# Cognitive organization of roadway scenes, part II 

An empirical study of roads inside built-up areas

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This report describes two experimental studies designed to elucidate road users' cognitive organization of urban roadway scenes. (The present study may be viewed in conjunction with the highly similar study of Gundy (1994), conducted on rural roads.)

A sample of urban road locations was stratified by seven road classes, three levels of urbanization, and by the presence (or absence) of a intersection nearby. These classes were:
Class 0: dual carriageway arteries closed to slow traffic ( $70 \mathrm{~km} / \mathrm{hour}$ )
Class 1: dual carriageway arteries closed to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 2: single carriageway arteries closed to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 3: single carriageway arteries open to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 4: residential roads open to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 5: residential roads open to slow traffic ( $30 \mathrm{~km} / \mathrm{hour}$ )
Class 6: 'woonerf' residential roads open to slow traffic ( $<15 \mathrm{~km} / \mathrm{hour}$ ).
These locations were then photographed from the viewpoint of a driver, and roadside characteristics were registered. The presence of other traffic was avoided as much as possible.
A selection of 94 photographs were presented to approximately 25 volunteer subjects per experimental task. (Subjects were chosen such that their age and sex distribution roughly matched that of the Dutch driving popula tion.)

In the first experiment, subjects were asked to sort these photographs onto 'piles' of photographs, placing 'similar' photographs together, and placing 'dissimilar' photographs apart. These piles were intended to be 'meaningful' and 'useful' to the subjects (as determined by the subjects themselves) in their role as automobile drivers.

The sorting data was collected into similarity matrices and analyzed by means of Multi Dimensional Scaling and Analysis of Variance. The findings were quite clear. Namely, subjective similarity judgements were almost entirely 'explained' by the seven categories mentioned above.

In a following study, other subjects were asked to estimate a safe driving speed and the chance of encountering 'slow' traffic for each of the 94 photographs investigated in the previous study. The results were again analyzed by means of Analysis of Variance, with results clearly mirroring those of the first study.
Surprisingly, in contrast to the findings of Gundy's (1994) investigation of rural roads, the presence (or absence) of intersections played only a rather negligible role in the subjects' judgement.

Traffic safety implications and possibilities for future research are also considered. More concretely, it is tentatively indicated that there should be essentially three types of urban roads:

- high-speed arteries where slow traffic is prohibited,
- specially designed residential areas, where all forms of traffic are allowed, yet only (very) low speeds are possible,
- and transitional type(s), intermediate to the previous two types.


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## 1. Introduction

### 1.1. General

It is generally accepted that road administrators (should) apply some form of categorization or standardization in the form and intended use of the road network. One of the purposes of this standardization would be to somehow regulate road user behaviour, by indicating what is to be expected of them. This would then increase the predictability of road user behaviour, with attendant safety benefits.
It is also generally assumed (with good reason) that road users act as if they apply some form of categorization of road situations, which may have consequences for traffic safety.

We have some indication of how road administrators categorize roads, at least at a formal level.
Unfortunately, we have little idea of the 'categories' that road users' may apply. Nor do we know how these categories develop in time (although we must assume that it is a function of initial training and practical experience). Finally, we also have only a limited idea of how a formal road categorization system, either existing or proposed, would actually mesh with what road users' already know. To the extent that this last possibility is unknown, enormous conflicts, between one and the other, could arise.

To a great extent, future road systems will become safer by practically eliminating the possibility of unsafe behaviour.
However, we may also wish to believe that some form of standardization will promote desirable behaviour (and thus, safety). To the extent that the 'wish to believe' is outpacing the ability to know, we can only state that the traffic safety world is suffering from an enormous research blind spot.

### 1.2. Background

While much work has been done in subjective risk assessment and aesthetic experience of road-way scenes, road-user-centred subjective categorization has been largely ignored as a subject of study.

We know of two major exceptions. First of all, we refer to the work of Riemersma (1988a+b) in the Netherlands, and of Fleury and his colleagues (1991a+b, 1993) in France. Unfortunately, both groups of studies are rather limited in their generality.

Riemersma selected triads of road scenes which he presented to subjects. Subjects were asked to divide the three scenes into two groups and to mention the primary difference between the groups. All scenes were then scored on these differences and the results were subjected to a number of multivariate techniques.

The are several problems with the application of this technique.

First of all, the number of possible triads (of scenes) is a cubic power of the number of scenes. Twenty-five scenes yields almost 14,000 possible triads. Since it is impossible to present all possible triads, one must make a selection. However, seemingly innocent and small differences in selection procedures can have enormous consequences in final results. For this reason, it is absolutely necessary that procedures be clearly spelled out.

Secondly, all of the resulting score data (hundred or even thousands of variables) has to be reduced. Some of this reduction may be done subjectively, in which case the previous remark remains applicable. More 'objective' reductions may be consciously or unconsciously biased by 'loading the deck' against some possible interpretations.

Third of all, one must obtain some estimate of how important a difference is for road users. It is potentially misleading to simply to state that a (nameable) difference exists.

Finally, one should realize that mathematical techniques, such as multivariate clustering techniques, yield representations which may have some relation to road user categories. They are only hypotheses, which may be tested, and are not the 'actual things' themselves.

These criticisms may sound rather general.
However, the problem in the present case is that are situations wherein it is possible to generate everything but important subjective categories, by using the technique in the manner described by Riemersma. Such a 'worst case' is highly unlikely, and there is a continuum between 'worst' and 'best' possible representations. Unfortunately, we cannot determine where these studies lie on the continuum. As such, the validity and generality of Riemersma's results are difficult to assess.

Regardless of diverse criticisms, we view Riemersma's work as breaking new ground, for (from the viewpoint of the present report) his work is asking essential questions.

The work of Fleury and his associates has only recently become (somewhat) available to the present author. It is not possible, at this moment, to cover their entire oeuvre, mainly due to language difficulties. In general, however, we'd like to remark that our impression of the work of Fleury et al. is that generally quite skilfully done.

First of all, instead of using the method of triads (which is cubic in the number of objects) or paired comparisons (which is quadratic), they used a sorting procedure (which is only linear in the number of objects). (See van der Kloot and van Herk (1991) or Kruskal and Wish (1978) for examples.) Among other things, the analysis of an enormous number of (verbal) labels was thereby avoided.
The big advantage here is that one can score an enormous amount of material in relatively little time. A disadvantage is that individual differences are more difficult to investigate.

Secondly, Fleury et al. treated road scene categories as a hierarchal taxonomy, and systematically added and deleted branches of this 'tree'. This,
however, would be problematical if road scene categories were more veridically treated as 'tangled heterarchies', or as a hierarchy with a completely different structure.

Third of all, Fleury and his associates showed a great deal of sophistication in their use of multivariate analysis techniques. Unfortunately, this sophistication occasionally resulted in using the data as a vehicle to compare techniques. As a result, clarity sometimes suffered.

As may become apparent in the course of this report, we feel a great deal of affinity for the work of Fleury and his colleagues.

One thing that troubles us though, is that neither of these studies actually involved testing psychological models of categorization. Some mention is made of Rosch's early work in the 1970's on prototypes.
However, the consequences of Rosch's work for these studies is hardly clear. Alternative models, or formulations, are not mentioned, much less tested. We can only deplore the lack of application of existing psychological models in the field of traffic safety research.

### 1.3. Objectives

As indicated in the first section, understanding of road-user categorization (of road situations) underlies many assumptions of how we should more safely organize the driving task.

In the second section, we indicated that there is little empirical and even less theoretical work done to bolster this understanding. One cannot hope to remedy this situation with a single research report. The present report hopes at least to achieve two rather mundane objectives.

