

# TRAFFIC BEHAVIOUR AS SOCIAL INTERACTION - IMPLICATIONS FOR THE DESIGN OF ARTIFICIAL DRIVERS

Oskar Juhlin Ph D  
oskar.juhlin@ctv.gu.se  
www.sts.gu.se/

## Abstract<sup>1</sup>

This paper is a contribution to the research on the application of information technology to road traffic. An empirical investigation of road use is analysed. It is argued that road users' communication is essential in achieving co-ordination. This has troublesome implications for the design of artificial driving technologies. An artificial driver must be able to function in a social situation and communicate with other individuals in a shared road space. However it seems that road users co-ordinate their driving through situated activities which take account of the particular details of each situation. This would make road use more difficult to formalise and implement in an AI-system, than if it were understood as merely rule-following activity.

## Artificial Drivers in a Social Context

Since the start of the Prometheus-programme in 1986, which was a joint research programme among the European car manufacturers, a considerable amount of work has been carried out by engineers to develop the idea of the artificial driver.<sup>2</sup> In the spring of 1998, a demonstration was held in the Netherlands by European and American researchers on "Automated Vehicle Guidance" (AVG).<sup>3</sup> Automated vehicle driving is discussed in three steps: "beginning with ...automated highway systems providing 'information' to the driver for collision avoidance and other safety-related issues, moving on to AVG for control-systems that assist the driver and take over some of the driving tasks, and ultimately leading to...fully automatic systems for inter-city transportation." The description of the demonstrations included fully automated cars that detect the curve of the road and holds the car in its lane, cruise control systems that adapt to the speed of cars in front, or platooning, where the manned first truck in a column controls the following unmanned trucks. The number of demonstrations, and the discussions by the designers, show that confidence in the possibility of artificial driving is still strong in the research community of ITS.

However, in the pursuit of the automatic driver it is essential to recognise that the model on which the computer algorithms are based should not be that of the individual driver's brain and its interaction with the car, rather that of a driver situated within a driving context. In a broader discussion on expert systems, sociologist Harry Collins argues for a consideration of such systems working in a social context:

...when we build an expert system it is meant to fit into a social organism where a human fitted before. An ideal expert system would replace an expert, possibly making him or her redundant. It would fit where a real expert once fitted without anyone noticing much difference in the way the corresponding social group functions.<sup>4</sup>

The social context of an artificial driver is of course traffic where drivers (artificial or real) interact with other people to work his/her way through the road net. Finding out what the other road users are doing and what they are up to is most important to avoid accidents.<sup>5</sup>

As in social interaction in general, a driver has to interpret other people's intentions by interpreting their behaviour.

In designing this new technology, irrespective of whether the computers are to serve as drivers, co-drivers, or teachers, it is essential to understand how drivers themselves achieve co-ordination. The research should not aim at mimicking an individual driver's mental structure, but at imitating his/her activities in traffic. Computers, running by rules or algorithms, must function together with other road users. They must adapt to them, or the drivers will have to adapt to the new machines. If the artificial drivers are socially incompetent, this could put serious strains on other road users. The designers of ITS have acknowledged the importance of modelling even this aspect of driving.<sup>6</sup> However, the subject is rarely treated in behavioural research in the area.<sup>7</sup> The purpose of this paper is to make a contribution to our knowledge of the interaction between road users and how they achieve a common understanding, and its implication for the design of artificial driving.

## **Mutual understanding through plans or situated actions**

Road use is understood as a co-operative activity, since a number of actors share a common resource (the road) and through its use change the conditions and possibilities for other users.<sup>8</sup> They are forced to show consideration, or at least adapt their activities to each other, that is to co-ordinate them, in order to avoid accidents and disturbances.

Understanding how people interact and achieve common understanding is a central issue in social science. Furthermore, there is a growing body of sociological and anthropological literature on artificial expertise in social contexts.<sup>9</sup> This paper is informed by research at Rank Xerox. The research, regarded as an important contribution to computer science, is presented in Lucy Suchman's book *Plans and Situated Action*.<sup>10</sup>

Suchman compares two different ways of understanding social interaction: the planning model, which has been influential in the efforts to construct so called expert systems; and situated action. In the former, mutual understanding is achieved between individuals because they have the ability to represent a situation similarly e.g. a traffic situation. Furthermore, they both have a similar set of plans available as means to achieve a specific goal. If an individual performs a particular behaviour in a particular situation, the other individuals can reconstruct what he/she is up to, by interpreting the relationship between the behaviour and the situation as belonging to a specific category of events.

