

INTERACTING DRIVERS AT INTERSECTIONS: WHAT CAN MAKE THEM MORE SAFE AND MORE EFFICIENT?

Maura Houtenbos
SWOV Institute for Road Safety Research
The Netherlands
Paper Number 09-0240

ABSTRACT

Technological applications not only affect individual behaviour in traffic, but also influence interaction behaviour. However, not much research has been conducted in this area. This paper attempts to fill the gap by investigating the effects of manipulations of the time and space ("interaction space") drivers have to safely negotiate an intersection. Interaction space was manipulated by providing drivers at intersections with information about other approaching drivers, and also by varying the expectedness of the approach speed of the other driver. An experiment was conducted using an innovative and promising approach with two linked driving simulators, where participants (N=26) were provided with in-vehicle information (flashing lights in their dashboard and beeps), indicating the direction and speed with which another driver approached on the intersecting road. Based on the right of way regulation, speed could be either expected or unexpected. The use of linked simulators allowed the participants to interact with a real driver (the experimenter), rather than with pre-programmed drivers and thus provided important information concerning the interaction process. Different behavioural indicators of the safety and efficiency of the interaction process were recorded. Also, concerning the information provided, the level of acceptance and experienced mental effort is reported. The results regarding the behavioural indicators suggest a proactive and reactive stage within an intersection approach, where the latter stage seems more prone to manipulations of interaction space. The acceptance results indicated that the lights were not appreciated whereas the beeps were regarded as quite useful. Mental effort was (subjectively) lower in the condition where extra information was provided. This experiment provides a valuable indication of the effect information would have on driving behaviour, although it should be noted that the precise way information was provided here is too simplistic for direct application in real traffic.

INTRODUCTION

Today, more and more technology finds its way into our daily lives and affects the way we interact with each other. Interactions with other road users

are no exception to this observation. In a considerable number of studies technological applications have been shown to affect each road users' *individual* behaviour [e.g., 1, 2, 3, 4, 5]. A less explicitly researched aspect is the way technological applications ultimately affect the *interaction* between road users. Although there are studies [e.g., 6, 7, 8] that have included measures indicating effects of technological applications on the interactive aspect of the driving task (e.g., approach and turning behaviour at intersections, gap acceptance, braking behaviour), the interactive aspect of the driving task is rarely, if ever, the main issue in these studies. It appears that the phenomenon where one road user's behaviour is affected by what happens in the environment, *including* the behaviour of other road users, remains an undervalued topic in research on driving behaviour. This paper aims to fill the gap by focusing on the consequences for the safety and efficiency with which road users will (potentially) interact.

Interactive driving behaviour is easily observed at intersections where drivers encounter other drivers on their paths. To regulate the interaction, traffic lights are often installed, preventing drivers on conflicting paths being in the same place at the same time. However, traffic lights cannot totally prevent crashes at intersections which is partly due to the well documented "amber light dilemma". The amber light dilemma occurs on a road section upstream from a signalised intersection in which a driver approaching the intersection will neither be able to stop safely after the onset of amber, nor be able to clear the intersection before the end of the amber duration, while overall complying with the traffic regulations (i.e., not accelerating at an amber light)[9]. Besides signalised intersections, where interactive driving behaviour is largely controlled and eliminated by traffic lights, intersections without traffic lights also exist, where interactive behaviour can be observed more easily. At the latter intersections, the amber light dilemma, by definition, does not exist. However, a similar dilemma can still occur at intersections without any designated priority. Take two different drivers approaching an intersection. A third driver's approach from the right can be interpreted as a traffic light with different colours. If the driver is far away and/or approaching slowly, this can be

interpreted as a green light. If the driver is rather close and/or approaching at a high speed, this can be interpreted as a red light. Everything in between can be interpreted as the amber phase of the light and is up to the specific interpretation of the drivers' approach. For example, one driver might interpret the third driver's approach as a potential conflict and decide to yield, whereas a second driver might decide to accelerate and clear the intersection before the approaching driver has reached it. These different interpretations could lead to a rear-end collision if the second driver does not anticipate the first driver braking for the approaching driver. The dilemma here is in interpreting the approach of third road user and anticipating if this will conflict with your own trajectory. How is it, that without time or facilities to negotiate who goes first, drivers usually are able to stay out of each other's way?

