Strategies to influence habitual road user behaviour

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Abstract

In traffic, many attempts have been made to influence road users' behaviour in order to prevent accidents and to reduce air pollution and congestion. What motivates people to behave in a certain manner also determines to a large extent how behavioural change can be elicited. Road user behaviours vary from new (planned) behaviour to habitual behaviour. Behaviour change strategies are therefore more or less successful in realizing desired road user behaviour.

As it is often unclear which behaviour change strategy will be most effective in influencing road user behaviour, we explore in this paper the hypothesis that habitual road user behaviour can be altered by applying behaviour change strategies in such a way that seizes the underlying motive and therefore enables road users to detect the changes in the traffic situation.

Therefore, we designed and conducted a driving simulator experiment that compared three experimental scenarios (media campaign, adapted road design and in-car message) with a baseline scenario to improve rush-hour lane use. Results showed that habitual road user behaviour (merging into traffic) can be changed to new behaviour (using rush-hour lane) by applying behaviour change strategies in such a way that takes the underlying motive of the habitual behaviour into account. Knowing how to apply behaviour change strategies improves the government's measures' effectiveness.

1. Introduction

Many attempts have been made to influence road users' behaviour in order to prevent accidents, air pollution and congestion. People are for example persuaded to drive soberly, to use public transport more often, to drive slowly in the vicinity of schools, to use their seatbelt, and to use the rush-hour lane.

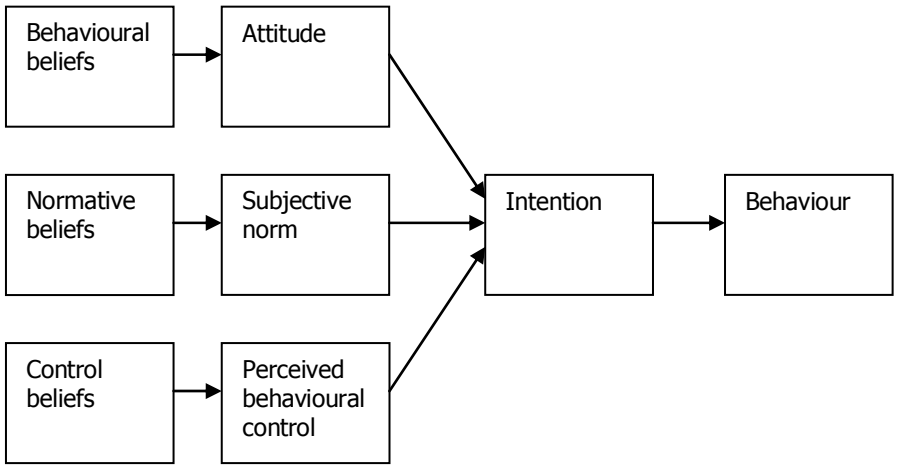
What motivates people to behave in a certain manner to a large extent also determines how behaviour can be changed. In describing driver behaviour two theoretical notions have been used: the first being reasoned (or planned) behaviour, the second deals with habitual behaviour (Goldenbeld, Levelt & Heidstra, 2000). In the following sections both notions will be elaborated. Next we describe two behaviour change strategies.

1.1 Reasoned or planned behaviour

The models of reasoned behaviour used in traffic psychology are based on the theory of reasoned action (Fishbein & Ajzen, 1975) and its extension, the theory of planned behaviour (Ajzen, 1985). According to Ajzen's (1991) theory of planned behaviour, when people

perform an action for the first time, people's attitude (positive or negative evaluation of the behaviour), their subjective norm (perceived social pressure) and their perceived behavioural control (the perceived ease or difficulty of performing the behaviour) determine their behaviour (a defined action) indirectly via their intentions (a willingness to try to perform the behaviour).