In the case of traffic, it could seem rather reasonable to view the formal traffic rules as the plans by which road users achieve co-ordination in a specific and commonly understood situation. A formalised set of rules has been developed, mostly through the agency of government authorities, to solve the problems of co-ordination. The individual driver is required to keep in the right hand lane and for instance obey the speed limit, otherwise he/she will be punished. However communication between drivers is still essential in traffic.

Traffic researchers Alex Swan and Belinda Owens, focus on the interaction as important in understanding the co-ordination of traffic and the cause of accidents:

Fitting lines of action together or establishing joint-action in the driving environment requires taking note of the action of others as indications are made. This assumes that the meaning of the indications are shared by the actors in the environment.<sup>11</sup>

Thus, for drivers to fit their actions together smoothly and reduce accidents, they must understand the intended meaning of one another's gestures and must interpret the actions similarly. The whole process of driving interaction depends upon the ability of the driver to take another's role, and thereby to understand what other drivers are thinking and planning to do.<sup>12</sup>

Their understanding of social interaction is close to what Suchman labelled the planning model. However, according to Suchman, this perspective begs the question of how the individuals come to understand the situation similarly. Many ethnomethodological studies show the openness of the representation of situations. Representation of a situation seems to depend on a choice of priorities. In addition, a specific behaviour can always be interpreted as a sign of many different intentions. In the latter perspective, situated actions create and sustain shared understanding on specific occasions of interaction. Social constraints on appropriate action are always identified in relation to some unique set of circumstances.

Therefore, Suchman recommends a perspective where the actors struggle back and forth to work their way to a common understanding and to establish co-operative actions. With reference to the sociologist Harold Garfinkel, she understands the users' activities as following "the documentary method of interpretation."<sup>13</sup> Garfinkel writes:

The method consists of treating actual appearance as "the document of," as "pointing to," as "standing on behalf of," a presupposed underlying pattern. Not only is the underlying pattern derived from its individual documentary evidences, but the individual documentary evidences, in their turn, are interpreted on the basis of "what is known" about the underlying pattern. Each is used to elaborate the other.<sup>14</sup>

Each event, confronting the actors who share a resource, is unique. Thus the co-operating individuals must also work to make sense of it, and identification becomes more than just a recognition. Despite the difficulties the actors often succeed in establishing agreement on how to understand it and how to achieve co-operation. But this work should be taken account of, rather than taken for granted, in a theory of social interaction. Suchman writes:

The stability of the social world, from this standpoint, is not due to an eternal structure, but to situated actions that create and sustain shared understanding on specific occasions of interaction. Social constraints on appropriate action are always identified relative to some unique and unreproducible set of circumstances.<sup>15</sup>

To better understand co-ordination Suchman proposes an empirical focus on the occurrence of mutual understanding, instead of an a priori attribution of plans and plan identification as the base in establishing mutual understanding and co-ordination.

In this case the focus should be on road users as they solve co-ordination problems with other road users both understood by the actors as following the formal set of rules or doing something else. The unit of analysis is road users' work in achieving co-ordination. And specifically when road users try to influence each other. Here, a useful distinction is drawn by the sociologist Erving Goffman. He separates between co-ordination achieved between individuals without anyone having the purpose of communicating with another, and co-ordination involving such activities. A clear case of the first kind is when two drivers just pass each other in two separate lanes on a major road without trying to communicate. However, in other cases the opposite is applicable. Goffman refers to this form of interaction as performances: "A performance may be defined as all the activity of a given participant on a given occasion which serves to influence in any way any of the other participants."<sup>16</sup>

### *Method and Unit of Analysis*

This study was performed at a Driving School in Stockholm during the summer of 1998. The training of drivers was observed as they exercised in and around the city centre. I participated

in twenty sessions, and recorded the conversation on minidisks. The driving school uses camcorders in one of their cars as part of the education. When this equipment is used, the teacher and the student meet directly afterwards view the videotape and discuss the lesson. In these cases too, I recorded the events.