To be able to successfully interact in traffic, we can assume that road users need *expectations*. Adequate expectations help drivers anticipate what other road users might do allowing them to prepare for a certain action. Expectations are a way of coping with the time constraints that apply in many situations where interactive driving is required. There are also other ways to help drivers cope with the time constraints in these kinds of situations. For example, allowing drivers a better view of the intersection will help them to better anticipate what will happen. Or, by behaving as could be expected, drivers can help other drivers anticipate their behaviour better. These examples all illustrate how increasing the time and space drivers have to safely negotiate an intersection (the so-called "interaction-space" [10]) can help drivers with their interactive driving. Different manipulations of interaction space have been a central issue in the experiment discussed here. What happens with the safety and efficiency of the interaction when interaction space is increased? Are there ways that have a particularly positive effect on either safety or efficiency?

Safety might come at the cost of efficiency. For example, when confronted with another road user slowing down who has right of way (i.e. an unexpected situation), one could decide to come to a complete standstill, which increases the amount of time needed for both road users to cross the intersection. On the other hand, interactions in this particular situation can be considered to be rather safe as well. The abovementioned behaviour of the road user could be identified as a "stop and wait" strategy as opposed to a "flying" strategy, where either one or both road users adapt to the other's behaviour so they can both cross the intersection without anyone having to come to a standstill. Perhaps when the available interaction space is sufficient to ensure a safe interaction, the road user

might choose to decrease the interaction space by increasing speed, thus creating a trade-off between "excess" safety and efficiency of the interaction. Literature discussing a trade-off between safety and efficiency has focused mainly on the engineering aspects of the situation rather than on the behavioural aspects [e.g., 11]. To investigate the presumed trade-off relationship between safety and efficiency, the present experiment also included several behavioural indicators of the efficiency of the interaction.

In this experiment interaction space was manipulated by varying the expectedness of the approach speed of the other driver relating to the righthand –right of way regulation that applies in the Netherlands. Additionally, interaction space was manipulated by providing drivers at intersections with information about other approaching drivers through a (virtual) technological application.

METHOD

Twenty-six experienced participants took part in an experiment conducted in two linked Green Dino fixed-base simulators[12]. These simulators were connected in a way that allows the drivers of both simulators to encounter each other in the same virtual world.

The experiment attempted to manipulate the interaction space through several independent variables: varying expectancy, varying visibility and varying the information provided. The approach speed of other drivers could either be *expected* or *unexpected* in relation to their right of way. The route included intersections that varied in *visibility* of the intersecting road. The final manipulation of interaction space concerned providing participants with extra information concerning the behaviour of other road users approaching the intersection. The extra information was presented through headphones (auditory information) as well as on the dashboard (visual information). Through the headphones, participants were alerted by a series of beeps, presented to the ear which corresponded to the direction from which the other driver was approaching. The length and pitch of the beeps corresponded to the approach speed of the other road user. That is, long and low pitched beeps indicated a slowly approaching road user, whereas short high pitched beeps indicated a rapidly approaching road user. A red flashing light to the left or right of the centre of the speedometer indicated road users approaching from either the left or the right. The rate of flashing of the light corresponded to speed of the other road user as well (Figure 1).



Figure 1. Location of flashing lights on speedometer.