Figure 1: Schematic representation of the theory of planned behaviour (after Ajzen, 2006)



An attitude towards behaviour is determined by behavioural beliefs, which are beliefs about the likely consequences of the behaviour (behavioural belief strength) weighted by the evaluation of how good or bad these outcomes would be (outcome evaluation). Subjective norm is determined by normative beliefs which are beliefs about what important others think of the behaviour (normative belief strength), weighted by the motivation to comply with these important others (motivation to comply). Perceived behavioural control is determined by control beliefs, which are beliefs about factors that may facilitate or impede performance of the behaviour (control belief strength), weighted by the perceived power of these factors (control belief power). According to Ajzen (2006), the more positive the attitude and subjective norm, and the larger the perceived behavioural control, the stronger the person's intention to perform the behaviour will be. Given enough actual control of the behaviour, people are expected to carry out their intention as soon as an opportunity arises. Figure 1 shows a schematic representation of the theory.

The theory of planned behaviour has been used in traffic safety research to predict behaviours such as drinking and driving (Marcil, Bergeron & Audet, 2001), speeding (Paris & Van den Broucke, 2008; Forward, 2006; Warner & Aberg, 2006) and to design interventions such as mass media campaigns (Parker, 2002; Stead, Tagg, MacKintosh & Eadie, 2005).

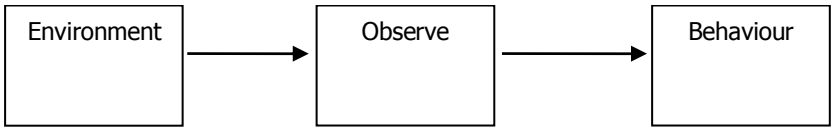
1.2 Habitual behaviour

If people behave regularly in a particular way without explicit deliberation beforehand, their behaviour may be considered habitual. So, when people act in a certain manner for the first time, they typically decide what to do and how to do it to achieve certain outcomes and avoid other outcomes. But, as people repeat these actions within the same context, explicit conscious decision making decreases, and the actions come to be cued by the environment (Verplanken & Wood, 2006). Figure 2 shows a schematic representation of habitual behaviour.

When road users can observe from the environment what behaviours are expected from them (such as speed) and what other road users' behaviours can be expected (such as

overtaking, merging), traffic is more predictable and consequently more safe (Aarts & Davidse, 2007). So automatic habitual behaviour is efficient, and allows road users to drive safely. An important disadvantage, however, is that when people behave in an automatic manner, they fail to detect changes in traffic situations. This can be attributed to the failure to apprehend (Martens, 2007).

Figure 2: Schematic representation of habitual behavior



1.3 Behaviour change strategies

Two behaviour change strategies may be distinguished:

Engineering

Engineering covers design of road and vehicles.
Infrastructure contributes to traffic safety by forming behaviours which can be performed automatically. When roads trigger the right expectations about which driving behaviours are appropriate, they allow drivers to perform those behaviours more or less automatically (Theeuwes & Godthelp, 1995). By influencing road users' observations of traffic situations, they may change their behaviour accordingly (Lewis-Evans & Charlton, 2006; Martens, 2007).

Traffic signs, such as Variable Message Signs, are commonly used devices for controlling traffic. These signs convey messages in words and/or symbols and aim at regulating, warning or guiding the road users. VMS can be used to inform road users about congestion, estimated driving times, dangerous situations, and alternative routes.

In-car systems can inform drivers at all times and places what the appropriate driving behaviour or (speed) limit is, and warn them at all times and all places when they are not showing the appropriate driving behaviour (such as driving within the speed limit). By working at all times and places, and by enabling drivers to react to their own violations, these systems offer drivers a measure of insight, comfort, and support.

Education

Education encompasses road safety education and road safety campaigns, and is meant to contribute to traffic safety by attempting to change road users' knowledge, skills, attitudes, and behaviour.

