ROAD USER BEHAVIOUR STUDIES - AN EFFECTIVE TOOL FOR EVALUATION OF TRAFFIC SAFETY MEASURES

Stein Johannessen

Visiting Research Fellow (Aug99 – July00)
Transportation Research Group
University of Southampton
Highfield, 5017 1 BJ Southampton, Great Britain
Phone: 4423 8059 3316
Fax: 4423 8059 3152
e-mail: S.Johannessen@soton.ac.uk

Permanent affiliation:
Norwegian Institute of Science and Technology,
NTNU Trondheim, Norway

ABSTRACT

This paper contains a description of and a discussion on how the application of road user behaviour studies can serve as a tool for evaluation of traffic safety measures and other traffic control or road design measures. The basis for the paper is a set of periodically performed road user behaviour studies set into operation on a national basis by the Norwegian Public Roads Administration from 1998 and onwards. The author took part in the planning group for these studies, and in some of the pilot tests. Examples of selected road user behaviour studies are red light driving (motorists and cyclists), driver/pedestrian interaction (give-way practice) at pedestrian crossings without traffic lights, give-way practice (driver/driver) at roundabout entries, and merging practice at entry ramps. The paper discusses the planning process for these studies, methodology, and some results. An important point is how road user behaviour data can be applied for evaluation of traffic safety measures at local, regional, and national level, and even for international comparisons of differences in road user behaviour related to traffic rules and “traffic culture” in different countries.

1. WHY?

The Norwegian Public Roads Administration (NPRA) has increased its activities on road user and vehicle related aspects during the last years. However, the documented knowledge about the effects of measures to improve the road user and vehicle quality on the stated main goals of NPRA (traffic safety, and "traffic quality", among others) are uncertain and insufficient.

To provide the basis for filling in this "knowledge gap", NPRA has planned, and partly implemented, systematic and periodically "state-of-the-art" studies related to a lot of measures, in order to be able to evaluate the way financial and planning resources are distributed today. Studies of this kind are also meant to provide a basis for developing more effective goals within the road user and vehicle area. The practice so far has been to apply "process control" (i.e. the number of vehicle inspections carried out), instead of "goal oriented control" (i.e. the quality or condition of the vehicle fleet, from a safety point of view).

The state-of-the-art studies are related to 3 main study types:

- road user behaviour,
- knowledge and attitudes , and
- administrative/technical and other matters.

Examples of the last two types of studies are the quality of driving licence candidates ("knowledge/attitudes"), and lorry drivers' violations of the regulations of maximum driving hours ("administrative/technical/others"). These two types of studies will not be commented on further.

The planning process (see Section 2) resulted in the selection of eleven different "road user behaviour" studies for this national survey. These are shown in Table 1, which also contains information about the frequency of the various studies, whether assistance from the regional County Public Road Administrations (County PRA's) is required, and start-up year for the various surveys.

A preliminary 1998 report of the results of the manual studies performed by the County PRA's is available, as well as some 1999 results (Statens vegvesen, Vegdirektoratet 1998/1999). Results are further discussed in Section 3.

In addition to the national overall goals stated above, the accomplishment of the road user behaviour studies is also meant to serve important goals both at regional and local level. The results might even be applied for international comparisons of differences in road user behaviour related to traffic rules and “traffic culture” in different countries. Application areas are discussed further in Section 4 of this paper.

Table 1 "Road user behaviour" studies carried out by the Norwegian Public Roads Administration (NPRA).

Study Subject	Automatic Survey?	Assistance from County Road Admin.s?	Frequency	First year to carry out the survey
Use of Safety Equipment:				
1. Safety belt	No	Yes	Each year	1998
2. Safety helmet (cyclists)	No	Yes	Each year	1998 *)
3. Studded tyres	No	Yes	Each year	1998 *)
Single road user behaviour				
4. Speed	Yes	No	Each year	1998
5. Distance between vehicles	Yes	No	Each year	1998
6. Red light driving (vehicles)	No	Yes	Each 2nd year	1999 *)
7. Red light driving (cyclists)	No	Yes	Each 2nd year	1999 *)
8. Pedestrians use of zebra crossings	No	Yes	Each 2nd year	1999
Road user interaction				
9. Give way practice at roundabouts (driver/driver)	No	Yes	Each 2nd year	1998
10. Give way practice at zebra crossings (driver/ped.)	No	Yes	Each 2nd year	1999
11. Driving behaviour at ramps with shared responsibility	No	Yes	Each 2nd year	1999