Thirteen of the sessions have been transcribed and thematically coded according to a number subjects discussed between the student and the teacher. In this paper, I have specifically chosen to focus on the co-operation with other road users, which are the sequences in the conversation where they refer to e.g. other drivers or pedestrians. Since the subject is often raised, it seems to be an important issue in the training.<sup>17</sup> This main category has been further analysed and interpreted which has resulted in a number of subcategories of which some are presented in this article.

## **Co-operation in traffic**

Other drivers are, in many situations, treated as uncontactable for collaboration. They are more or less viewed as physical projectiles on a steady course. There is only co-ordination without performance, without road users intending to communicate with each other. In other situations, a driver chooses to constitute the presence of road users as a possibility to perform. The interaction could be short e.g. making an “appeal” and receiving an answer. Among the signals available to communicate this intention are using the blinkers, waving, turning one’s head, and demonstratively positioning oneself in the road. She can use the blinkers to send a message to fellow road users that she wants to change lanes or turn. During the lessons, it is primarily the proper use of this signal that is discussed. But she can also use eye contact to send the same message. If the car that constitutes the audience is close behind, a distinct turn of the driver’s head could be enough to make a plea.

Speed and its variations also give opportunities to influence other road users. In the following case, it is used to say, “you are welcome:”

Teacher: Continue down the street that hasn’t turned into a one-way street. Good! You clearly show her that you will wait, then you can start to move directly. So, you don’t really need to stop the car. You can aim at passing behind her as soon as she has started to walk.

A single pedestrian stands at the edge of a zebra crossing looking towards our vehicle. We are a bit away and the student brakes with a distinct jerk. The teacher interprets this tiny, but marked adjustment of the speed, as the message “I have seen you, and will give you right-of-way.” The pedestrian seems to understand it similarly and starts to cross the street.

## **Rules as resources to interpret behaviour**

In the discussion between student and teacher many different forms of rules or goals are used as resources to interpret road users’ behaviour. Examples of these are the law and the requirements of safety. These sets of rules are at times discussed as coming into conflict. The task of interpreting other peoples’ behaviour is made even more difficult with the inclusion of more informal rules such as flow priority rules or identity based rules.

In the following, the actions of other road users are discussed as documents of general rules governing behaviour. In an article on the co-ordination of traffic, the sociologist Dale Dannefer refers to these as rules governing “situationally-based interaction.”

Such interaction patterns are governed by universalistic norms, applicable to all drivers regardless of their characteristics or the characteristics of their vehicles. These norms are purely situational-generated by the problems of co-ordination to which they apply...<sup>1</sup>

### *The law and traffic safety*

At the driving school, the most discussed set of rules was that formally prescribed by the authorities. However, another set of rules had to do with how to establish safe co-operation with other road users. In many cases the general discourse on traffic safety equates following the formal rules with driving safely. In practice, however, those ambitions could be at odds with safe driving. The student can e.g. be told to drive faster than the regulations stipulate. In the next case, the student is heading north entering a major road into the centre of Stockholm. There is heavy traffic on this trunk road:

Teacher: Good preparation! Good speed to enter! (Student: There was rather heavy traffic.) Yeah, you have to find a gap. Did you think about the speed on the ramp?

Student: 70 a bit ahead. (Teacher: Yeah, seventy. But what was it on the ramp?) Didn't see. But I was driving 50.

Teacher: Yes. It was 50 so to speak. But if you think about the speed necessary to enter the road, then it is idiotic beyond belief that you're supposed to drive at a certain speed on the ramp. And then you should enter a road where the other cars are driving at least at the speed limit. No one can dispute, that if you're entering a road with a speed limit of 70 you may drive at that speed. For safety reasons. Not just because you are enjoying driving fast, but also that if you see a gap you must be able to match the speed of the other drivers.