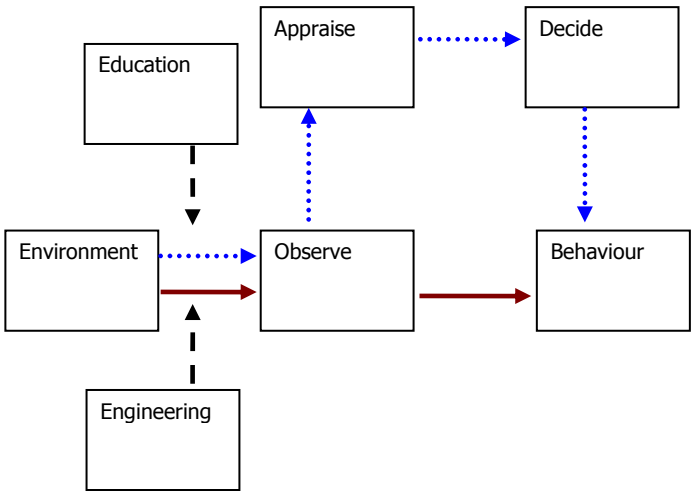
Road safety education is used to instruct road users. Driver training focuses on novice drivers and motorcyclists. Traffic education focuses on specific road users such as children, elderly, and young drivers, and is meant to promote safe traffic behaviour.

Campaigns can be defined broadly as: (a) purposive attempts; (b) to inform, persuade, or motivate behaviour changes; (c) in a relatively well-defined and large audience; (d) generally for non-commercial benefits to the individuals and/or society at large; (e) typically within a given time period; (f) by means of organized communication activities involving mass media; and (g) often complemented by interpersonal support (Rice & Atkin, 2002, p. 427).

1.4 Effectiveness of behaviour change strategies

Researchers have investigated and found support for the effectiveness of these separate strategies repeatedly [for example Van Driel, Davidse & van Maarseveen (2004), Chatterjee, Hounsell, Firmin & Bonsall (2002), Comte & Jamson (2000), Ulleberg (2001), Stead et al., 2005, Elder, Shults, Sleet, Nichols, Thompson & Rajab (2004)] but little is known about the relative effectiveness of these behaviour change strategies. Goldenbeld, Levelt & Heidstra (2000) argue that the motivation underlying driver behaviour determines to a large degree how successful behaviour change strategies may be. In this paper we explore the hypothesis that habitual driver behaviour can be altered by applying behaviour change strategies in such a way that seizes the underlying motive and therefore enables road users to detect changes in the traffic situation. Figure 3 gives a schematic representation of this.

Figure 3: Schematic representation of aspects of different types of behaviour ranging from new to habitual behaviour and behaviour change strategies.



The blue path of dashed arrows shows our assumption that when novel road users encounter a traffic situation for the first time, they observe the situation's characteristics, then they appraise possible actions, next they decide on the best action, and finally they act. We therefore think that Engineering (shapes observation of traffic situation) and Education (updates skills and knowledge leading to re-appraisal of the traffic situation) are possible strategies to learn new behaviour.

The red path of solid arrows shows our assumption that after encountering similar traffic situations repeatedly, road users carry out actions relatively automatically. They observe the situation, and act as usual in this situation. However, when people behave in an automatic manner, they fail to detect changes in traffic situations. So, we believe that when people behave automatically, changes in traffic situation (Engineering) and features of mass media campaigns (Education) have to be eye-catching enough to be captured before leading to re-appraisal and new decisions and new behaviour consequently.

To conclude, we hypothesize that habitual road user behaviour can be altered into new behaviour when the behaviour change strategy connects to the underlying motive for the behaviour. This means in our view that behaviour change strategies have to be noticeable enough to enable road users to detect changes in traffic situations. To test this assumption for habitual behaviour we designed and conducted a driving simulator experiment that is described in the next paragraphs.

2. Method

2.1 Introduction

In the following experiment we tested the hypothesis that habitual driver behaviour can be altered to new behaviour by applying behaviour change strategies in such a way that seizes the underlying motive and therefore enables road users to detect changes in the traffic situation.