First of all, we wish to describe the major dimensions along which road users evaluate road scenes. Of course, there would be limitations in generality, and we will encounter handicaps in the methodology chosen. However, we would hope that the results would be sufficiently 'hard' and general enough to provide an adequate initial description of the situation in the Netherlands.

Secondly, we would like to create a calibrated archive of road-scenes. Again, there will be limitations in generality. However, careful (future) experimentation demands a preliminary quantification of the experimental stimuli used. We feel that one should build from a well understood, relatively simple, basis; research situations become extremely complex soon enough.

There are other, subsidiary, goals pursued in the course of this study. For example, we wanted to investigate the 'transparency' of existing road categories by comparing them to a more psychologically-based categorization scheme.
We also wanted to investigate the degree to which existing road categories, with their attendant speed limits, can be derived from roadway scenes.

Of course, the primary, long-term objective of the present study is to provide building blocks for the basic task of proposing, evaluating, and using psychological models of road-user categorization of road situations. A coherent body of empirical and theoretical results could be of great value when developing future roads, or training future road users.

## 2. General Overview Experiments

### 2.1. Introduction

The present experimental study is largely a replication of Gundy (1994). The methodology, the software and hardware, the collection of stimuli, and recruitment of subjects, are essentially the same.
There are, however, two important differences. First of all, the present study is much more limited in scope, utilizing only two experimental tasks: a sorting task, and an estimation task (i.e., safe driving speeds and chance of encountering slow traffic).
More importantly, the present study investigates urban roadway scenes, as opposed to the rural scenes studied previously.

### 2.2. General Methods

The two experimental tasks mentioned in the previous section both have their own specific procedures, objectives, and results. These will be reported in the appropriate section. Nevertheless, both studies used the same photographic images, apparatus and software, and pool of subjects. To prevent repetition, the following sections will describe aspects common to both studies mentioned in this report. Departures from these standards will be explicitly mentioned if and when relevant.

### 2.2.1. Materials

The present investigation used (photographic) images of roads located inside built-up areas. The actual material used was the result of a series of selections and processes.
Namely, we first selected a medium, then road locations and moments in time, and finally, actual images. These images had then to be converted to a form compatible with existing hard- and software. We will discuss each of these aspects and the resulting choices in turn.

## Photographs as a Medium

We chose to use photographic images, instead of other types of images. We deemed photographs to represent a suitable choice in the trade-off between cost and veridicality, at least for the present study.

## Road Locations

The choice of locations is crucial for obtaining results that are not only generalizable, but also believable for practitioners, as well as researchers. That is, one would like to make general statements about roads inside builtup areas, as well as making use of previous research. Furthermore, one would like to make use of existing knowledge concerning actual road types and locations, if only for practical reasons.
Two questions arise. First of all, is there a clear consensus (among practitioners/colleagues/researchers) about the main structures in urban road networks? (And what is that consensus?) Secondly, can we obtain access to a database of urban roads, coded according to this consensus?

Janssen (1991) shows that although there is some structure in general design principles, this rarely survives contact with actual roads in actual cities. Janssen (1993) does refer, however, to a database of a sample of urban arteries, partitioned according to the number of carriageways and the types of traffic permitted. It was our intention to use this database.
Unfortunately this database is rather old, and error-laden ${ }^{1}$. In addition, many types of roads, such as dual carriageway highways (autowegen) and residential streets, are only sparsely included or not at all. Finally, the sample is very heavily biased towards small town and villages, and is concentrated in a small portion of the Netherlands.

It was felt that the best compromise between practical limitations and scientific rigour would involve drawing a sample of locations stratified by three variables.

First of all, we selected the following road classes for explicit inclusion in our sample:
Class 0: dual carriageway arteries closed to slow traffic ( $70 \mathrm{~km} / \mathrm{hour}$ )
Class 1: dual carriageway arteries closed to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 2: single carriageway arteries closed to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 3: single carriageway arteries open to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 4: residential roads open to slow traffic ( $50 \mathrm{~km} / \mathrm{hour}$ )
Class 5: residential roads open to slow traffic ( $30 \mathrm{~km} / \mathrm{hour}$ )
Class 6: 'woonerf' residential roads open to slow traffic ( $<15 \mathrm{~km} / \mathrm{hour}$ ).
Classes 1 through 3 were included in the database mentioned above, and classes 0 and 4 through 6 were added afterwards, as a result of discussions.

Secondly, we stratified our selection of roads by three levels of urban population (density):

- less than 20,000 inhabitants,
- between 20,000 and 50,000 inhabitants, and
- more than 100,000 inhabitants.

Populations centers of other sizes were not directly available. Fortunately, we were able to supplement the largest population category with locations gleaned from other ongoing research activities.

Third of all, per selected road we chosen two further locations: intersections and straight road sections.
For a list of the locations chosen, and their corresponding road class, see Appendix 1.
As it turned out, there was a great deal of empty cells in the citysize x road CLASS design matrix. Namely, smaller urban areas are less likely to have extreme road CLASSes (i.e., 'woonerven' or $70 \mathrm{~km} / \mathrm{hour}$ dual carriageway arteries). This is, of course, quite understandable. However, a major consequence of this is that we cannot use simple Analysis of Variance, and that we can better avoid including interactions in that analysis.

[^0]A protocol was also developed for determining how the actual photographs were to be made (and other information gathered), once a road had been chosen:

An automatic 35 mm camera, with a 50 mm lens, was mounted on a tripod fastened on the passengers'-seat of an automobile. The camera was oriented through the front wind shield along the major axis of the automobile. The driver of this automobile then proceeded to one of the selected roads, and located:

- the first intersection located on that road, and
- a straight road section at least 100 meters after the intersection.

Having familiarized himself with the route and the two locations mentioned above, the driver then retraced the route from the opposite direction and made a photograph at each of the two locations from his moving vehicle. This 'run' was then repeated from the opposite direction, for a total of ( 2 locations $\times 2$ directions =) 4 photographs per road.
A final 'run' was made to collect information about the locations, while parked in the vicinity. The form used for this purpose is found in Appendix 2.

In this way, a total of approximately ( 7 road classes x 3 city sizes x 3 roads per citysize-road CLASS $\times 2$ locations per road $\times 2$ directions per location $\Rightarrow 252$ photographs were made ${ }^{2}$.

Four points were emphasized:

1. safety was the overriding priority;
2. a distance of at least 100 meters from preceding traffic was necessary to ensure that other traffic would not obscure part of the photograph;
3. the photographs should be made at a distance of about 50 meters from the location in question, in order to ensure a good view of that location.
4. if at all possible, one should avoid including traffic signs in the photographs.

This material was collected during working hours for about 15 days spread over the months of August through October 1995. Photographs were not collected during days with predominantly poor weather.

The negatives were developed and placed on Kodak Photo CD's. The images were then converted to 16 grey-levels, and reduced to a size of 640 by 426 pixels. (This size fits onto a VGA screen and also preserves the original aspect ratio). The images were then translated to PCX image files. These steps were necessary in order to ensure compatibility between the images and the MEL software which would be using them (see apparatus section). Please see Figure 1 for a general sketch of the steps necessary to prepare and present the materials to our experimental subjects.

[^1]

Figure 1. Sketch of stimulus processing steps.
All images were then examined and those with substandard quality ${ }^{3}$ were eliminated. After this initial process of elimination, only those roads with at least one adequate image of straight-road section and an intersection, were further considered. Except for these two provisions, further sampling of images was done randomly. See Appendix 3 for some examples.
Three comments should be made here.
First of all, there seemed to be a general consensus (among colleagues and experimental subjects) that the images were clear and understandable depictions of Dutch roads. In fact, the present author was quite pleased with their quality.