***)** *1999 results are available*

2. HOW?

2.1. The planning group

The planning process took place during 1997 and 1998. NPRA established a multi-disciplinary planning group with representatives from the NPRA central administration, from some County PRA's, and from research/education (the author). Disciplines covered were transport planning, traffic engineering, psychology (driver tests) and sociology. This mixture is in a way a result of a significant turning of focus away from the more traditional road and traffic engineering, and towards a focus on the road user himself, not only the driver, but also with a strong weight on the "soft" road user groups.

Parts of the platform for the planning process were

- selected behavioural road user studies carried out, in a more or less systematic way, during the preceding years (i.e. safety belt usage),
- a stated NPRA goal putting more weight on the road user (the "customer")
- a pilot report (Johannessen 1997) discussing possible broad applications of road user behaviour studies, including "The Swedish Traffic Conflicts Technique", and examples of a few practical applications of this in Norway, and
- examples of road user behaviour studies carried out as part of research projects (i.e. Giaever 1997).

2.2. Criteria

The following criteria were set up for the selection of studies and choice of methodology:

- each type of study should be linked to an important problem area (related to NPRA goals),
- a common measure of the state-of-the-art would be "the percentage of proper behaviour" (defined according to the Highway Code etc),
- all County PRA's should take part in the annual/biannual surveys,
- for each study type, the number of sites, and the number of observations, should allow rather small changes in national behavioural trends to be statistically documented,
- the amount of work and resources spent on this task, should be limited according to the limited budget and staff situation at the County PRA's, and, lastly,
- survey methods (forms, description, method, reporting) should be clear and self-instructive, in order to avoid extensive instruction activities for County PRA staff, and in order to secure rather similar and consistent study performance at all sites.

This set of criteria inevitably lead to a compromise, where scientific research needs not necessarily could be met, and where use of methods like The Swedish Traffic Conflicts Technique (usually requiring a one week course) were not regarded possible. The result had to be more simplified methods, inevitably involving some kind of (uncontrollable) judgement.

The usual planning practice was, for each type of study, to estimate how much survey time and related preparing/reporting time each County PRA could be expected to direct to this activity. From such considerations and related assumptions, statistical analyses made on beforehand would make it possible to state which change in "the percentage of proper behaviour" that would be required in order to show a statistically significant change (usually at a 5%-level).

2.3. Notes on the selected study types

General

For each selected study, a description was made, containing the following elements:

- The problem area
- Definition of "proper behaviour"
- The state-of-the-art, according to former studies
- The goal for this type of study ("desired percentage of proper behaviour")
- How to perform the survey (method, forms, required number of study sites and observations, set-up for reporting of results)
- In most observations of situations with pedestrians or cyclists involved, three age groups were applied (usually <16, 16-60, >60). Vehicles were usually classified as cars, buses and lorries.

Some examples, listed below, will illustrate these points.

Red light driving (motorists)

In 12% of injury junction accidents in Oslo, a car driver or a pedestrian/cyclist did cross on red light. The most common definition of "proper behaviour" for this safety problem is linked to "the percentage of drivers driving on a red signal". This is a kind of figure, usually around 1%, which would come out of automatic recording of red light driving, as performed in Norway earlier.

In this manual method we concentrated on the drivers who really had a choice, defined as drivers arriving during the first three seconds of red light, and having the possibility to either drive on or stop. With this type observation, a more typical experienced percentage of "improper behaviour" would be around 15%.

Driver/pedestrian interaction at pedestrian at zebra crossings

In contradiction to the preceding survey type, which can be classified as "a single road user behaviour", the driver/pedestrian interactions at zebra crossings is a typical "road user interaction" situation. According to the Norwegian Highway Code, the driver is obliged to stop and give way for a pedestrian crossing, or (obviously) ready to cross. International rules and interpretation can differ for this type of situation.

For this study, it was found interesting to look at how different driver groups (car, bus and lorry drivers) behaved related to the age of the (youngest) pedestrian wanting to cross. Three age groups (<16, 16-60, >60) were applied for this study.