Table 1.
Dependent variables

Variable	Explanation	Range
TTCmin	Minimum Time to Collision[13]	≥ 0 s
Safety	The natural log of the difference between the time in seconds to the estimated collision point of the participant and the other road user [14], when the participant is 15m from the centre of the intersection. N.B. Values >3 indicate that one of the interaction partners stood still, and cannot really discriminate anymore.	≥ 0
DTI_Brake	The participant's mean distance to the intersection (DTI) in meters when the brake is first pressed.	0 -150m
Hard Braking	Indicates how often the participant pushed the brake for more than 60%	0 (never) – 1 (always)
DTI_Throttle	The participant's mean distance to the intersection (DTI) in meters when the throttle is first released.	0 -150m
Near miss	Indicates how often the difference in time to the estimated collision point of the participant and the other road user was less than 1.5 seconds	0 (never) – 1 (always)
Collision	Did a collision occur?	0: no; 1: yes
Efficiency	Sum of average speeds of both interaction partners (km/h) from when they were between 150 m. before the intersection to reaching the centre of the intersection	≥ 0 km/h
Speed_after	Participant's speed at the moment of leaving the intersection	≥ 0 km/h
Standstill	Indicates how often a participant's speed was < 1 km/h (proportionally over all encounters).	0 (never) – 1 (always)
Mean Yield	Indicates how often a participant yielded (proportionally over all encounters).	0 (never) – 1 (always)
Mental Effort	Subjectively perceived mental effort as indicated on the RSME[15]	0-150
Usefulness	Mean score on items on subscale of Acceptance[16] concerning Usefulness	
Pleasantness	Mean score on items on subscale of Acceptance[16] concerning Pleasantness	

The present experiment included a wide variety of measures that could provide information concerning the safety and efficiency of the interaction (Table 1). To help interpret the quantitative behavioural data derived in this experiment, a measure indicating mental workload [15, Rating Scale Mental Effort] and a measure to assess the acceptance of new car features [16, Acceptance scale] were also included.

In total, there were 4 driving sessions; 2 with and 2 without extra information. Participants drove through a simulated urban environment with intersections where they could encounter another road user, who was controlled by the experimenter in the second driving simulator.

RESULTS & DISCUSSION

This paper will only address the results of the experiment quite sketchily in order to focus more on the implications. For a more detailed account of the experiment and its results, the reader is referred to Houtenbos, 2008[10].

Interaction space and safety

A large number of statistical analyses included different measures of safety. It is plausible that increasing interaction space should lead to increased safety, as the increased interaction space allows road users more time to adapt their expectancies to the situation as it develops and select an appropriate course of action. There are some results that support that idea, but also results that seem to suggest the contrary.

To start with the supporting results, the results for TTC_{min} show shorter values (safety ↓) in the medium visibility condition compared with the high visibility condition (interaction space ↓). More hard braking (safety ↓) also seemed to occur in the low visibility condition (interaction space ↓). Also, more near misses (safety ↓) were found in encounters where the other road users approached while maintaining speed (interaction space ↓), in encounters where participants were not provided with extra information (interaction space ↓), when visibility was very low (interaction space ↓) and when the other road users approached in a way that would not be expected (interaction space ↓). Results suggesting the contrary include the results for the Safety index (Figure 2). The lowest scores were found when visibility was medium or high (interaction space ↑) and when the other road users approached normally (interaction space ↑). Participants tended to release the throttle and apply the brakes when they were closer to the intersection (safety ↓) when extra information was provided (interaction space ↑). Although the

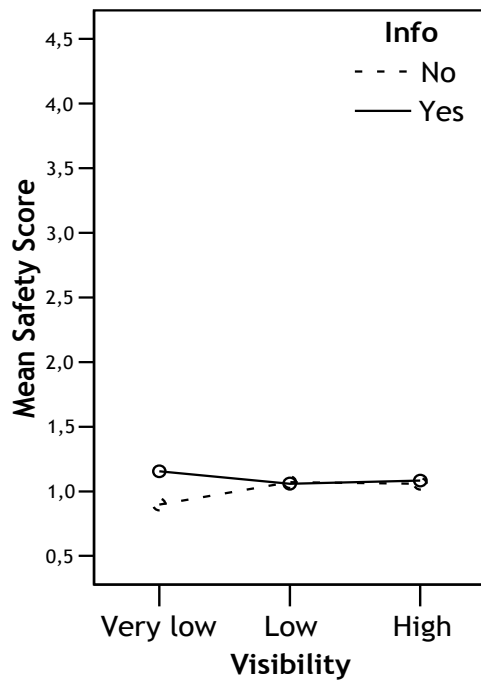
abovementioned results might seem contradictory, they can be explained by the differences between these measures. Near misses and hard braking are perhaps measures more closely related to the critical aspects of (unsafe) situations as they correspond to a relatively late stage in the interaction process compared with measures such as DTI_Brake, DTI_Throttle and Safety. To explain, near misses and hard braking will generally occur closer to an estimated collision point than releasing the throttle and applying the brake and also past the 15m to the intersection used to determine the Safety index. Thus, near misses and Hard Braking might be indicators of a more critical stage in the interaction process and thus more direct indicators of interaction safety, whilst early brake and throttle manipulations might be more relevant related to efficiency.