Secondly, it was initially surprising to note that there was very little traffic in the photographs. It should be noted that the photographer was instructed to avoid taking pictures while closing following another vehicle. It is possible that the photographer had a rather wide interpretation of this instruction. More likely is that most of the selected roads are lightly travelled during non-rush hours (when most of the photographs were made). Completely eliminating, or systematically manipulating, all traffic in these photographs, by means of police or software intervention, would have been prohibitively expensive.
It should nevertheless be emphasized that we sought a sample of road locations and not of traffic situations.

A third point concerns the information that was gathered at each road location (see Appendix 2). This data was intended as additional information to support interpretation based on other (psychological) measurements. As such, it was never intended as a data file of interest in itself. This is fortunate because, as it turned out, there are no easily available standardized

[^2]instruments for doing road section inventories. The data form and the data collection protocol are therefore somewhat ad hoc.
The upshot is that more than a small amount of expense was made in creating a computerized inventory of the road locations photographed, yet the usefulness thereof remains to be seen.

### 2.2.2. Subjects

It was clear that resource limitations precluded collecting a representative sample of road users. Nevertheless, it was felt that some, albeit crude, indication of sample quality was needed. To this end, we decided to emulate the sex and age distribution of the Dutch driving population.

According to the Dutch Central Bureau for Statistics (CBS, 1991, p. 215), the following numbers of people were in possession of a Class B driving licence:

| AGE |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 18-24 | 25-39 | 40-49 | 50-64 | $65+$ | Total |
| SEX |  |  |  |  |  |  |
| $\begin{aligned} & \text { Males } \\ & (\times 1000) \end{aligned}$ | 527 | 1646 | 1000 | 1062 | 497 | 4732 |
| Percent | 11\% | 35\% | 21\% | 22\% | 11\% | 100\% |
| $\begin{aligned} & \text { Females } \\ & (\times 1000) \end{aligned}$ | 500 | 1596 | 836 | 641 | 248\% | 3821 |
| Percent | 13\% | 42\% | 22\% | 17\% | 6\% | 100\% |

Figure 2. Number of people (x1000) in the Netherlands with a driving license in 1991, split by age and sex.

Even though there are more male than female drivers, we decided to strive for equal numbers of male and female subjects, albeit with their respective age distributions.

We approached a potential subject population by means of an advertisement in local shopping newspapers. We asked that potential subjects have normal (corrected) vision and a valid driving licence, and be able to read the Dutch language easily. The study would take place during office hours, and participants were offered a gift certificate of an un-specified amount.

Almost eighty subjects responded. However, older males were heavily over-represented; younger males and females were heavily underrepresented.
In order to (partially) remedy this problem, the subjects pool was supplemented by the population of SWOV administrative personnel(!).

While this last supplement is rather unusual, we feel that it improves, rather than detracts from, the general representativeness of the final sample.

The total number of subjects (categorized by sex and age) who actually participated in one of the following studies is shown below:

|  |  | AGE |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $?$ | $18-24$ | $25-39$ | $40-49$ | $50-64$ | $65+$ | Total |  |
| SEX |  |  |  |  |  |  |  |  |
| Males | 1 | 2 | 8 | 7 | 4 | 3 | 25 |  |
| $\%$ | $4 \%$ | $8 \%$ | $32 \%$ | $28 \%$ | $16 \%$ | $12 \%$ | $100 \%$ |  |
| Females | 1 | 2 | 9 | 8 | 4 | 2 | 26 |  |
| $\%$ | $4 \%$ | $8 \%$ | $35 \%$ | $31 \%$ | $15 \%$ | $8 \%$ | $100 \%$ |  |

Figure 3. Number of people participating as a subject, split by age and sex.

Each participating subject also answered a number of questions concerning demographics and automobile use. This data will not be discussed here.

### 2.2.3. Apparatus

The apparatus used in these studies were (more or less) identical high performance, $486-\mathrm{DX} 50 \mathrm{MHz}$, MS-DOS compatible PC's, with Tseng (ET4000) super VGA video cards, and Samtron SC 428 TXL low-radiation color monitors. All extraneous utilities, TSRs, and drivers were removed.

The Micro-computer Experimental Laboratory (MEL), version 1.0, was used to run all of the experiments. Since MEL version 1.0 uses only 16 color VGA, which we implemented as 16 grey shade images, these computers were more than adequate to run the experiments. Wait times (for calling up images from the hard disk) were barely noticeable, being on the order of perhaps a few tenths of a second.
The studies were all conducted in a smoke-free room, whose windows were partially shuttered to prevent annoying light reflections. Subjects were encouraged to call the experimenter if viewing conditions were suboptimal. De-briefed subjects indicated that the images were sharp, and the viewing conditions were acceptable.

### 2.2.4. Procedure

Of course, each experiment had its own specific procedure. However, a number of aspects were common to both studies.

The experimenter provided a verbal introduction, making use of an overhead projector and hand-outs. Therein information was given about the

SWOV, the purpose of the study, the procedure to be followed, and a general timetable. More practical details were mentioned and materials were distributed.
Subjects were ensured that their responses would not (in fact, could not) be coupled to their persona.

Since it was not our intention to 'surprise' subjects, instructions were not only given verbally, but were also presented on the computer screen at appropriate times. They were also encouraged to ask for help if needed. In addition, subjects were also given the opportunity to view a sample of images in order to familiarize themselves with the material. This approach attempted to ensure that the experimental procedure was self explanatory.

Subjects were asked, when finished, to fill in a short biographical questionnaire, and to contact the experimenter before leaving. The experimenter answered any remaining questions, and invited subjects to place their names and addresses on a mailing list for a summary of the experimental results. The experimenter also attempted to obtain an impression of subjective evaluations concerning the study. Subjects were then personally thanked for their participation, and presented with a gift certificate (value of approximately US\$ 15 ) and a pen with the SWOV logo.

The entire session was intended to require not more than 1 hour. Subjects worked at their own speed, and almost all were able to finish well within that amount of time.
It was pleasing to note that many, if not all, subjects were quite enthusiastic about their experience. Many spontaneously offered to participate in future studies.

## 3. Experiment 1: Sorting Photographs of Roadway Scenes

### 3.1. Introduction

The objective of this experiment is simple, and the methodology straightforward.
The objective is to obtain a description of the primary dimensions along which road users', in their role of road users', differentiate between road scenes. It is important that we specify the road user role; otherwise, we might elicit aesthetic (or other) judgements, whose relation to driving behaviour is unclear.

The methodology consists of presenting subjects with pictures of road scenes, and asking them to sort those pictures into piles. Similar pictures should be sorted onto the same pile; dissimilar pictures onto different piles. A similarity measure, which depends upon how often subjects place two stimuli onto the same pile, is then calculated. These measures may be collected into a matrix and analyzed by means of Multidimensional Scaling. The method assumes either that different subject are (noisy) replications of each other, or that the final matrix represents some sort of common ground between subjects.

### 3.2. Methods

3.2.1. Materials

### 3.2.2. Subjects

3.2.3. Apparatus

Ninety four still photographs, described in section 2.2 .1 (see p. 10) and identical to those investigated in the following study, were used in the present study.

Twenty six subjects, fourteen men and twelve women, participated in this study. See section 2.2 .2 (p. 14) for a description of the studied population.

See section 2.2.3 (p. 15).

### 3.2.4. Procedure

In addition to the standard procedure mentioned in section 2.2.4, subjects were presented with a sample of 25 photographs drawn from the sample of 94 just mentioned. The Subjects were asked to consider these photographs as if they were road scenes that the Subjects may come across in their role as a driver. It was emphasized that aesthetics, picture quality, and other non-functional aspects should not be considered.