Give-way practice (driver/driver) at roundabout entries

This is an example of another "road user interaction" study. Research in Norway (i.e. Giaever 1997) have shown that roundabout entries with a high number of drivers not

giving way to circulating traffic or traffic coming from the left (in countries with traffic driving on the right hand side of the road), usually have an imperfect design.

Merging practice at entry ramps

This was the most challenging situation to develop a survey method for, because the interaction between drivers takes place at high speeds, and can take on many forms. In Norway, common practice or rule is that the drivers on the through road and the drivers from the ramp have equal rights and are obliged to co-operate in the merging process. This is a driver task that also creates problems during the driver pre-licence training activities. The experience of the psychologist in the planning group (working on driver tests) was very valuable for the method development for this survey.

The method chosen was that one observer should concentrate on vehicles on the through road, and the errors these might do, while the other observer was given the same task for the drivers coming from the ramp. Defined driver "errors" on the through road were: Keeping a too short gap to the vehicle in front (defined as less than 3 seconds, which can be discussed), and shortening or "closing" the gap to the vehicle in front. An error not included, but which should be included, is failing to switch to an outside lane, when possible, in order to provide more space for the ramp driver

Five defined driver errors on the ramp were: Stopping at the start of the ramp before trying to enter, driving too slowly, overtaking a ramp vehicle in front, forcing itself into a (too) small gap, and stopping at the end of the ramp.

2.4. Pilot studies

Some of the survey methods, or rather similar methods, had been applied earlier, in research projects or in local site studies. However, for the new method description, and especially for the brand new methods (like the one above), it was found necessary to perform pilot tests.

The Department of Transport Engineering at NTNU (Norwegian University of Science and Technology), and its collaborating research organisation SINTEF, played an important role in these pilot studies. NTNU has for some years now arranged an annual Traffic Safety Course (2 single weeks with an intermediate period) for practicing engineers (Road Administrations, City Councils, consultants), typically with 30 participants. The author is responsible for this course, where a one-day traffic survey during the first week, with a following safety evaluation, has been an important PBL (Project Based Learning) activity. This gave a very good possibility to carry out pilot surveys as part of the course late summer 1998, and to get valuable feedback and input to revisions from the six course groups taking part in these pilot tests.

3. RESULTS

Some selected survey results are included in this section, in order to give an idea about the state-of-the-art in Norway, and what applications and traffic safety measures the results might lead to. Survey numbers given relate to the numbering in Table 1.

3.1. Results from selected national and pilot surveys in Norway

Survey 1: Safety belt usage (National study, 1998)

This type of survey has been carried out nearly annual since 1973. All the 10 counties took part in the survey, which covered around 66.000 drivers. 79.1% (80.0) wore safety belt within built-up areas, 91.3% (93.0) in rural areas, and 90.9% (86.0) on motorways (1987 numbers in brackets). A methodical problem with this survey is to cover short trips in a right way. To come around this problem, a depth study at schools and nursery schools was carried out, showing a belt usage of 75%.

Possible measures to apply and evaluate are national or local campaigns, and increased enforcement (fines).

Survey 2: Cyclists use of safety helmets (National study, 1999)

The stated goal for this safety measure is to obtain 60% usage of helmets within year 2002 (average for all age groups), and, within year 2007, 90% usage for cyclists under 12 years old, and 75% for cyclists older than this.

The results from the 1998 and 1999 surveys (Table 2) show that there still is a long way to go to reach the goal, and that the "teenager age group" will be a special challenge. Mandatory usage of cyclist helmets has been discussed, but other measures (campaigns) have been selected so far.

Table 2 Percentage of cyclists wearing safety helmets

Age	< 12 years		12 - 17 years		> 17 years		All ages		All
Gender	F	M	F	M	F	M	F	M	Both
1998	61.4 %	54.3%	11.3%	12.6%	17.8%	24.7%	19.1%	24.8%	22.4%
1999	57.5 %	52.2%	13.5%	14.3%	19.0%	29.0%	20.6%	28.1%	24.9%

Survey 3: Use of studded tyres, and Surveys 4 and 5: Automatic data collection of driving speeds and driving distances

Results are not included or discussed here.