Nowadays, several strategies of reducing congestion are introduced, for example rush-hour lanes. A rush-hour lane is an additional traffic lane that opens at peak moments, especially during rush-hours. Rush-hour lanes can be positioned on the right side as well as the left side of the road. When the shoulder is being used as an additional lane, it is situated on the right side. During merging and exiting a rush-hour lane at the right side, people are allowed to cross the continuous line. In normal situations crossing a continuous line is not allowed.

Using these rush-hour lanes during peak times could potentially lead to less congestion. However, this is largely dependent on the people who should use these rush-hour lanes. In practice, a lot of people do not use the rush-hour lane when it is opened. They stay in the same lane, and do not dare to cross the continuous line. Or, when driving on the acceleration lane they nevertheless merge into the traffic instead of driving straight ahead on the rush-hour lane (see Figure 4).

Figure 4: Merging into traffic instead of using the rush-hour lane

2.2 Hypotheses

In the driving simulator experiment we focused on the latter situation (i.e., people merging into traffic instead of using the rush-hour lane). We considered this a traffic situation in which habitual road user behaviour (i.e. merging into traffic) has to be changed in new behaviour (i.e. using the rush-hour lane). The actual situation in the Netherlands, when the rush-hour lane is open, already contains elements of Engineering and Education, but we assume that these features are not visible enough to change habitual merging behaviour into rush-hour lane use (for details see section design and scenarios). We therefore compared alterations of these two strategies to this baseline scenario.

The experimental scenarios were:

- Education: participants are shown a television *advertisement* that is aimed at updating knowledge and skills, and enabling participants to re-appraise, decide, and act
- Engineering: participants are shown changes in *road design* that are made more saliant in order to enable participants to observe, appraise, decide and act.
- Engineering: participants are aided by an *in-car system* that makes changes in traffic situation more saliant in order to help participants select and process new information and stimulate to act upon this.

First, we tested our assumption that merging into traffic is more habitual than using the rush-hour lane. Second, we tested our hypothesis that participants with a high merging into traffic-habit will use the rush-hour lane more often in the three experimental scenarios than in the baseline scenario. Subsequent research questions dealt with attitudes towards the television advertisement, the adapted road design and the in-car message.

2.3 Participants

The participants were recruited from a TNO-database which contains volunteers who are willing to participate in experiments conducted at TNO. Twenty-four participants took part in the experiment. Their ages varied from 21 to 67 (M=45) and both male (67%) and female Dutch drivers were included. Participants had their driving license on average for 24 years (range: 3 – 47 years) and were paid for their participation.

2.4 Driving simulator

A virtual driving task in a fixed-base driving simulator was used since this allowed control of the traffic situation and road environment. By using the driving simulator, it was possible to let each subject drive under the same conditions except for the last merging situation that could be relatively easy modified according to the different scenarios.

2.5 Design and scenarios

The 24 participants were randomly assigned to one of four scenarios (between-subjects design). The road contained six exits and six merging situations. The first part of the route was similar for all the participants. The sixth merging situation differed. Their performance on the sixth merging situation was recorded manually by the experimenter.

Scenario 1: baseline

The participants drove a route in which they had to exit and merge into the traffic on the highway five times. The rush-hour lane was closed. The sixth time the merging situation was different: the rush-hour lane was available. It was presented in the way as in the Netherlands a rush-hour lane is designed. This design means that three green arrows are presented above the lanes on Variable Message Signs panels. In addition a road sign posted at the road side states "Rush-hour lane open".

Scenario 2: television advertisement

In the Netherlands the government tries to persuade people to use the rush-hour lane by broadcasting messages on television, radio and the internet (the complete advertisement can be seen at: http://www.vananaarbeter.nl). Before driving this scenario, this persuasive message was shown to the participants. After viewing the advertisement, the participants drove a route in which they had to exit and merge into the traffic on the highway five times.

The rush-hour lane was closed. The sixth time the merging situation was different: the rush-hour lane was available.