Subjects were then instructed that the intention was to sort pictures (similar to the ones just seen) into piles, such that similar pictures are placed onto the same pile and dissimilar pictures onto different piles.

Subjects would be presented with these pictures, one at a time, after which a pile would have to be selected. Decisions, once made, were irrevocable ${ }^{4}$.

Subjects were asked to spend no more than 30 seconds a picture, even though no penalty was extracted.
Subjects were furthermore asked to use at least three piles and no more than nine. Subjects were warned that the more piles they used, the more difficult it would be to keep track of them.
Pencil and paper, and a HELP function which displayed the last four pictures placed on a pile, were to be used as memory aids.

Subjects were told that they were free in choosing how piles were to be formed: the only requirement was that it should make good sense to them in their role as a road user. Subjects were also informed that they would be asked to describe these piles at the end of the study.

All subjects saw the same pictures in different random orders.

### 3.3. Results

2,444 classifications ( 26 subjects times 94 photographs) were made. No data were missing.
These data were then aggregated into a similarity matrix (see van der Kloot \& van Herk, 1991).

We analyzed this matrix by means of the Multi-Dimensional Scaling routine available in SAS (1992) ${ }^{5}$. We fit one through four dimensions, with fits of $0.22,0.15,0.11$, and 0.09 .
In comparison with the results mentioned in Gundy (1994, p. 21), there is clearly a much simpler structure in the present case.

The ninety four objects are plotted in Figure 4. The first two dimensions of the three dimensional solution are shown.

[^3]The two dimensional structure shown here is a clear example of a socalled 'horseshoe', which indicates that the data matrix had indeed a low dimensionality.


Figure 4. First two dimensions of the 3D Multi Dimensional Scaling Results.

The three dimensions of the MDS representation were analyzed by means of (type III) analysis of variance. The sampling variables (citysize, road CLASS, and road type) were utilized as independent variables. The results of the three ANOVA's and the corresponding parameter estimates are presented in Tables 1.a and 1.b (p. 31 and 32). Only one interaction was tested due to the rather severe incompleteness of the design matrix. (That is, many of the cells in the road CLASS x CITYSIZE interaction were empty.)

Inspection of Tables 1.a (p.31) and 1.b (p. 32) reveals the following:

- The first dimension of the MDS solution, which is clearly extremely important, is predominantly 'explained' by the road CLASS variable. No other independent variable is even remotely significant.
- The second MDS dimension, which is much less important, is also largely 'explained' by the CLASS variable. The horseshoe form (and the results of the ANOVA) indicates that the second dimension is only improving the overall fit without adding any adding any insight above that already gleaned from the first dimension.
- The third dimension is rather unimportant in terms of adding to overall fit. All independent variables (with the exception of road CLASS) are
statistically significant, yet only the road TYPE variable carries any weight.
- Considering the parameter estimates and the results of planned comparisons (not presented here) for the road CLASS variable for the first dimension indicates that Subjects clearly order the photographs by the order of the road CLASS.
That is, subjects clearly distinguish between 'woonerven' and 30 $\mathrm{km} /$ hour residential areas (lumping together classes 5 and 6 ), on the one hand, and dual carriageway arteries (combining classes 0 and 1 ), on the other.
'Normal' residential streets and single carriageway arteries (open to all traffic, classes 3 and 4) take in intermediate positions, between the two previously mentioned groups. These two classes ( 3 and 4) are also distinct from each other.
Interestingly enough, single carriageway arteries (closed to slow traffic, class 2 ) are lumped together with the dual carriageway arteries.


### 3.4. Discussion and Conclusions

Summarizing, the lions' share of the variance is explained by road classes. CLASSES 0,1 , and 2 are lumped together and are contrasted with CLASSES 5 and 6, which are also lumped together. CLASSES 3 and 4 take in distinct, intermediate positions.

Amazingly, the effects of road section TYPE, which distinguishes between straight road sections and intersections, plays a relatively weak role, only appearing in the third (and perhaps second) MDS dimension. This surprises due to the face that Gundy (1994) reports that in the case of rural roads, this distinction is of utmost importance. The question arises: why does this result not also obtain in the present case?

We believe that a partial explanation lies buried in the parameter estimates for the TYPE and the TYPE x CLASS interaction in the third MDS dimension. Namely, we see (in Table 1.b) that intersections and straight road sections are distinguished for arteries closed to slow traffic (CLASSES 0,1, and 2). However, this distinction disappears when we consider residential streets (CLASSES 4,5, and 6). Even so, please bear in mind that this effect is rather minuscule in comparison to the dominating influence of the CLASS variable mentioned above.

We defer interpretation of this finding for the general discussion section.

## 4. Experiment 2: Estimating Safe Speeds and Chances of Meeting Slow Traffic

### 4.1. Introduction

This section describes a study which provides a quantification of two important road characteristics, which are crucial for traffic safety considerations.
Our question then is whether subjects are able to systematically assign safe speeds and chances of encountering 'slow' traffic to road scenes. If so, then we would like to know which factors play important roles in these discriminations.

### 4.2. Methods

### 4.2.1. Materials

### 4.2.2. Subjects

### 4.2.3. Apparatus

See section 2.2 .3 (p. 15).

### 4.2.4. Procedure

Ninety four still photographs, described in section 2.2 .1 (p. 10) and identical to those investigated in the previous study were used in the present study.

Twenty five subjects, eleven men and fourteen women, participated in the present study. See section 2.2 .2 (p. 14) for a description of the studied population..

Subjects were presented with 94 photographs per block, one at a time, and asked to type in a number which indicated:

- the 'driving speed that they felt to be safe', or
- the 'chance that they might encounter slow traffic' in the road scene depicted.

The presentation order of photographs was randomized for each subjectblock combination. The presentation order of the question asked in a block was also counter-balanced over subjects.

### 4.3. Results

None of the ( 2 questions $\times 25$ subjects $\times 94$ photographs $=$ ) 4,700 possible responses were missing.

First of all, considering the 'Safe Driving Speed' variable, please consult Table 2.a (p. 33), which summarize the results of a type III Analysis of Variance, with the previously mentioned sampling variables, and subjects,
and the independent variables. As previously indicated, most interactions were not included in the analysis, due to the unbalanced design matrix. Table 2.b (p. 33) summarizes the corresponding least mean squares parameter estimates.
In those tables, we find that all independent variables play a significant role in 'explaining' our variance.

Road CLASS again dominates the situation. High 'safe speeds' are indicated on arteries (closed to slow traffic), and lower 'safe speeds' are tolerated in residential areas. Planned comparisons indicate that only CLASSES 1 and 2 are actually indistinguishable.
While all other classes are significantly different, and in the 'correct' order, the differences may not be as large as one would like. For example, the difference in estimated safe speed in a $50 \mathrm{~km} / \mathrm{hour}$ and a $30 \mathrm{~km} / \mathrm{hour}$ residential zone is only about 3.5 km per hour.

Road section TYPE plays a subservient yet non-negligible role here: safe speed at intersections are lower than at other road sections.

Other effects are statistically significant, yet not especially interesting. The tiny CLASS x TYPE interaction may be an exception.

Concerning the 'Chance of encountering slow traffic' variable, please consult Table 3.a (p. 35) for a type III Analysis of Variance, and Table 3.b (p. 35) for the corresponding parameter estimates.

The results are quite familiar by now. Road CLASS clearly explains a major portion of the variance. One has (apparently) a relatively low chance of encountering slow traffic on dual carriageway arteries and a relatively high chance of the same in residential areas. Planned comparisons revealed that all individual classes are distinguishable from each other, with the exception of CLASSES 1 and 2. One's chances are also a tiny bit higher of encountering slow traffic at an intersection as opposed to other road sections.