These results also imply that the interaction process consists of a stage where there is a tendency towards proactive caution, which, depending on the way the situation develops, might be followed by a stage where there is a tendency to reactive caution. Further away from the estimated collision point, a driver is more likely to be in the “proactive stage” and act accordingly by releasing the throttle or gently applying the brakes. As the driver comes closer to the estimated collision point, it is plausible that the need for reactive caution is assessed and the brakes might need to be instantly applied with considerable force and the result could be a near miss. Assuming such a distinction between a proactive and reactive stage, the results of this experiment suggest that the measures of safety related to the latter stage are more prone to the applied manipulations of interaction space.

Interaction space and efficiency

Concerning the effect of increasing interaction space on efficiency of the interaction two opposing effects could also be imagined. It is possible a trade-off relationship exists between safety and efficiency. Charlton [17], for example, shows that the interaction space can also be too large for optimal safety results. He conducted a field test on an intersection where the intersecting road was visually restricted to improve safety and reduce approach speeds. Perhaps in situations that are experienced as sufficiently safe, “excess” safety is traded for increased interaction efficiency. If so, we would expect to find opposite effects for measures of efficiency compared to the effects we found for measures of safety. On the other hand, we could expect participants to use the increased interaction space to increase interaction efficiency, which would imply that increased efficiency should be found for situations with increased interaction space. The results for the different measures of

Other road user maintained speed (expected)



Other road user slowed down (expected)

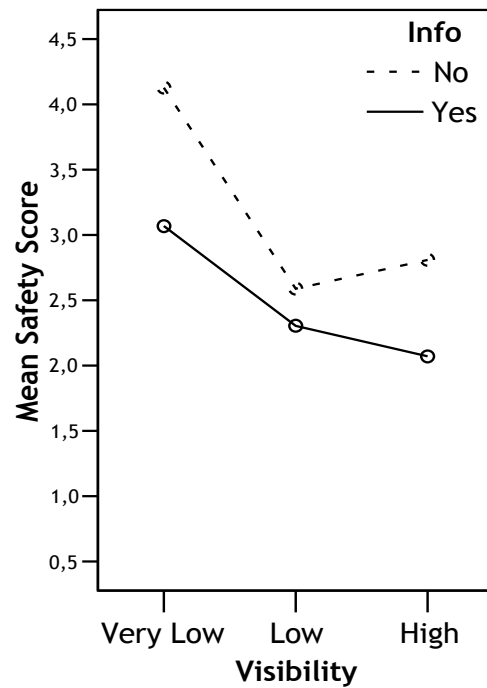
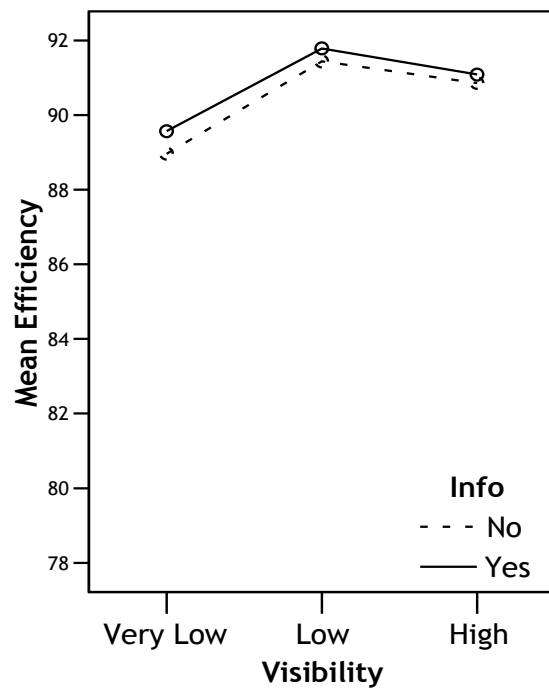


