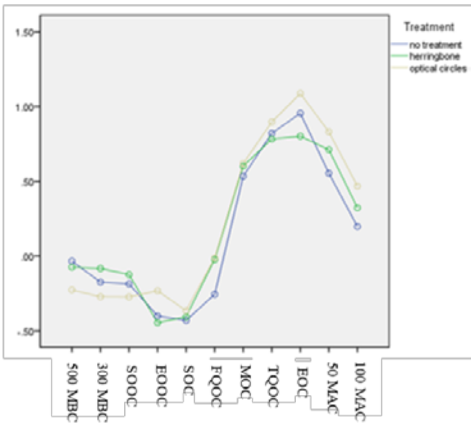


(a) Optical Circles (b) Herringbone Pattern

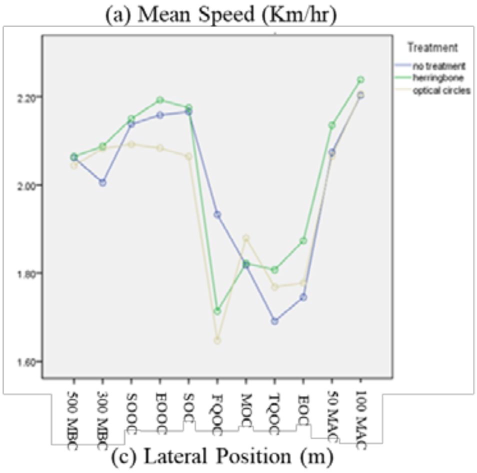
Figure 1: (a) Top view of optical circles, (b) Top view of Herringbone Pattern,



(a) Mean Speed (Km/hr)



(b) Mean acceleration (m/s^2)

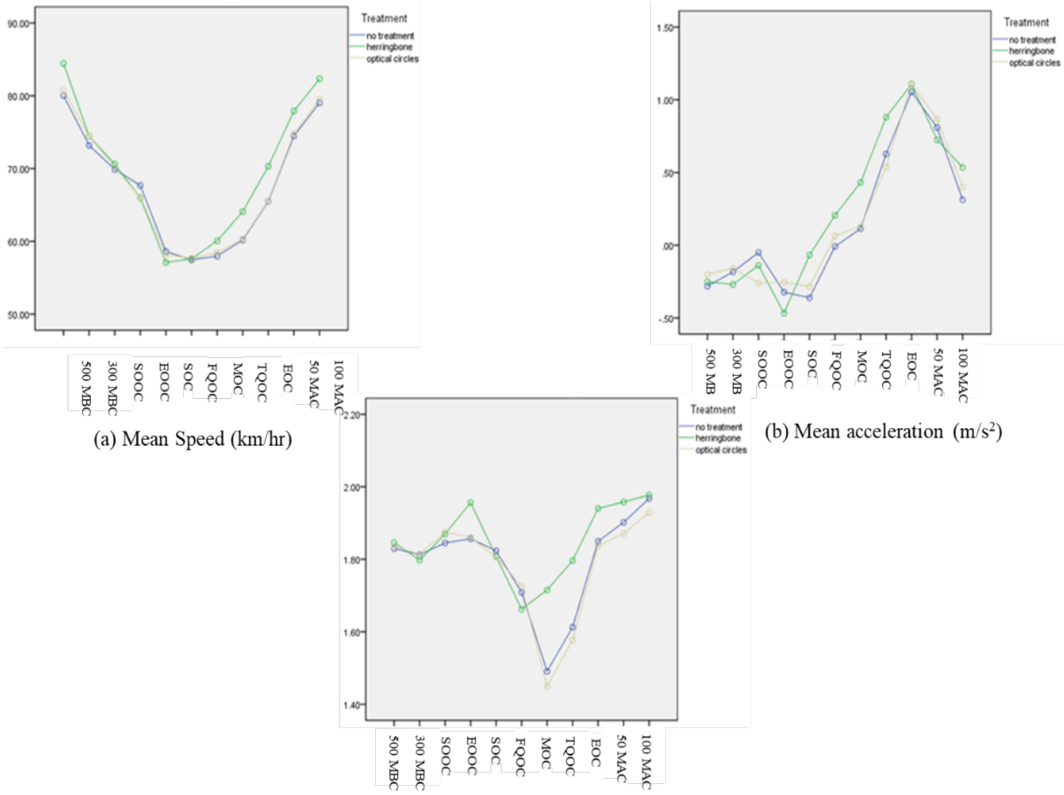


(c) Lateral Position (m)