Survey 6: Red light driving - motorised vehicles (National study, 1999)

The chosen method for this survey is described in broad terms in Section 2.3. The study was performed in 11 counties during the spring 1999, and the local results were sent to NPRA. The analysis here of the total survey showed a total population of 2364 drivers having a choice, whereof 295 drivers did not stop, in other words 11,1% "improper behaviour" (see Table 3 for details). Hence the goal set up, a maximum of 5% driving on red light, was not met. Measures like a campaign to effect attitudes and behaviour, or a more extensive control, are discussed.

Table 3 Percentage of drivers choosing to drive on red signal during the first three seconds of the red period

Site description	No of drivers arriving during the first 3 seconds	Number driving on red during the first 3 seconds	Percentage driving on red light
One lane	341	52	13.2%
Two lanes	1691	136	7.4%
Three or more lanes	332	107	24.4%
Total	2364	295	11.1%

Survey 7 (National study, 1999): Red light driving - cyclists

The implementation of good road and traffic control arrangements for cyclists is a quite challenging task. Cyclists are the weak part related to cars, and they are the strong part related to pedestrians. Further, there are at least three groups of cyclists with quite different behaviour and safety needs: the "transport cyclist" (grown-up, choosing the fastest way), the young ones (unpredictable, need safe surroundings), and the elderly cyclists (careful, vulnerable).

Cycling on red signal seems to be quite usual among cyclists, creating safety problems for themselves and others. Earlier studies had shown that 36% of the cyclists chose to drive on red signal. A survey of red light cycling was hence included in the national "road user behaviour" studies, and a preliminary goal of reducing this percentage of red light cycling to 25 was set up.

The results of the 1999 survey (Table 4) underline the variation in behaviour. Further actions, like a campaign on one hand, or, on the other hand, a closer look into the traffic light and detector arrangements at junctions, are possible measures to improve the state-of-the-art, especially for the middle age group.

Table 4 Cyclists driving on red signal

Age group	Number of cyclists choosing to wait	Number of cyclists driving on red	Percentage improper behaviour
0 - 15	62	38	38.0%
16 - 60	419	283	40.3%
> 60	228	16	6.6%

Survey 8: Use of pedestrian crossings

No pilot study is performed. National survey to be carried out during 1999.

Survey 9: Give way practice at roundabouts (National study, 1998):

The background for this type of survey is described in Section 2.3. Research studies had shown quite large variations in the percentage of driver giving way in proper way entering the roundabout. Variations were found among roundabouts, as well as among entries in the single roundabouts. At some entries nearly 50% of the drivers did not

give way as they should, compared to an average number for all roundabouts around 90%. Variations in average entry speeds, which is quite dependent on design (number of entry lanes, deflections, the size of the central island) and the traffic stream balance, were considered to be the main key to explain this.

The 1998 survey was carried out in 8 counties, covering a total of 15 roundabouts and 31 different entries. A total number of 3500 "give way" situations were observed. For each of these the observers made a record of whether the give way rule was followed in a proper way, and if the situation lead to a "conflict" (fast braking, fast evasive manoeuvre etc, by judgement). Geometric characteristics for the roundabout were also recorded.

Table 5 contains an overview of the percentage of give way violations, and the percentage of conflicts related to these, for various geometric situations. On average, 9.1% of the drivers did not give way in a proper way, and around 12% of these "give way violations" led to conflicts (as defined above). Some influence of geometric and speed parameters on the percentage of "give way violations" can be read from this cross-tabulation (number of lanes in the entry, diameter of the central island, the speed limit). The diameter of the central island seem to be a key factor in whether the give way violation leads to a conflict or not. It is somewhat surprising that the variation in deflection do not show any obvious influence. As far as the author know, however, the data has only been studied by cross-tabulation, and not by regression analysis or other analysis covering the combined and joint influence of several factors. An analysis of this kind might have shown other "hidden" results.