We also refer the reader to the tiny, yet interesting CLASS x TYPE interactions for both questions. In Table 2.b and 3.b, one finds that they difference between intersections and straight road sections are pronounced in the case of road CLASS 0 , and hardly interesting for other road classes. We will return to this point in the General Discussion.

### 4.4. Discussion and Conclusions

The results of this experiment only reinforce the findings mentioned in the previous one: road class is, apparently, the primary objective 'explanation' for differences in (subjective) evaluations of urban roads. Differences due to the presence of intersections are apparently only of secondary importance ${ }^{6}$.

[^4]There are, of course, situations in which important (i.e., safety relevant) distinctions are not made as emphatically as we would want them to be. For example, the estimated difference in safe driving speed between a $70 \mathrm{~km} /$ hour and a $50 \mathrm{~km} /$ hour artery is only about $5 \mathrm{~km} / \mathrm{hour}$. The same applies to the difference between $50 \mathrm{~km} /$ hour and a $30 \mathrm{~km} / \mathrm{hour}$ residential zone.

## 5. General Discussion and Conclusions

### 5.1. Primary Findings

Our primary findings are quite simple. Subjects organize (photographs of) urban road scenes in a manner describable by road CLASS. (See p. 11 for a description of the system of road classes used here.)
This organizational structure is, for the most part, simple and uni-dimensional. It is also highly correlated with the ordering of the road CLASS variable.
No other explanatory variables were found to play a role of similar magnitude, nor do they seem to be necessary.

These results are obtained whether one asks subjects to sort road scenes onto similar piles, to estimate safe driving speeds, or to estimate the chance of encountering 'slow traffic'.
We would suppose that these results, at least for these stimuli and tasks, are rather robust. Whether these results would obtain in other evaluative tasks, and whether these results are generalizable to more dynamic stimuli, is a matter of study.

However, we are confronted with a puzzle, and with some less simple implications for traffic safety.

### 5.2. A Puzzle

The puzzle is simple to describe: we have already alluded to it previously. Namely, the presence of an intersection nearby played no appreciable role in the present study of urban road scenes. This finding stands starkly in contrast with the findings of Gundy (1994) for rural road scenes. In that study, intersections played an essential and dominant role.

Why, in one study, does (almost) everything revolve around the presence of intersections, and in another study is this role almost reduced to irrelevance?
It would almost seem that Subjects view urban roads as one, continuous intersection, while rural roads are places where they drive unhindered, until they come to an intersection.
While such a descriptive 'explanation' is a bit too facile, it nevertheless does receive some empirical support, already alluded to in sections 3.4. and 4.4. There we find small, yet interesting interactions between road CLASS and road TYPE. Namely, intersections play a role of some importance for the lower level road CLASSes (i.e., arteries which may seem similar to rural roads), while being almost completely irrelevant for higher level road CLASSES (i.e., residential situations).
In other words, intersections apparently play a unique role to the extent that a road generally allows one to drive without hindrance.

Of course, this phenomenon requires further study.

### 5.3. Traffic Safety Implications

The findings mentioned in section 5.1 are simple and direct. However, this does not necessarily mean that all is well, with little room for improvement.

First of all, the apparent lack of regard for the (relative) uniqueness of intersections in urban situations may be viewed optimistically: Subjects apparently know that in urban environments one can expect almost everything (e.g., merging, turning, braking, and crossing traffic), almost everywhere.
The other side of the coin is that it's difficult to be continuously prepared for almost everything, almost everywhere: disregard then threatens to become symptomatic.
This last possibility should not surprise those who investigate yielding right-of-way.

Secondly, while subjects generally order road sections by their correct CLASS, this does not mean that they make distinctions as clearly as we would prefer, if the distinctions are made at all.

For example, CLASSes 1 and 2 (dual- and single-carriageway arteries with $50 \mathrm{~km} /$ hour limits are closed to 'slow traffic') are routinely confused. This is surprising, because the number of carriageways is important for the presence of traffic from the opposite direction, and because this distinction was found to be very important for rural roads (see Gundy, 1994).
Do subjects lack the cues necessary to make the distinctions, or do they just consider the distinction to be inconsequential? Either way, there may be a problem.

Furthermore, CLASS 0 roads (dual carriageway $70 \mathrm{~km} /$ hour arteries) are also routinely confused with CLASSes 1 and 2 . However, we see that there is a small (and statistically significant) difference in estimated safe driving speed. This difference, however, is only a few kilometres per hour while the permitted difference is 20 kilometres per hour.

We see similar confusions and compressions on the other side of the scale. the difference between CLASSes 5 and $6(30 \mathrm{~km} /$ hour residential streets and 'woonerven') are not particularly important, as shown in the sorting task, yet the average difference in safe driving speed is a respectable 10 $\mathrm{km} /$ hour. Even so, this difference should be larger, say 15 to $20 \mathrm{~km} / \mathrm{hour}$ !

More critically, while a clear distinction is made between $50 \mathrm{~km} / \mathrm{hour}$ and $30 \mathrm{~km} /$ hour residential streets (CLASSes 4 and 5), estimated safe driving speeds differ only by a paltry few kilometres per hour.

Clearly, more research must be conducted in order to establish how we can emphasize important distinctions, perhaps noticed, but not always acted upon by drivers.

Thirdly, we, as safety experts, have to ascertain what we feel to be the important distinctions in the urban traffic network. We must build upon
the intuitions and experiences of drivers, yet are forced to implement our own design decisions.

More concretely, the preceding sections may indicate that there should be essentially three types of urban roads:

- high-speed arteries where slow traffic is prohibited,
- specially designed residential areas, where all forms of traffic are allowed, yet only (very) low speeds are possible,
- and transitional type(s), intermediate to the previous two types.

This suggestion is hardly shocking (see, for example, the literature concerning 'Sustainable traffic safety'). It is furthermore pleasing to note that there is some empirical support for such an opinion.

Implementing such a suggestion, however, is not a panacea, nor is it without its dangers. Combining (somewhat) dissimilar things into a super-category does violence to the uniqueness of the constituents. For example, CLASS 4 ( $50 \mathrm{~km} / \mathrm{hour}$ residential streets) resembles CLASSes 5 and 6. It also resembles CLASS 3 ( $50 \mathrm{~km} /$ hour arteries open for all traffic). Combining CLASSes 4,5 , and 6 is going to make the average residential area look more like a CLASS 3 artery; combining CLASSes 3 and 4 , on the other hand, is going to make the average artery (open for all traffic) look more like a residential area. (One could also leave well enough alone, and do nothing.)
Each choice has it pro's and con's: we would only argue that choices be explicitly argued and thoroughly tested before wide-scale implementation. Behavioural research is an essential component of this process.

### 5.4. Future Research

The previous sections have implications for future studies.
First of all, it seems rather apparent that a future study should combine rural and urban roads. Such a study should not only shed some light onto the 'intersection' puzzle, but also establish whether there is a clear distinction between the two situations.

Secondly, the present study was limited to static (i.e., photographic) stimuli, without reference to manoeuvres or other traffic. Future studies should not only include dynamic stimuli, but also systematically consider the role of specific manoeuvres and traffic.

A third nuance parallels the second: we only considered road scenes and not road routes. Transitions from one road scene to another road scene depend upon the type of road route followed: one only rarely encounters a special residential intersection on a dual carriageway $70 \mathrm{~km} /$ hour artery. Classification of road scenes, in the real world, could possibly also have a strong memory-dependent component. An experimental study, using the same materials as here, could investigate classification accuracy and latency as a function of memory load and congruency of transitions.