Figure 2. Safety results for different manipulations of interaction space.

Other road user maintained speed (expected)



Other road user slowed down (expected)

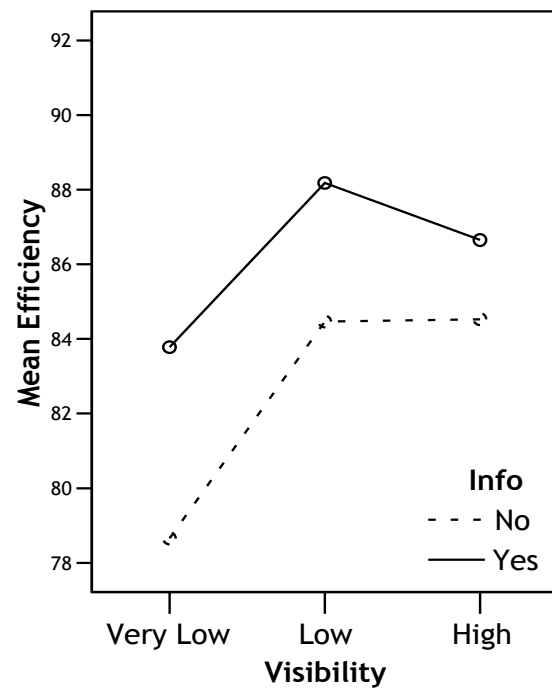


Figure 3. Efficiency results for different manipulations of interaction space.

efficiency seem to point in the direction of the latter hypothesis. The results for the different measures of efficiency seem to point in the direction of the latter hypothesis. The Efficiency index (Figure 3) shows higher scores (efficiency ↑) when extra information is provided, particularly in the situation where the other road user illustrated expected behaviour by slowing down (interaction space ↑), and in the medium and high Visibility conditions (interaction space ↑). Higher scores were also found when the other road user behaved as could be expected (interaction space ↑). In accordance, participants' speed when leaving the intersection was higher (efficiency ↑) when extra information was provided (interaction space ↑) and when the other road user behaved as could be expected (interaction space ↑). The final measure of efficiency also indicated less standing still by the participant in these expectancy conditions. In conclusion, the results indicate that particularly the extra information enabled participants to create a more efficient interaction (compared to when they did not receive extra information), allowing participants to cross the intersection without decreasing speed that much. When efficiency was already rather high, as was the case in the situations where the other road user approached the intersection while maintaining speed, providing extra information did not seem to increase efficiency any further.

Trade-off Safety vs. Efficiency

Do the abovementioned results for the safety and efficiency measures indeed indicate a trade-off relationship? If we were to divide the safety measures into measures of proactive vs. reactive behaviour, the effects found for proactive behaviour (DTI_throttle) indicate a trade-off with the effects found for the efficiency measures. For example, the results indicated that when information was not provided, participants tended to release the throttle further from the intersection. Values for the Efficiency index in those encounters were found to be lower, suggesting the existence of a trade-off relationship, in this case, efficiency being traded in for safety.

The fact that evidence for such a relationship is not found for the measures of safety relating to the "reactive stage" can be explained. Take the least safe result of an interaction process: a collision between the interaction partners. In that case, the situation is highly unsafe, but also highly inefficient, as both partners will not be moving. Perhaps the same holds for Near Misses, suggesting the existence of an optimum in the trade-off relationship between safety and efficiency, beyond which both suffer.