Table 5 Give way practice at Norwegian roundabouts 1998

	Percentage of "give way violations"	Percentage of "give way violations" leading to conflicts
Number of lanes in the entry:		
- one lane	13.0 %	10.8 %
- two lanes	6.9 %	13.5 %
Deflection:		
- good	9.5 %	12.8 %
- medium	8.1 %	11.2 %
- bad	9.8 %	11.5 %
Diameter, central island:		
- 10 -12 meter	6.0 %	19.5 %
- 13 - 14 meter	10.9 %	12.8 %
- 15 - 19 meter	10.0 %	10.1 %
- 20 meter or more	14.2 %	3.6 %
Speed limit:		
- 50 km/h	6.8 %	13.4 %
- 60 km/h	15.5 %	9.4 %
- 70 km/h	16.0 %	6.3 %
- 80 km/h	6.6 %	10.5 %
TOTAL	**9.1 %**	**12.1 %**

Survey 10: Give way practice at zebra crossings

Some Norwegian results are shown in Section 3, together with some UK observations.

Survey 11: Driving behaviour at ramps (Pilot study, 1998)

The background for this type of survey is described in Section 2.3. This survey has not yet been carried out on a nation-wide basis. Hence some results from a pilot study carried out during a NTNU course on Traffic safety at Lillehammer, Norway, are included here to illustrate this survey, see Table 6.

Table 6

ENTRY RAMP						THROUGH LANE		
Total	Early stop	Late stop	Too low speed	Driving into too short gap	Passing vehicle in front	**Total**	Too short gap	Shrinking the gap
Sannom, North-bound				**33 % errors**				**0 % errors**
63	0	0	21	0	0	**62**	0	0
Sannom, South-bound				**63 % errors**				**13 % errors**
63	6	1	29	4	0	**72**	6	3

The north-bound entry ramp in this intersection had a design according to the Norwegian design rules, while the south-bound ramp had a very sharp curvature just before the entry (radius 12 meter), and a very short acceleration distance (108 meters). The speed limit on the through lane was 90 km/h. The results demonstrate clearly how the sub-standard design of the south-bound ramp creates difficulties for the drivers, and a significant increase from the "normal" level of errors.

3.2. International comparisons - an example

It is quite easy to observe significant international variations in road user behaviour when we, as professionals, or as tourists (with our "traffic engineering glasses" on), travel around the world. The drivers' inclination to give way to pedestrians at zebra crossings (or other crossing facilities) is one of the most obvious examples of international variations in road user behaviour.

To illustrate this point, table 7 shows the results from two minor surveys carried out in Southampton this month, and the average results from some Norwegian studies.

Table 7 Percentage of drivers giving way to pedestrians at zebra crossings in UK and Norway

	Percentage of drivers giving way to pedestrians at zebra crossings (number of observations in brackets)			
Age group	**Less than 16**	**16 - 60**	**More than 60**	**Total**
UK (at junctions, Southampton):				
- Lodge Road (101 obs.)	91% (33)	86% (65)	67% (3) *	87% (101)
- London Road (95 obs)	100% (2) *	87% (84)	78% (9) *	86% (95)
- So'ton average (196 obs)	91% (35)	87% (149)	75% (12)	87% (196)
Norway (pilot studies):				
- Tønsberg (1 junction)	40% (5)	33% (45)	25% (12)	32% (62)
- Lillehammer, junction 1	--	72% (25)	60% (5)	70% (30)
- Lillehammer, into junction 2	83% (29)	66% (32)	100% (6)	76% (67)
- Lillehammer, out of junction 2	74% (27)	48% (40)	67% (6)	59% (73)

Without going into any detail, it is obvious that studies of this kind, showing variations from one country to another, give a good basis for discussions of why this is so, and what kind of measure it is possible to apply to improve a behaviour in the wanted direction. Examples:

- How is the traffic rule described and interpreted? Sweden changed their rule this summer, which changes did this change lead to?
- How is the information to the driver? UK applies flickering lamps (beacons) at the zebra crossings, in Norway only traffic signs are applied.
- How is the physical layout? Are pedestrian refuges installed? Is there a good maintenance of the zebra markings?
- What are the levels of police enforcements, and what are the fines?
- Are any campaigns performed concentrating on this problem?

Questions of this type, and the various answers given, will probably throw valuable light over both reasons for behavioural variations, and hence, possible measures to apply. This postulate is, as I see it, valid for all type of road user behaviour.

4. APPLICATIONS

The accomplishment of the road user behaviour studies performed by NPRA is meant to serve important goals at national, regional as well as on local level.