A fourth aspect reflects a holistic bias, perhaps encouraged by the stimuli used here. That is, we have considered 'residential areas' and 'dual-car-
riageway arteries' only in a general sense: we did not investigate which specific infra-structural elements were primarily responsible for distinguishing between one and the other.
This could be done by statistically coupling subjective judgements and road characteristics (for existing roads). This can be readily implemented with existing databases. An alternative is, of course, to actually manipulate road characteristics in an experimental setting. This could be done with suitable computer-aided image editing. The results of such studies could have important consequences for the layout of future roads.

Fifthly, this study remained on a rather high level of analysis, attempting to generalize over all urban road types. As indicated above, it would be useful to zoom in onto distinctions between 'neighbouring' road-classes. This could be investigated easily enough with the same kinds of technology used here or used by, e.g., Gundy (1994).

Sixth of all, it would be quite easy to consider individual differences (e.g., age, driving experience, and sex) in how road users organize their knowledge of roadway scenes. (As previously mentioned, the present study viewed subjects as replications of each other.) Namely, a 'one size fits all' traffic infrastructure is the simplest to implement, yet many researchers and policy makers may not want to ignore the unique problems of the elderly, for example.

A final, seventh, possibility stems from the consideration of whether future research should be problem-, technological-, or theory-driven. The answer, of course, is 'all three'. More to the point, much of the discussion around 'sustainably safe roads', 'self-explaining roads', 'road categorization', etc., is heavily influenced by ideas and theories about human categorization behaviour. Unfortunately, many of the ideas underlying this discussion are left implicit, and therefore remain inviolate.

We are convinced that the explicit consideration of existing psychological theories of categorization can usefully contribute to this discussion. These (existing) theories are practical, they organize data, they make predictions, and they can (and should) be explicitly applied, tested, and compared.

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## 7. Tables and Appendices

TABLE 1.a $\begin{aligned} & \text { ANOVA's for } 3 D \text { Multi-Dimensional Scaling Results (94 } \\ & \text { Photographs) }\end{aligned}$
TABLE 1.b Least Mean Squares Estimates for 3D Multi Dimensional Scaling Results (94 Photographs)

TABLE 2.a ANOVA for 'Safe Driving Speed' (94 Photographs)

TABLE 2.b Least Mean Squares Estimates for 'Safe Driving Speed' (94 Photographs)

TABLE 3.a ANOVA for 'Chance of Slow Traffic' (94 Photographs)

TABLE 3.b Least Mean Squares Estimates for 'Chance of Slow Traffic' (94 Photographs)

Appendix 1: Locations
Appendix 2: Data Collection Form
Appendix 3: A Few Example Photographs

TABLE 1.a ANOVA's for 3D Multi-Dimensional Scaling Results (94 Photographs)

Dependent Variable: DIM1

| Source | DF | Type III SS | Mean Square | F Value | Pr $>$ F |
| :--- | ---: | ---: | ---: | ---: | ---: |
|  |  |  |  |  |  |
| CLASS | 6 | 144.15467589 | 24.02577931 | 76.62 | 0.0001 |
| CITYSIZE | 2 | 0.24597972 | 0.12298986 | 0.39 | 0.6769 |
| TYPE | 1 | 0.36487773 | 0.36487773 | 1.16 | 0.2840 |
| CLASS*TYPE | 6 | 0.63196394 | 0.10532732 | 0.34 | 0.9160 |
| Error | 78 | 24.45747554 | 0.31355738 |  |  |
| Corrected Total | 93 | 171.44785325 |  |  |  |
| Model R-squared: | 0.857347 |  |  |  |  |

Dependent Variable: DIM2

| Source | DF | Type III SS | Mean Square | F Value | Pr $>$ F |
| :--- | ---: | ---: | ---: | ---: | ---: |
|  |  |  |  |  |  |
| CLASS | 6 | 30.79879852 | 5.13313309 | 12.48 | 0.0001 |
| CITYSIZE | 2 | 1.04184075 | 0.52092037 | 1.27 | 0.2875 |
| TYPE | 1 | 2.16007330 | 2.16007330 | 5.25 | 0.0246 |
| CLASS*TYPE | 6 | 3.52149414 | 0.58691569 | 1.43 | 0.2149 |
| Error | 78 | 32.07350359 | 0.41119876 |  |  |
| Corrected Total | 93 | 71.88215252 |  |  |  |

Model R-squared: 0.553804

Dependent Variable: DIM3

| Source | DF | Type III SS | Mean Square | F Value | Pr $>$ F |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: |
|  |  | 6 | 3.48545843 | 0.58090974 | 2.08 | 0.0653 |
| CLASS | 2 | 3.19905276 | 1.59952638 | 5.72 | 0.0048 |  |
| CITYSIZE | 1 | 7.25486840 | 7.25486840 | 25.95 | 0.0001 |  |
| TYPE | 6 | 5.84254757 | 0.97375793 | 3.48 | 0.0042 |  |
| CLASS*TYPE | 78 | 21.80839570 | 0.27959482 |  |  |  |
| Error | 93 | 38.66999423 |  |  |  |  |
| Corrected Total |  |  |  |  |  |  |
| Model R-squared: | 0.436038 |  |  |  |  |  |

TABLE 1.b Least Mean Squares Estimates for 3D Multi Dimensional Scaling Results (94 Photographs)

| CLASS | DIM1 | DIM2 | DIM3 |
| :--- | ---: | ---: | ---: |
|  |  | LSMEAN | LSMEAN |$\quad$ LSMEAN

TABLE 2.a ANOVA for 'Safe Driving Speed'

| Source | DF | Type III SS | Mean Square | Fralue | Pr $>$ F |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: |
| CITYSIZE | 2 | 1417.3906492 | 708.6953246 | 4.96 | 0.0071 |
| CLASS | 6 | 358198.7260358 | 59699.7876726 | 417.43 | 0.0001 |
| TYPE | 1 | 12487.3535620 | 12487.3535620 | 87.31 | 0.0001 |
| PPN | 23 | 119729.1791341 | 5205.6164840 | 36.40 | 0.0001 |
| CLASS *TYPE | 6 | 7330.8876772 | 1221.8146128 | 8.54 | 0.0001 |
| Error | 2308 | 330082.6410102 | 143.0167422 |  |  |
| Corrected Total | 2346 | 836465.3089049 |  |  |  |
| Model R-squared | 0.605384 |  |  |  |  |

TABLE 2.b Least Mean Square Estimates for 'Safe Driving Speed'
\(\left.\begin{array}{lr}CITYSIZE \& SPEED <br>

LSMEAN\end{array}\right]\)| 1 | 42.2900622 |
| :--- | ---: |
| 2 | 41.1300857 |
| 3 | 42.9214300 |
|  |  |
| CLASS | SPEED |
|  |  |
| 0 | 58.8712822 |
| 1 | 53.7383075 |
| 2 | 55.6113599 |
| 3 | 40.9535977 |
| 4 | 34.1513754 |
| 5 | 30.8682783 |
| 6 | 20.6028141 |
|  |  |
| TYPE | SPEED |
|  |  |
| 1 | 44.5441074 |
| 2 | 39.6836112 |


| CLASS | TYPE | SPEED <br> LSMEAN |
| :--- | :--- | ---: |
|  |  |  |
| 0 | 1 | 66.6383075 |
| 0 | 2 | 51.1042569 |
| 1 | 1 | 55.1883075 |
| 1 | 2 | 52.2883075 |
| 2 | 1 | 57.5650675 |
| 2 | 2 | 53.6576523 |
| 3 | 1 | 42.6313754 |
| 3 | 2 | 39.2758199 |
| 4 | 1 | 36.1647088 |
| 4 | 2 | 32.1380421 |
| 5 | 1 | 32.3881708 |
| 5 | 2 | 29.3483858 |
| 6 | 1 | 21.2328141 |
| 6 | 2 | 19.9728141 |