The speed limit on the ramp is 50 km/h, while it is 70 km/h on the road itself. She can indeed disturb the co-ordination if she enters the traffic stream on the big road driving much more slowly than the other drivers. Therefore the teacher gives two rather different recommendations, that both seem to contradict the formal traffic laws. Firstly, she says that the student should drive on the ramp at the speed, which is prescribed on the road signs on the main road. Secondly, she says that she should match the speed of the traffic. The principal motivation is to avoid danger for all of the road users. Thus obeying laws and driving safely is not always conceived to be the same thing.

### *Giving priority to the flow*

The sociologist Dale Dannefer discusses a universal but informal rule to co-ordinate road use called "flow priority". The fieldwork at the driving school supports his arguments. The concept of flow was frequently used to invoke special forms of priority. But its application referred to such heterogenous characteristics as speed, quantity, road structure and identity. In the following, examples of the first category will be given:

Teacher: He chose to reverse. Think that here...did you see the blue sign? In any case you should go first...slow down there. It could be that he can't see that well in the beginning. (Student: No.) Slow down. If someone would be in the middle, then you could let him pass first. To get better flow in traffic.

In this case, the student is told to give a car on the left priority because it has higher speed. Flow is defined as a single car with higher speed.

---

1

### *Drive like you are!*

Another set of rules relates issues of co-ordination to general characteristics of the other drivers. The teacher and the student discuss the behaviour of other drivers in terms of "oldies", "poor creatures", "lunatics" and "men." Dannefer refer to them as identity-based rules. These rules could also be discerned in the discussion between teachers and students at the driving school. In the following example, the behaviour of other drivers are explained by the sign on the back of our car telling that it is a student driver. Thus other drivers treat the driver in our car as a student influencing the traffic co-ordination.

Another car is overtaking us on our left. The driver signals with his horn as he passes us. The teacher comments on the situation by saying that he signalled just because our bumper sticker said "student driver": "He wouldn't have signalled if it had said "Your Neighborhood Plumber", and we had been driving a van". Various actions in traffic are interpreted differently given the meaning that is read into the vehicles appearance. A "Plumber's van", presumably driven by middle age men, is allowed to do things, which other drivers are not. Another teacher interpreted the frequent overtakings, and drunkards' waving their fists as hostility towards our driver's student identity: "people get allergic when we come."

But the student identity could also be favourable in the co-ordination of road use. According to one of the teachers, the other road users become more helpful when they face a beginner in traffic. Furthermore, at the test to get the drivers licence, the sticker on the back of the car is removed just to avoid other drivers helping the novice.

## **Co-ordination as a situated activity**

The discussion between student and teacher indicates that many different rules are essential in achieving co-operation. Most of these rules refer to the context of the meeting between road users, rather than to their identities. These rules could be both formal, such as the regulations prescribed by the authorities, or informal, such as e.g. the flow priority rules. According to Dannefer, both informal and formal rules are situational because they refer to the characteristics of the infrastructure or the vehicles, rather than to the behaviour of other road users (see earlier quotation). At the same time, the characteristics are recurrent making the situations repeat themselves. Thus situations could be classified as belonging to a more aggregated series of events, given a stable set of backgrounds provided by the road infrastructure. However, the empirical material seems to contest such an interpretation of the concept of situations. Instead the road infrastructure seems to also be constructed as a result of the co-operation.

### *Situational road use*

Most of the rules discussed by the teachers, with the exception of the identity rules, interpret the meaning with reference to generalised representation of the road net such as "You should always drive in the right-hand lane!" To be able to follow such rules you have to interpret the situation as part of a specific class of roads with various numbers of lanes. However, the empirical material reveals that the classification of the infrastructure is uncertain and is based on a specific interpretation of the situation, where many seem to be possible.

In the previous sequence the ongoing discussion reveals uncertainties about the classification of the infrastructure into general categories:

Teacher: Then you are coming in at the speed limit, which he wasn't. He is getting upset and wants to overtake you. In this phase, the ramp is widening making room for two cars besides each other. No

markings indicating two lanes. And you thought: "what a wide and nice lane. I'll put myself in the middle." That lane! But according to the law it's two lanes if there's enough room for two four-wheeled vehicles, even though there's no centre marking. So, you can't see it clearly from this camera angle, but you can see it anyway (Student: yeah) that there is very little space left on that side. And I bet he's not that comfortable in this situation. Because he doesn't know if you will continue gliding as he overtakes you, and he hasn't got much to choose from. Because he just has a pole over there. So, there is no where to go. And here I felt that you really scared him. Really!