Proactive and reactive

The distinction between proactive and reactive control has also been made by, for example, Fuller [18] and Hollnagel [19]. Fuller pointed out that a driver can either make an anticipatory avoidance response (i.e. proactive) or a delayed avoidance response (reactive). The first is generally made before being certain that it is really necessary to ensure safety. If an anticipatory avoidance response is not made, a delayed avoidance response might eventually become necessary. However, in that case, less time is left to make an adequate avoidance response.

Hollnagel's Contextual Control Model (COCOM) provides a more detailed account of the distinction between proactive and reactive control [19]. He identified four control modes, which vary in the degree of forward planning and reactivity to the environment. The first two modes, "strategic" and "tactical", are based on long term planning and procedural short term planning respectively and can be considered more proactive, as they allow road users to anticipate future events. Behaviour in the latter two modes, "opportunistic" and particularly the "scrambled" mode, is much less planned but highly reactive to the immediate environment [20]. The mode is determined by several factors; the knowledge and experience of the individual, the rate of change of the process and the subjective (and objective) time available. The first two factors can be related to the concept of expectancy, as expectancy also depends on prior knowledge and experience (reflected in a rather general *long term expectancy*) and adapts to changes that occur in the process (reflected in a quite specific *short term expectancy*). The latter factor, the available time, can be linked to the concept of "interaction space", which will be discussed further on in this paper.

According to Hollnagel, people tend to move between control modes in linear fashion, which is corroborated by Stanton, Ashleigh, Roberts and Xu [20]. This suggests a continuous scale ranging from proactive control to reactive control. People should attempt to achieve strategic or at least tactical control which allows for a certain amount planning and anticipation, increasing the potential of reaching the desired outcome. The reactive modes, the opportunistic mode and particularly the scrambled mode should be avoided as these modes provide rather limited opportunities to recover from errors[21].

During the phase of the interaction process in which proactive control is most likely, the environment will provide less of the specific

information needed to adapt the long term expectancy into a detailed short term expectancy than during the phase of the interaction process, in which reactive control is more likely. For example, one road user might not even see any other road users but proactively release the throttle based on the general knowledge that the intersection ahead is often rather busy. In such a situation, the short term expectancy used to select the proactive throttle action is not so much more specific than the long term expectancy concerning how busy such an intersection can be. In contrast, during the reactive phase, the environment provides many more elements that allow the long term expectancy to become a rather specific short term expectancy.

The results of this experiment, which used a variety of measures to indicate the level of interaction safety, seem to support the distinction between a proactive phase and a reactive phase. The results suggested that the transition from the proactive phase towards the reactive phase is not only affected by the amount of situational information available, but also by the interaction space available, which is in line with Hollnagel's [19] idea about the time available determining the control mode. The Safety index and initial throttle and braking behaviour seemed to be indicators of the proactive phase, referring to behaviour more towards the start of the interaction situation, where the remaining interaction space is still relatively large. TTC_{min} , near misses and hard braking seemed to be indicators of a reactive phase, referring to behaviour more towards the end of the interaction situation, which generally coincides with limited interaction space.

Supporting interacting drivers

The results indicated that the extra information did not affect participants' decision to yield, but did affect other behavioural aspects concerning the approach to the intersection. For example, the safety indicators relating to the phase in the interaction situation in which the proactive mode is likely to be active (Safety index and throttle behaviour) indicated a decrease in safety as a result of providing extra information. However, a lower proportion of near misses occurred in the session with extra information indicating an increase in safety in the phase of the interaction in which the reactive mode is likely to be active. Thus, providing extra information seemed to weaken performance in the proactive mode and improve performance in the reactive mode. Furthermore, the efficiency indicators (Efficiency index and the participants' speed when leaving the intersection) indicated an increase in efficiency as an effect of extra information.