Points	
500 MBC	500 meters before the curve
300 MBC	300 meters before the curve
SOOC	Start of optical circles
EOOC	End of optical circles
SOC	Start of the curve
FQOC	1/4th of the curve
MOC	Middle of the curve
TQOC	3/4th of the curve
EOC	End of the curve
50 MAC	50 meters after the curve
100 MAC	100 meters after the curve

(d) Points before, at and after the curve

Figure 2: a) Mean Speed, b) Mean acceleration, c) lateral position for the curve Hoogstraat, and d) description of 11 data points before, at and after the curve.



(a) Mean Speed (km/hr)

(b) Mean acceleration (m/s^2)

(c) Mean lateral position (m)

Figure 3: a) Mean speed, b) Mean acceleration, and c) Mean lateral position for the curve Masseik

Table 1: Curve lengths and their radii

	Curve Radius (m)		Curve Length(m)	
	Hoogstraat	**Masseik**	**Hoogstraat**	**Masseik**
Curve 1	170	169	17.21	51.13
Curve 2	94	92	28.92	18.80
Curve 3	161	97	45.76	21.28
Curve 4	219	688	38.15	25.27

Table 2: Statistical analysis results for the curve Hoogstraat

MANOVA results for Hoogstraat (Wilks' Lambda)						
Independent factor	**F value**			**_p_-value**		
Road Markings	206.048			.000		
Points	6.636			.000		
Road Marking * Points	2.077			.000		
Test of With-in Subject Effects (Greenhouse-Geisser)						
Independent Factor	**Speed**		**Acceleration/ Deceleration**		**Lateral Position**	
	F value	**_p_-value**	**F value**	**_p_-value**	**F value**	**_p_-value**
Road Markings	.185	.815	6.342	.003	.634	.488
Points	112.909	.000	91.303	.000	55.238	.000
Road Markings * Points	5.899	.000	2.108	.015	5.375	.001

Table 3: Statistical analysis results for the curve Masseik

MANOVA results for Masseik (Wilks' Lambda)						
Independent factor	**F value**			**_p_-value**		
Road Markings	10.568			.000		
Points	6.636114.454			.000		
Road Marking * Points	2.279			.000		
Test of With-in Subject Effects (Greenhouse-Geisser)						
Independent Factor	**Speed**		**Acceleration/ Deceleration**		**Lateral Position**	
	F value	**_p_-value**	**F value**	**_p_-value**	**F value**	**_p_-value**
Road Markings	6.265	.002	5.734	.005	12.955	.000
Points	119.579	.000	78.543	.000	45.798	.000
Road Markings * Points	3.730	.001	3.195	.000	5.463	.000

Table 4: Post-Hoc Analysis results for Masseik and Hoogstraat Curves (_p_-values)

	Road Marking		**Speed**	**Acceleration**	**Lateral Position**
Hoogstraat	No marking	Herringbone	0.024	0.009	0.007
		Optical Circles	0.031	0.004	0.384
	Herringbone	No marking	0.024	0.009	0.007
		Optical circles	1.000	0.04	0.021
	Optical circles	No marking	0.031	0.004	0.384
		Herringbone	1.000	0.04	0.021
Masseik	No marking	Herringbone	0.023	0.009	0.002
		Optical Circles	0.022	0.008	0.805
	Herringbone	No marking	0.023	0.009	0.002
		Optical circles	0.005	0.071	0.000
	Optical circles	No marking	0.022	0.008	0.805
		Herringbone	0.005	0.071	0.000