Student: I felt it myself. It wasn't that good. Clearly!

The student seems to be uncertain about what kind of infrastructure she is moving in. Should she act like the road consisted of one or two lanes? The teacher is, on the one hand, certain about the situation as caused by incompetent interpretation and disturbances from the infrastructure, but on the other hand she admits that the road was gradually widening. The issue in this situation is a problem of boundaries. At what particular point should a specific part of the infrastructure be classified in one rather than another category? The driver has to make their actions function in that fluid setting.

Similarly, the interpretation of road signs is made in specific situations. A student is driving through a tunnel headed towards downtown:

Student: I am staying in the right lane.

Teacher: On what do you base the decision? (Students: Signs with two arrows.) What does it mean?

Student: Two lanes. Here, the sign has only one arrow, and then I became a bit uncertain. Then, I saw...

Teacher: Did you see that it was a bit sooty? Someone has bumped into it there. Actually, there used to be an arrow there too. I can understand that you started to wonder. But it's better that you start to look ahead, and try to get new information from the next sign. To see how is it now? What's up?

The student is uncertain about how to interpret the road sign. Is it a dirty two-lane marking or is it a dirty one-lane marking? The sign itself can not tell her how to interpret it correctly. Thus, the details of the situation influence the driver's action.

Furthermore, the infrastructure (the road) is not a stable backdrop to the co-ordination of the road user. One day the road is perceived as straight and even. The next day it is curving and uneven since the road administration has started to dig. And they have also filled the roadside with new signs and fences.

### *Constructing the "background" through co-operation*

From the previous examples it is evident that co-operation between road users is flawed by uncertainty. It is not even pursued on the basis of a given road structure as background. This does not mean that it is necessarily dangerous or requires remedying. Rather, it is necessary to look for those practices that sustain co-operation despite the immanent uncertainty. Here, "the documentary method of interpretation" could be of interest. In the co-operation between road users, an individual user goes back and forth between interpretation of both the behaviour of other users, the contexts, and the responses to her own behaviour to establish a working behaviour in a situation. In the following example, road users' activities are used as "documents" when interpreting the characteristics of the infrastructure. The student sees parked cars ahead of her and uses them to interpret the formal rules applicable to that road strip. We discuss the situation as we watch the videotape:

Teacher: What does it look like on the ground? (Student: Yeah) Do you see any arrows pointing to the right there? (Student: No!) It is a bit hard since the truck is standing there.

Student: Yeah. I didn't get it. Then I became too occupied to see the road sign.

Teacher: Was it okay to drive straight ahead? (Student: Yeah [*hesitating*]) Of course, it was allowed. You can drive straight ahead here. The reason you got a bit thrown off. It was because you can see a row of parked cars over there. (Student: Exactly) So, there was only enough room in that single lane to drive straight ahead. Then you have to change lanes. Still, you can drive straight ahead. (Student: Exactly)

The student chose to turn right at the junction since she is uncertain about the formal rules applicable to the lane she is using. She is not sure if it continues straight ahead. Maybe it demands its users to turn right? Road users' activities influenced her decision to turn. Firstly, parked cars in the continuation of her lane after the junction can indicate that the lane is not supposed to be used for through-traffic. Secondly, the truck in her lane could have blocked a traffic sign. The student asks the teacher to rewind the tape. She wants to see what stood on the road sign at the side of the road to see if she was mistaken:

Student: I believe there's a road sign somewhere around here, or further ahead. It says something about "Bantorget". Here! I don't know where it comes. No, further ahead. Just before the truck. So that you don't see all of it. Somewhere there! There! Or is it a road sign? There's some kind of tree [*teacher laughs*] in the way? All you can see is half of the sign. And then I think that there's an arrow pointing towards Bantorget.