TABLE 3.a ANOVA for 'Chance of Slow Traffic'

| Source | DF | Type III SS | Mean Square | F Value | Pr $>$ F |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: |
| CITYSIZE | 2 | 4881.3714373 | 2440.6857186 | 6.19 | 0.0021 |
| CLASS | 6 | 1283624.6330616 | 213937.4388436 | 542.21 | 0.0001 |
| TYPE | 1 | 6523.7064731 | 6523.7064731 | 16.53 | 0.0001 |
| SUBJ | 23 | 433457.4999863 | 18845.9782602 | 47.76 | 0.0001 |
| CLASS *TYPE | 6 | 9981.0484709 | 1663.5080784 | 4.22 | 0.0003 |
| Error | 2310 | 911442.7153003 | 394.5639460 |  |  |
| Corrected Total | 2348 | 2683783.9574286 |  |  |  |
| Model R-squared: | 0.660389 |  |  |  |  |

TABLE 3.b Least Mean Square Estimates for 'Chance of Slow Traffic'

| CITYSIZE | CHANCE <br> LSMEAN |
| :--- | ---: |
|  |  |
| 1 | 46.2882730 |
| 2 | 49.9176964 |
| 3 | 47.2884068 |
| CLASS | CHANCE |
|  | LSMEAN |
|  |  |
| 0 | 15.7055649 |
| 1 | 21.3205649 |
| 2 | 21.0069372 |
| 3 | 58.6369832 |
| 4 | 67.8776132 |
| 5 | 71.8360680 |
| 6 | 78.4364798 |


| TYPE | CHANCE |
| :--- | ---: |
|  | LSMEAN |


| CLASS | TYPE | CHANCE <br> LSMEAN |
| :--- | :--- | ---: |
|  |  |  |
| 0 | 1 | 9.7255649 |
| 0 | 2 | 21.6855649 |
| 1 | 1 | 21.0655649 |
| 1 | 2 | 21.5755649 |
| 2 | 1 | 17.2219372 |
| 2 | 2 | 24.7919372 |
| 3 | 1 | 56.7674643 |
| 3 | 2 | 60.5065021 |
| 4 | 1 | 66.3953910 |
| 4 | 2 | 69.3598354 |
| 5 | 1 | 71.0446395 |
| 5 | 2 | 72.6274966 |
| 6 | 1 | 80.3131464 |
| 6 | 2 | 76.5598131 |

## Appendix 1: Locations

STEEKPROEF WEGEN BIBEKO.

Categorie, vorm, gebruik van wegen. AANVULLING + CORRECTIES.
versie : 22-09-195

| Gem code | Pro | Gemeente | Loc code | Cat | Straatnaam | Nwe <br> Cat Bijzonderheden |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 216 | GE | CULEMBORG | 216019 | 3 | Varkensmarkt | 3 |
| 216 | GE | CULEMBORG | 216024 | 2 | Weth. Schoutenweg | 2 |
| 216 | GE | CULEMBORG | 216301 | 5 | Dahliastraat | 5 |
| 216 | GE | CULEMBORG | 216wol | 6 | geen | 9 |
| 281 | GE | TIEL | 281020 | 1 | Laan v Westrooyen | 2 ! |
| 281 | GE | TIEL | 281058 | 2 | Provincialeweg* | $2!70 \mathrm{~km} / \mathrm{uur}$ |
| 281 | GE | TIEL | 281098 | 4 | Achterweg * | 4 |
| 281 | GE | TIEL | 281099 | 4 | Bachstraat | 4 |
| 281 | GE | TIEL | 281301 | 5 | Fabriekslaantje | 5 |
| 281 | GE | TIEL | 281wol | 6 | De Henepe 215-263 | 6 |
| 347 | UT | VLEUTEN de MEERN | 347008 | 1 | Meerndijk * | 2 |
| 392 | ZH | HAARLEM | 392701 | 0 | Schipholw | 0 |
| 392 | ZH | HAARLEM | 392702 | 0 | w. Randw | 0 |
| 392 | ZH | HAARLEM | 392077 | 1 | Fonteinlaan | 1 |
| 392 | ZH | HAARLEM | 392081 | 2 | Oudeweg | 2 |
| 392 | ZH | HAARLEM | 392085 | 2 | Industrieweg | 2 |
| 392 | ZH | HAARLEM | 392097 | 3 | Engelandlaan * | 3 |
| 392 | ZH | HAARLEM | 392098 | 4 | Spaansevaartstr | 4 |
| 392 | ZH | HAARLEM | 392099 | 4 | Slachthuisstr * | 4 |
| 392 | ZH | HAARLEM | 392301 | 5 | Spaarnhovenstr | 5 |
| 392 | ZH | HAARLEM | 392wol | 6 | Vroomstraat | 6 |
| 518 | ZH | ROTTERDAM | 518701 | 0 | Bosdreef | 0 |
| 518 | ZH | ROTTERDAM | 518702 | 0 | Horvathweg | 0 |
| 518 | ZH | ROTTERDAM | 518077 | 1 | Westzeedijk * | 1 |
| 518 | ZH | ROTTERDAM | 518078 | 1 | Maasboulevard | 1 |
| 518 | ZH | ROTTERDAM | 518082 | 2 | Matlingeweg * | 2 |
| 518 | ZH | ROTTERDAM | 518092 | 3 | Heidekruid | 3 |
| 518 | ZH | ROTTERDAM | 518098 | 4 | Lisztstraat | 4 |
| 518 | ZH | ROTTERDAM | 518099 | 4 | Resedastraat | 4 |
| 518 | ZH | ROTTERDAM | 518301 | 5 | Koningsvaren | 5 |
| 518 | ZH | ROTTERDAM | 518wo1 | 6 | Narcissenstraat | 6 |
| 534 | ZH | HILLEGOM | 534009 | 1 | Weerlaan | gn compens |
| 534 | ZH | HILLEGOM | 534047 | 1 | Weeresteinstraat | 2 |
| 534 | ZH | HILLEGOM | 534008 | 3 | Pr . Irenelaan * | 3 |
| 534 | ZH | HILLEGOM | 534098 | 4 | Hofstraat * | 5 |
| 534 | ZH | HILLEGOM | 534099 | 4 | L.v.Deyssellaan | 5 |
| 534 | ZH | HILLEGOM | 534301 | 5 | Valckstraat | 4 |
| 534 | ZH | HILLEGOM | 534wol | 6 | v. Meerbeekstr. | 4 |