When asked about their experience with the extra information, participants indicated that they found the beeps to be quite useful, particularly compared to the lights, which they regarded as unpleasant and not useful at all. Participants indicated that the presentation of lights in the speedometer often went unnoticed as they tended to look towards the intersecting roads for relevant information rather than on their speedometer. This tendency could be taken as a suggestion for human machine interface design not to place information intended to aid a user at a location where the user would need to search for it before being able to perceive it. Instead, using a modality not dependent on search behaviour such as audition or touch could be a solution.

Furthermore, participants indicated that although they experienced the beeps as quite helpful, they did not experience them as pleasant to the same extent. Several participants even indicated that they experienced the driving task to be less interesting when provided with extra information. This observation corresponds to the findings regarding the decrease in subjective mental effort in sessions with extra information. Although a decrease in workload implies a road user would be better able to adequately react to unexpected situations (more resources to adapt the expectancy), it should be kept in mind that a workload that is too low is also undesirable [22].

Another consideration involves the effect technological applications will have on expectancies of drivers, which could cause behavioural adaptation. The effect of behavioural adaptation can range from positive, through neutral, to negative, where the negative effects are considered most important to be able to predict in the context of traffic safety [23]. Future research endeavours to develop a system to support the interacting driver should take the concept of behavioural adaptation into account when discussing the potential safety effects.

The results indicated that the extra information, and in particular the beeps, did help participants to create more safe and more efficient interactions. However, it would be premature and unwise to conclude that we have proved that the extra information "works" in general to create safe and efficient interactions. All that can be concluded is that the particular way in which we provided extra information, worked in the simple and small range of situations that were presented to the participants. For example, imagine what would happen if not one, but two road users would approach the intersection at the same time or even shortly after each other. How would the participant be able to distinguish between the two approaches? It should

be noted that the aim of this experiment was not to test an application that is meant to help road users at intersections, but merely to determine the effects of different manipulations of interactions space on road users' interactive behaviour. The results of the experiment do, however, provide encouragement for further research in this direction.

CONCLUSIONS

The results suggested that the available interaction space is primarily used for safety and if there is any additional interaction space it is used to increase efficiency. Thus safety generally has priority over efficiency. Additionally, the results indicated a trade-off relationship between proactive caution and efficiency: when participants tended to be rather cautious in the proactive phase, these interactions tended to be less efficient. Interactions where participants tended to rely on reactive control tended to be more efficient. More studies of this interaction space-time are recommended to explore how drivers' strategies are influenced by the different parameters manipulated here, but also others that were not included in the present studies. This would need more parameters of the behaviour of both vehicles and drivers to be recorded than was the case in the experiments in this thesis, and would require more exploration of interactions with a more 'natural' behaviour of the experimenter's vehicle (as the experimenter followed a protocol in the present experiment).

This paper has discussed a start on research in a much neglected area, that of interaction behaviour in traffic. It has shown that there is a world of insight to be gained in the subtleties of how road users react to each other. Since technological applications intervene in this subtle and complex world of prediction and feedback, reaction and learning, we need to know a great deal more about how this all works if we are to avoid making expensive mistakes in introducing it, or to avoid missing opportunities which it can offer.

ACKNOWLEDGEMENTS

This research for this paper was part of a PhD project within the BAMADAS research program and funded by NWO and CONNEKT. The research was carried out at SWOV Institute for Road Safety Research and Delft University of Technology. The linked driving simulators used were created by Green Dino[12].

REFERENCES

[1] Rook, A.M. and J.H. Hogema. 2005. "Effects of human-machine interface design for intelligent speed adaptation on driving behavior and

acceptance", *Transportation Research Record: Journal of the Transportation Research Board*, No.1937, 79-86

[2] Jamson, S. 2006. "Would those who need ISA, use it? Investigating the relationship between drivers' speed choice and their use of a voluntary ISA system", *Transportation Research Part F- Traffic Psychology and Behaviour*, 9, No.3, 195-206