Teacher: So, there was some kind of impulse from a sign? (Student: Exactly. As well...)

The activities of other road users are interpreted as indicators of the markings on the street and the presence of road signs. But she should not only organise her own activities as a response to the other drivers' activities and the infrastructure. Her own presence is interpreted in a similar way, according to the teacher:

Teacher: You're a bit indistinct towards them as you're driving slowly. They want to stop. And then you start to drive really slow, and then they start to wonder "Ooooh, did I miss any road sign? What's up? Are they about to run out of gas?" (Student: Yeah) Often you think that it is not possible to drive to slow. It can't go wrong. You can never be too careful. But sometimes in traffic, it could imply that you give very indistinct signals to the other road users. Like in this case, you had the right-of-way, and they had started to slow down. There wasn't really any problem. And yet, you started to slow down and drive much slower, and looked really carefully at them. They were standing still and weren't a danger.

Similarly to the previous example, the road users' activities are interpreted as signs of the infrastructure's characteristics and the formal rules applicable in that situation. The issue is not what speed to choose, but who had right-of-way. Generally, it is difficult for a road user to know if she really has seen all the signs applicable in a situation. One possibility, such as in these cases, is to interpret what the other road users are doing. The users see the other road users' activities as "documents of," as "pointing at" the formal rules, in line with the documentary method of interpretation. But they also interpret the other road users' activities in line with "what is known" of the underlying pattern, e.g. the formal rules in that situation.

The following sequence provides yet another example of how they construct a situation through their co-operation, rather than simply reacting to messages from other road users. Thus, the student makes use of other road users' application of the documentary method of interpretation:

Teacher: That thing about communication with your fellow road users, you'll see that it is rather pleasant. It is better for yourself having complete control of what you are doing, and what all the others are doing. You also get better treated if you, so to speak, dare to meet the gaze from another car or pedestrian. You radiate more certainty yourself, and you get more certainty in the...

The teacher's advice is ambivalent. She promises full control through communication. Uncertainty can be cured by more information about the other road users activities. But their activities can not be isolated from the student's own activities. So uncertainty can also be decreased if the student acts as though she already had the information. If you perform "as if" you are certain, the situation will become certain; you "get better treated." The advice could also be formulated as "fake it till you make it." If that advice is taken as a general feature of road use co-ordination, the individual is caught in an interpretative process concerning the documents as information on what the other road users want and documents as a comment on her own activities, in this case to sooth her fellow road user. Other road users' activities are interpreted as documents of what they want, what they will do, or documents of other road users' actions as affirmations that everything is all right: "you are doing okay".

## Conclusion

How to interpret other road users' activity is an essential part of driver training. The empirical material supports the presence of many different types of rules in the interpretation of other road users' behaviour. But these seem to figure as "weak resources" in situated activity. The learning process by which the students become sensible of the meaning of other peoples' behaviour is hardly explained by the formal application of rules to an easily given and structured context. The road users achieve co-ordination despite three theoretical problems. Firstly, the identification of the situation, or the background for the co-ordination, is not simple or given. The fieldwork makes visible the interpretative flexibility of "the background." Secondly, it seems that many rulesets are applicable to a particular background such as various formal and informal rules. The informal rules are either applicable to the context, or to the individual road users involved in the co-ordination. Thirdly, the drivers understand what the other road users want to do by interpreting their activities as documents of an underlying plan. But a single action can be interpreted as an expression of many different plans according to sociologist Harry Collins.<sup>18</sup> Acceleration by a nearby car could be a document of him following the flow-priority rule, that he is following a formal rule of which the other driver is not aware of, or just a message telling the other driver that he is incompetent or has acted badly. Those "inconsistencies" are mostly solved in local situations. Mutual understandings of how to achieve co-ordination seem to be reached anew in each situation. Thus, driving is more like "muddling through" despite uncertain background knowledge.