Scenario 3: adapted road design

The participants drove a route in which they had to exit and merge into the traffic on the highway five times. The sixth time the merging situation was different: the rush-hour lane was available. The design of the rush-hour lane had been adapted (see Figure 8). The continuous line had been made discontinuous. The three green arrows above the lanes on Variable Message Signs panels and the road sign containing "Rush-hour lane open" were still present.

Scenario 4: in-car message

The participants drove a route in which they had to exit and merge into the traffic on the highway five times. The sixth time the merging situation was different: the rush-hour lane was available. Just before entering the acceleration lane participants were informed by a vocal message from an in-car system that the rush-hour lane was open.

2.6 Procedure

Prior to driving in the simulator, the participants signed a form of informed consent and received an outline of the research and written instructions. The instruction contained information about the driving simulator and the specific scenario. Participants were instructed to drive as they normally would. Next, participants drove an introductory run to get used to driving in the simulator. Then, the participants drove one of the four scenarios and filled out a questionnaire (see below). Afterwards, they were thanked for their participation.

2.7 Questionnaire

Merging into traffic

- Habit

The questionnaire assessed to what degree merging into traffic was habitual. Participants filled out a 12-item self-report index of habit strength scale (Verplanken & Orbell, 2003) for merging into traffic. We used a 7-point Likert scale, ranging from -3 to +3. The item with the lowest item-to-total correlation (i.e. Not merging into traffic is difficult) was deleted. Some participants had also indicated that they did not understand this item, or that this item was poorly formulated. The habit-scale's reliability was high (alpha coefficient = .89). The items were summed to form a single habit variable that was dichotomized into low and high 'merging into traffic-habit' based on median split.

Using rush-hour lanes

- Habit

The questionnaire assessed to what degree using rush-hour lanes was habitual. Participants filled out a 12-item self-report index of habit strength scale (Verplanken & Orbell, 2003) for using rush-hour lanes. W used a 7-point Likert scale, ranging from -3 to +3. The item with the lowest item-to-total correlation (i.e. Not using rush-hour lanes is difficult) was deleted. Some participants had also indicated that they did not understand this item, or that this item was poorly formulated. The habit-scale's reliability was high (alpha coefficient = .91). The items were summed to form a single habit variable that was dichotomized into low and high 'rush-hour lane using-habit' based on median split.

Opinions towards behaviour change strategies

All participants were asked which measure (advertisement, adapted road design, or in-car message) they found most suitable (1) to receive information about (new) traffic situations, (2) to receive information about rush-hour lanes, and (3) to influence rush-hour lanes use.

3. Results

One participant developed motion sickness and could not complete the experiment. Data analysis is therefore based on 23 cases. Missing values were replaced with the mean for the variable.

Is merging into traffic more habitual than using rush-hour lanes?

Participants filled out a 12-item self-report index of habit strength scale (Verplanken & Orbell, 2003) on a 7-point Likert scale, ranging from -3 to +3. The mean score on the items about merging into traffic was .74. The mean score on the items about rush-hour lane use was -.71. Merging into traffic is more habitual than using rush-hour lanes [$t(22)= 4.28$, $p<.001$].

Do road users with a high merging into traffic-habit use the rush-hour lane more often when behaviour change strategies are applied?

Table 1: Number and percentage of participants with a high 'merging into traffic-habit' that use or do not use the rush-hour lane in the baseline scenario vs. experimental scenarios

Variable	N	Did not use rush-hour lane N (%)	Did use rush-hour lane N (%)	Likelihood ratio χ^2 P-value (one-sided)
Scenario				
Baseline scenario	2	2 (100)	0 (0)	
Experimental scenario: advertisement, adapted road design or in-car message	9	3 (33)	6 (67)	.027

Fifty-five percent of the participants did use the rush-hour lane in the sixth merging situation. Table 1 shows the number of participants with a high 'merging into traffic-habit' that did not use or did use the rush-hour lane and the values of the Likelihood ratio's $\chi 2$ for the cross-tabulations between rush-hour lane use category and baseline scenario vs. intervention scenario. Significantly more participants who drove an intervention scenario, i.e. with advertisement, adapted road design, or in-car message (67%), than participants who drove the normal situation scenario (0%) did use the rush-hour lane.