| Gem code | Pro | Gemeente | Loc code | Cat | Straatnaam |  | Bijzonderheden |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 553 | ZH | LISSE | 553008 | 3 | Nassaustraat | 2 | ! zie 553012 |
| 553 | ZH | LISSE | 553026 | 1 | Westelijke Randweg | 9 | ! andere cat |
| 553 | ZH | LISSE | 553012 | 0 | Hereweg * | 3 | $!$ comp v 553008 |
| 584 | ZH | OUD BEIJERLAND | 584004 | 1 | onbekend | 9 |  |
| 584 | ZH | OUD BEIJERLAND | 584006 | 2 | Oostdijk | 2 |  |
| 584 | ZH | OUD BEIJERLAND | 584026 | 2 | Randweg | 2 |  |
| 584 | ZH | OUD BEIJERLAND | 584098 | 4 | Pr. Bernhardstr | 4 |  |
| 584 | ZH | OUD BEIJERLAND | 584099 | 4 | Piet Heinstraat | 4 |  |
| 585 | ZH | BINNENMAAS | 585109 | 2 | Maasdamsedyk | 3 | ! |
| 585 | ZH | BINNENMAAS | 585204 | 2 | Wilhelminastr | 2 |  |
| 585 | ZH | BINNENMAAS | 585304 | 3 | Dorpstraat | 3 |  |
| 611 | ZH | CROMSTRIJEN | 611005 | 3 |  | 9 | ! geen kaart |
| 611 | ZH | CROMSTRIJEN | 611098 | 4 |  | 9 |  |
| 611 | ZH | CROMSTRIJEN | 611099 | 4 |  | 9 |  |
| 754 | NB | BLADEL en NET | 754002 | 1 | Randweg | 2 | ! niet aanw |
| 754 | NB | BLADEL en NET | 754002 | 3 | Sniederslaan | 3 | ! wegvak 5 ipv 2 |
| 754 | NB | BLADEL en NET | 754020 | 1 | P.G.Ballingl | 2 | ! niet aanw |
| 770 | NB | EERSEL | 770013 | 1 | Niewstr | 9 | !n.a. |
| 772 | NB | EINDHOVEN | 772701 | 0 | Boutensl | 0 |  |
| 772 | NB | EINDHOVEN | 772702 | 0 | Insulindel | 0 |  |
| 772 | NB | EINDHOVEN | 772079 | 1 | Sir W. Churchillln | 1 |  |
| 772 | NB | EINDHOVEN | 772083 | 2 | Tempellaan | 2 |  |
| 772 | NB | EINDHOVEN | 772094 | 3 | Muzenlaan | 3 |  |
| 772 | NB | EINDHOVEN | 772096 | 3 | Gen Bothastraat | 3 |  |
| 772 | NB | EINDHOVEN | 772098 | 4 | Bergstraat | 4 |  |
| 772 | NB | EINDHOVEN | 772099 | 4 | Gen Marshallweg | 4 |  |
| 772 | NB | EINDHOVEN | 772301 | 5 | SvWuchtenbergl | 5 |  |
| 772 | NB | EINDHOVEN | 772302 | 5 | Gen Cronjestr | 5 |  |
| 772 | NB | EINDHOVEN | 772wo1 | 6 | Dopheide | 6 |  |
| 772 | NB | EINDHOVEN | 772wo2 | 6 | Spireastr | 6 |  |
| 800 | NB | HOOGELOON | 800029 | 1 | Burg.v.Woenseldr | 2 | $!$ |
| 800 | NB | HOOGELOON | 800060 | 3 | Vessemsestr | 3 |  |
| 800 | NB | HOOGELOON | 800098 | 4 | Volderstraat | 4 |  |
| 800 | NB | HOOGELOON | 800099 | 4 | Corvus | 4 |  |
| 800 | NB | HOOGELOON | 800301 | 5 | niet aanw | 5 |  |
| 861 | NB | VELDHOVEN | 861130 | 3 | Sondervinck | 2 | $!$ |
| 861 | NB | VELDHOVEN | 861174 | 1 | Heemraad | 1 |  |
| 861 | NB | VELDHOVEN | 861098 | 4 | Kapelstr_Zuid * | 4 |  |
| 861 | NB | VELDHOVEN | 861099 | 4 | v. Hulstlaan | 4 |  |
| 861 | NB | VELDHOVEN | 861301 | 5 | Draaiboomstr | 5 |  |
| 861 | NB | VELDHOVEN | 861wol | 6 | Wikkebeek | 6 |  |
| 862 | NB | VESSEM | 862098 | 4 | J.Smuldesstr | 4 |  |
| 862 | NB | VESSEM | 862099 | 4 | Domineeshof | 4 |  |



## Appendix 2: Data Collection Form



I

| Type lok | : RECHTSTAND WEGVAK |  |  |
| :---: | :---: | :---: | :---: |
| Filmrol nr | : |  |  |
| Gegevens | RIJRICHTING | : $-\cdots-$ CENTRUM | : PERIEERIE <- |
|  | negatief nrs |  |  |
|  | foto nrs |  |  |
| 1 | aant rijbanen | $: 1 / 2$ |  |
| 2 | aantal rijstroken | $: 1 / 2 / 3 / 4$ rijst | $: 1 / 2 / 3 / 4$ |
| 3 | rijbaanbreedte |  |  |
| 4 | parallel stroken | : 1 ja/ 2 nee | : 1 ta/ 2 nee |
| 5 | P mogelijkheden | : 1 ja/ 2 nee | : 1 ja/ 2 nee |
| 6 | welke borden (nrs) | - | - |
| 7 | eenrichtings verk | :1 ja/ 2 nee | : 1 ja/ 2 nee |
| 8 | voorrangsweg | : 1 ia/ 2 nee | $: 1$ ja/ 2 nee |
| 9 | wegindeling (gebr) | : 1 gesl (b) $\mathrm{f} / 2$ open v verk | : 1 gel (b) $f / 2$ open verk |
| 10 | openbare verlicht | : 1 hoog/2 laag/3 geen | : 1 hoog/2 laag/3 afw |
| 11 | fietspad annwezig | :1 vrij/2 strook/3 geen | : 1 vrif/2 strook/3 geen |
| 12 | voorz. openb verv | :1 midd/2 links/3 rechts | : 1 midd/2 links/3 re |
|  |  | 4 geen | :4 geen |
| 13 | voetgangers voorz | :1 vod/ 2 geen | :1 vop/ 2 geen |
| 14 | verharding | :1 zoab/2 asf/3 beton/4 klin | $: 1 \mathrm{zo} / 2 \mathrm{asf} / 3 \mathrm{bet} / 4 \mathrm{kl}$ |
| 15 | kantstreep | :1 aanwezig/2 geen | :1 aanw/2 geen |
| 16 | midden afscheid. | :1 gelra/2 $\mathrm{berm} / 3$ ande/4 gn | $: 1 \mathrm{gelra} / 2 \mathrm{be} / 3$ and/4 gn |
| 17 | wegas | :1 getrokk/2 onderbr/3 geen | :1 getrokk/2 ondbr/3 gn |

Bijzonderheden:
bouwdichtheid : 1 beide zijden/2 beide zijden open/3 beide zijd geen
41 ziid aaneen and open/ 51 ziid aaneengesl and ag 61 zijd open andere geen

| $: 1$ woning $/ 2$ winkel/ | $: 1$ woning/2 winkels |
| :--- | :--- |
| 3 bedrijven/4 mengv/5 geen | $: 3$ bedrifv/4 mengv/5 gn |
| $: 5 \mathrm{~min}: \quad \mathrm{mtv}, \mathrm{br}, \quad \mathrm{mtv} \quad \mathrm{br}, \quad \mathrm{f}$ |  |

II


Bijzonderheden:

Appendix 3: A Few Example Photographs



[^0]:    ${ }^{1}$ Interestingly, this database is presently being updated. Unfortunately, the present study could not profit from this long overdue activity.

[^1]:    ${ }^{2}$ Actually, a number of extra photographs were made for administrative and experimental purposes, and a number were re-made due to poor quality. Not all locations originally chosen were actually photographed due to other problems.

[^2]:    ${ }^{3}$ Scratches on the film, wind shield reflections, too little contrast, poor focus or mounting, etc.

[^3]:    ${ }^{4}$ We feel that this procedure is commensurate with directionality of time, which is so important in the driving task. Furthermore, we feel that this is a natural implementation of the classification task as described by Anderson (1991).
    ${ }^{5}$ The following SAS options were used: Level=Ordinal, Coefficient=Identity, Formula=1, and Condition=Unconditional. Fit=Distance and Fit=Squared (distance) were both run, but the results hardly differed. In this report, therefore, we will discuss the results for Fit=Distance.

[^4]:    ${ }^{6}$ There are also rather large individual differences, but this is not of direct concern for the present study.