There are at least two consequences of such understanding for the design of information technology to support road use. The ITS-community should be expected to have a thorough understanding of traffic as the artificial driver will be introduced in a setting where inappropriate design could have fatal consequences. An interpretation of traffic as a situated social activity where rules only figure as weak resources in establishing mutual understanding, has consequences for future research. A *weak interpretation* of these results calls for extended research before the introduction in traffic. Here, the issue is not only to present a cognitive model of a general driver but also to understand how people co-ordinate their common road use, that is the social aspects of traffic. A *strong interpretation* of the empirical findings calls for a redirection of the technical development towards more modest design principles for ITS.<sup>19</sup> In a specific field of informatics, devoted to a study of so called "computer supported co-operative work", empirical studies of collaborative work including computers, has raised a call for less interfering tools. Instead of developing expert systems, they suggest the use of technologies to support human experts in their work, such as technologies for virtual meetings, and enhanced e-post applications. In traffic a similar perspective could e.g. stress

technologies to support road user interaction such as enhanced communication systems beyond blinkers and horns.

---

<sup>1</sup> The findings presented in this paper are preliminary results of a four-year project called *Road Talk Informatics* carried out at Göteborg University. The purpose of the project is to study traffic from a micro oriented sociological perspective, and generate principles for a user friendly design of ITS. Results from this research were first presented at a Nordic workshop on microriented studies of technical practices at Göteborg University in November '98. I would like to thank the participants for their comments. I would also like to thank Lars Erik Sjöberg at the Swedish National Road Administration for his incisive comments and great interest in this research.

<sup>2</sup> Catling, I. (ed) *Advanced Technology for Road Transport: IVHS and ATT* (London, Artech House, 1994), Whelan, R., *Smart Highways Smart Cars* (London, Artech House, 1995)

<sup>3</sup> 1998 AVG demo project Rijnwoude. URL: <http://www.minvenw.nl/rws/wnt/avg/uk/demo98/demo98->

<sup>4</sup> Collins, H., *Artificial Experts: Social Knowledge and Intelligent Machines*, (Boston, MIT Press, 1990), 15

<sup>5</sup> Swan, A. L. and B. M. Owens, "The Social-Psychology of Driving Behaviour: Communicative Aspects of Joint-Action", in *Mid-American Review of Sociology*, vol 13 ( 1988), 59

<sup>6</sup> Groeger, J., "Degrees of freedom and the limits of learning: support needs of inexperienced drivers", in Parkes and Franzén (eds.), *Driving Future Vehicles*, ( London, Taylor and Francis, 1993)

<sup>7</sup> A. M. Parkes and S. Franzén (eds.), *Driving Future Vehicles*, (London, Taylor and Francis, 1993)

<sup>8</sup> K. Schmidt and C. Simone, 'Coordination Mechanisms: Towards a conceptual foundation of CSCW systems design', *Computer Supported Cooperative Work*, Vol. 5 (1996), 155-200

<sup>9</sup> Collins, H., "Science Studies and Machine Intelligence", in Jasanoff, S et al (eds), *Handbook of Science and Technology Studies* (London, Sage, 1995)

<sup>10</sup> Suchman, Lucy, *Plans and Situated Actions: The Problem with Human Machine Interaction* (Cambridge, Cambridge University Press, 1991), Berg, M., 'The Politics of Technology: On Bringing Social Theory into Technological Design', in *Science, Technology and Human Values*, Vol. 23 (1998), 460

<sup>11</sup> Swan and Owens, op.cit note 5, 59

<sup>12</sup> Ibid, 62

<sup>13</sup> Suchman, op cit note 10, 63

<sup>14</sup> H. Garfinkel, *Studies in Ethnomethodology* (Cambridge, Polity Press, 1996 (1967))

<sup>15</sup> Suchman, op cit note 10, 66

<sup>16</sup> Goffman, E., *The Representation of Self in Everyday Life*,( London, Penguin Press, 1990), 26

<sup>17</sup> Groeger, op cit. not 6

<sup>18</sup> Collins, op cit not 4

<sup>19</sup> For a discussion on a modest design approach , see O. Juhlin and L. E. Sjöberg, 'Road Talk Informatics (vägpratsteknik) -Informatik för samverkan på väg och dess möjliga betydelse för trafikplaneringen i IT-samhället', *Vest-Tidskrift för vetenskapsstudier*, No 1 (1999) (forthcoming)