4.1 National and regional applications

On the national level road user behaviour studies are primarily meant to

- show the state-of-the-art and hence increase the knowledge data base concerning road user behaviour in Norway, and to
- provide a platform for evaluation of the way financial and planning resources are applied today.

Systematic national road user behaviour studies will provide a basis for studying long-term trends and changes related to changes in policy, changes in traffic rules, large scale introduction of specific safety measures, or changes in highway design recommendations. It is also a hope to provide a better basis for evaluation of possible road user behaviour changes related to national campaigns ("1001, 1002, 1003", "Use your safety belt", "Reduce your speed" etc).

Continuous work in this direction will inevitably influence on the development of quantified goals for improvement of road user behaviour, and development of a diversified set of measures to affect the behaviour in the right direction.

On the regional level, the County PRA's are meant to get a better platform for evaluation of the situation in their own county, related to "national standards" or related to other counties, and hence a better platform for setting up regional goals and selection of appropriate measures.

4.2 Local applications

On the local level, the results from the national surveys, and the survey methodology developed, will have most impedance on the operational aspects of traffic and safety management. Road user behaviour studies at anticipated "problem sites" are supposed to give good indications of possible deviations from "standard results", and will hence serve as a decision platform for possible actions.

When an action is decided upon, road user behaviour studies carried out as a "before-and-after study" will, within short time, give good indications of whether the measure applied was working according to expectations or not. The alternative will be to await the results from a traffic accident study several years after the introduction of a measure. The important aspect of this is the possibility to shorten the feed back process for the professionals, and to shorten the information process towards administrations, politicians, and "the man on the street". In this way, the "road user behaviour" studies will serve the same purpose as the somewhat more resource demanding "Conflict study technique". In all circumstances, road user behaviour studies as described in this paper, will provide a very useful supplement to The Swedish Traffic Conflicts Technique.

4.3 Concluding remarks

Systematic focus on and the various road users, and the road user behaviour studies described in this paper, is in many ways a new and significant element in the NPRA activities in Norway. The organisational challenge has been to introduce such studies as a part of the normal, annual follow up work in all regions (counties), in a way that creates understanding of the importance of such studies, and without putting a too large extra work burden on the counties. It has also been a challenge to develop simple, but robust survey techniques applicable for this purpose. The multi-disciplinary composition of the planning group has without doubt been a key to the development so far. "The Norwegian model" might be a good model for similar activities in other countries.

So far, during the second year of what you could call a start up period, activities and results seem promising, and press releases lead to comments in the media, following the analysis carried out by NPRA. It remains to see, however, what kind of impedance the results of such surveys will have on actions, measures applied and priorities made by NPRA and the regional County PRA's.

From an academic and educational point of view, it is valuable to take part in such work, especially in the survey technique development, and in the carrying out of pilot studies, for instance as "Problem Based Learning" elements in University courses. It is obvious, too, that the simplified methods applied in the national surveys, will raise unanswered questions that will have to be answered through more thorough in-depth research studies, where the Universities and their research groups can play a significant role.

For the local and practical traffic safety work, it is the authors view that the provision of a national "road user behaviour" knowledge platform, will be a very good basis for the local applications of "road user behaviour" study techniques in on-site studies, and as elements in before-and-after studies.

Last, but not least, development and performance of similar or identical studies in other countries will provide a useful platform for studies of national variations in "traffic culture", and of measures applied. This will lead to a better understanding of the driving forces behind development of attitudes, and new ideas about how to affect behaviour in the right direction.

REFERENCES

Giaever, T (1997)	Roundabouts in the Hordaland County. Accident analyses, junction design and driver behaviour. (Norwegian text). SINTEF Civil and Environmental Engineering, Report STF22A97601, Trondheim, February 1997.
Johannessen, S (1997)	Studies of conflicts and road user behaviour. Pilot study (Norwegian text). SINTEF Civil and Environmental Engineering, Report STF22A97604, Trondheim, April 1997.
Statens vegvesen, Vegdirektoratet (Norwegian Public Roads Administration), (1998)	Tilstandsundersøkelser, Manual. (State-of-the-art studies, Norwegian text). Oslo, May 1998.
Statens vegvesen, Vegdirektoratet (Norwegian Public Roads Administration), (1998/1999)	Preliminary reports/memos on "State-of-the-art" studies of road user behaviour 1998 and 1999