Next we compared the three experimental scenarios separately to the baseline scenario for the participants with a 'high merging into traffic-habit'. Table 2 shows the number of participants with a high 'merging into traffic-habit' that did not use or did use the rush-hour lane and the values of the Likelihood ratio's $\chi 2$ for the cross-tabulations between rush-hour lane use category and the separate experimental scenarios vs. the baseline scenario. When no behaviour change strategy was used (baseline scenario) none of the participants with a high 'merging into traffic-habit' (0%) would use the rush-hour lane. But when participants with a high 'merging into traffic-habit' were subjected to the advertisement or the in-car message significantly more participants, 75% ($p<.025$) respectively 100% ($p<.009$), did use the rush-hour lane.

Table 2: Number and percentage of participants with a high 'merging into traffic-habit' that use or do not use the rush-hour lane in the baseline scenario vs. the three experimental scenarios separately

Variable	N	Did not use rush-hour lane N (%)	Did use rush-hour lane N (%)	Likelihood ratio χ^2 P-value (one-sided)
Scenario				
Baseline	2	2 (100)	0 (0)	
Advertisement	4	1 (25)	3 (75)	.025
Scenario				
Baseline	2	2 (100)	0 (0)	
Adapted road design	3	2 (67)	1 (33)	.138
Scenario				
Baseline	2	2 (100)	0 (0)	
In-car message	2	0 (0)	2 (100)	.009

Opinions towards behaviour change strategies

Receiving information about (new) traffic situations

Forty-three percent of the participants found adapted road designs most suitable to receive information about (new) traffic situations. Of these participants only 33% had driven the scenario with the adapted road design. So, even though participants do not have experience with adapted road design, participants still think it is a good means to receive information about (new) traffic situations.

Receiving information about rush-hour lanes

Forty-three percent of the participants found in-car messages most suitable to receive information about rush-hour lanes. Of these participants 60% had driven the scenario with the in-car message. So, it may be the case that having experienced the in-car message leads to high acceptance.

Influencing rush-hour lane use

Participants found adapted road design (43%) and in-car messages (43%) equally suitable to influence rush-hour lanes use. Five out of six participants driving with the in-car message thought that in-car messages were the best way to influence rush-hour lane use.

4. Conclusions and discussion

Road user behaviour ranges from new behaviour to habitual behaviour. Therefore it is difficult to predict which behaviour change strategy will be most effective in changing road user behaviour. The purpose of this project was to explore the hypothesis that habitual driver behaviour can be altered by applying behaviour change strategies in such a way that seizes the underlying motive and therefore enables road users to detect changes in the traffic situation.

By means of a schematic representation we showed our assumption that habitual road user behaviour can be changes into new behaviour when the behaviour change strategy connects to the underlying motive for the behaviour. We argued that behaviour change strategies have to be noticeable enough to enable road users who behave habitual to detect changes in traffic situations.

From our experiment we conclude that habitual road user behaviour (such as merging into traffic) can be changed into new road user behaviour (such as using the rush-hour lane) by applying Engineering and Education in such a way that enables road users with a high 'merging into traffic-habit' to detect changes in the traffic situation.

A limitation of this experiment is the relatively small amount of participants, which automatically means few participants per scenario. Another limitation is the fact that the use of the media campaign strategy may be different from the real life setting. In a real life setting, people may not be aware of the media campaign at all. Driving in a simulated environment can be seen as a limitation, because of the limited external validity. However, driving in a simulator makes it more plausible to compare different scenarios without external bias.

To conclude, we have shown that habitual road user behaviour can be altered into new behaviour when the behaviour change strategy connects to the underlying motive for the behaviour. If we know how to influence habitual road user behaviour, the government can influence road users' behaviour better in order to prevent accidents, and reduce air pollution and congestion.

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