[3] Horrey, W.J., C.D. Wickens and K.P. Consalus. 2006. "Modeling drivers' visual attention allocation while interacting with in-vehicle technologies", *Journal of Experimental Psychology-Applied*, 12, No.2, 67-78

[4] Hoffman, J.D., J.D. Lee, D.V. McGehee, M. Macias and A.W. Gellatly. 2005. "Visual sampling of in-vehicle text messages: Effects of number of lines, page presentation, and message control", *Transportation Research Record: Journal of the Transportation Research Board*, No.1937, 22-30

[5] Cnossen, F., T. Meijman and T. Rothengatter. 2004. "Adaptive strategy changes as a function of task demands: A study of car drivers", *Ergonomics*, 47, No.2, 218-236

[6] Hjalmdahl, M. and A. Várhelyi. 2004. "Speed regulation by in-car active accelerator pedal: Effects on driver behaviour", *Transportation Research Part F: Traffic Psychology and Behaviour*, 7, No.2, 77-94

[7] Comte, S.L. 1996. "Response to automatic speed control in urban areas: A simulator study." ITS Working Paper No. 477, (University of Leeds)

[8] Anttila, V. and J. Luoma. 2005. "Surrogate in-vehicle information systems and driver behaviour in an urban environment: A field study on the effects of visual and cognitive load", *Transportation Research Part F: Traffic Psychology and Behaviour*, 8, No.2, 121-133

[9] Liu, C., R. Herman and D.C. Gazis. 1996. "A review of the yellow interval dilemma", *Transportation Research Part A: Policy and Practice*, 30, No.5, 333-348

[10] Houtenbos, M. 2008. "Expecting the unexpected: A study of interactive driving behaviour at intersections" SWOV Dissertationseries, Delft University of Technology, Delft

[11] Zhang, L. and P.D. Prevedouros. 2003. "Signalized intersection level of service incorporating safety risk" *Traffic flow theory and*

highway capacity 2003'

[12] www.greendino.nl

[13] Van Der Horst, A.R.A. 1990. "A time-based analysis of road user behaviour at intersections", ICTCT Conference Proceedings (Krakow). 91-104

[14] De Winter, J.C.F., M. Houtenbos, P.A. Wieringa, J.A. Mulder, J. Kuipers and S. De Groot. 2006. "Individual characteristics affecting intersection behaviour in a driving simulator", Proceedings of the 25th European Conference on human decision making and manual control (EAM) (Valenciennes, France).

[15] Zijlstra, F.R.H. and L. Van Doorn. 1985. "The construction of a subjective effort scale", (Delft University of Technology)

[16] Van Der Laan, J.D., A. Heino and D. De Waard. 1997. "A simple procedure for the assessment of acceptance of advanced transport telematics", Transportation Research Part C: Emerging Technologies, 5, No.1, 1-10

[17] Charlton, S.G. 2003. "Restricting intersection visibility to reduce approach speeds", Accident Analysis & Prevention, 35, No.5, 817-823

[18] Fuller, R.A. 1984. "A conceptualization of driving behaviour as threat avoidance", Ergonomics, 27, No.11, 1139-1155

[19] Hollnagel, E. 1993. "Human reliability analysis: Context and control" (Academic Press)

[20] Stanton, N.A., M.J. Ashleigh, A.D. Roberts and F. Xu. 2001. "Testing hollnagel's contextual control model: Assessing team behavior in a human supervisory control task", International Journal of Cognitive Ergonomics, 5, No.2, 111-123

[21] Fuller, R.A. 2005. "Towards a general theory of driver behaviour", Accident Analysis and Prevention, 37, No.3, 461-472

[22] Yerkes, R.M. and J.D. Dodson. 1908. "The relation of strength of stimulus to rapidity of habit-formation", Journal of Comparative Neurology and Psychology, 18, 459-482

[23] Dragutinovic, N., K.A. Brookhuis, M.P. Hagenzieker and V.A.W.J. Marchau. 2004. "Importance of behavioural adaptation in assessing effectiveness of ADAS", 10th World Conference on Transport Research (Istanbul: WTCR).