15 NOVEMBER 2000

SWOV
INSTITUTE FOR
ROAD SAFETY RESEARCH

RESEARCH ACTIVITIES


# Wrong-way driving on motorways

**WRONG-WAY DRIVING CAUSES A SMALL NUMBER OF SERIOUS ACCIDENTS. IN RECENT YEARS, WRONG-WAY DRIVING HAS ON AVERAGE RESULTED IN FIVE FATALITIES AND TWELVE CASES OF INJURY EVERY YEAR IN THE NETHERLANDS. RECENT SWOV RESEARCH SHOWS THAT WRONG-WAY DRIVING IS GENERALLY CAUSED NOT ONLY BY A REDUCED DRIVING ABILITY ON THE PART OF THE DRIVER BUT ALSO BY A ROAD SITUATION THAT COULD BE IMPROVED. COMPLYING WITH EXISITING GUIDELINES WHEN DESIGNING AND MAINTAINING ROADS COULD CONTRIBUTE GREATLY TO PREVENTING WRONG-WAY DRIVING.**

The conducting of the initial research into wrong-way driving was commissioned by the Netherlands Transport Research Centre (AVV). This research (D-2000-6) examined the causes of wrong way driving accidents on motorways, the sources of information for this research being the original official police reports. The reporting officers were also approached for obtaining additional information. Reasons of privacy precluded the possibility of approaching the wrong-way drivers themselves. Included in supplementary research was the examination of the factors associated with road design and driver behaviour that could have played a role in wrong-way driving. To accomplish this, junctions where drivers started

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wrong-way movements were visited. The supplementary research also examined legal liability in accidents involving wrong-way driving and the effectiveness of (new) measures to prevent wrong-way driving.

**Analysis of the official police reports**

Analysis of the official police reports showed that about half of the episodes of wrong-way driving started when drivers entered exits (off-ramps), while the other half started when drivers turned their cars (mainly on the main carriageway) or engaged in similar manoeuvres. Entering exits occurred predominantly during darkness and involved older drivers (aged 55 and older). These drivers wanted to enter the entry (on-ramp) to the motorway correctly but turned left too soon onto the off-ramp. This appears to be caused by a problem in processing visual and other information and occurs on both of the main kinds of junctions in the Netherlands: the half cloverleaf and the diamond ramp. Turning around is done primarily by younger drivers who generally start wrong-way driving deliberately to correct a previous mistake in their route planning.

**Supplementary research**

The supplementary research focused on situations in which exits were entered unintentionally. This error, made by the largest group, is the simplest to prevent due to its involuntary nature and the locations where it occurs. The junctions that have been the scene of mistaken entries are ones that reinforce turning off prematurely. Because the off-ramp is conspicuous and the driver's view to the on-ramp poor, drivers are drawn to it. Worn-out line markings and misplaced or missing signs make it difficult to know which movements are permitted. Also the curve of the subordinate road onto the exit is not tight enough to hinder a premature turn-off. Many of these situations are in violation of existing guidelines.

The supplementary research shows that it is not always correct to blame the wrong-way driver for the cause and effects of wrong-way accidents. In accidents in which blame can be attributed to a third party, it would be possible to plead force majeure. Road authorities are responsible for accidents caused by a road condition that fails to satisfy the requirements that pertain to it. According to legal precedents, they must also consider less attentive and cautious drivers. Unclear situations at junctions, that violate guidelines, may cause wrong-way entries and thus have consequences for the road authorities' liability. The division made by road management between the ramps themselves and subordinate roads can therefore cause unclear situations and thus provide legal and practical complications.

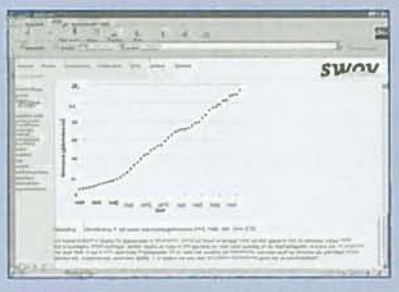
**Recommendations**

As a result of this research, certain recommendations are being made in regard to measures intended to prevent wrong-way driving. As the number of casualties involved in wrong-way driving accidents is limited, and as measures would have to be implemented on a great number of locations, extremely expensive measures would not be efficient. Measures intended to prevent wrong-way driving have to be simple, they must prevent the problem in time, and they must not hinder other traffic.

If the conjectures about the characteristics of junctions that have been the scene of wrong-way entries are correct, it means that complying with the existing guidelines for the signing and visibility of these junctions and the maintenance of line markings are amongst the most important measures to be taken to prevent wrong-way driving. To make an inventory of unclear situations and to correct them, inspections of all junctions can be conducted.

It has been shown that the "Go back" signs located in the median between the entry and the exit on half cloverleaf junctions often seem to be intended for drivers on the on-ramp. Due to this false alarm, drivers learn to ignore the signs, which can reduce the effectiveness of signs or even have an adverse effect. For this reason, it is recommended to place the signs or shield them in such a way that they do not appear to be intended for traffic on the entry. Also recommended is the placing of arrows on the exit and the constructing of an extended separation between the directions on the secondary road. This will guide left-turning drivers to the on-ramp and will impede drivers from entering the off-ramp.

# The SWOV Web site




*WWW.SWOV.NL*

The extensive Web site for the SWOV Institute for Road Safety Research provides information about the following topics:

- The latest information about SWOV and about new items on the SWOV Web site;
- A list of articles from the newsletter Research Activities;
- A conference schedule listing conferences throughout the world;
- A profile of SWOV;
- A databank containing information about such diverse road safety topics as alcohol, aggression and road safety developments;
- The SWOV report database, including abstracts of the reports;
- Entry to the SWOV library (over 80,000 titles);
- More than 80 links to other national and international organisations involved in road traffic and road safety;
- An extensive search function.

# Transforming main roads in urban areas into sustainably safe roads

**THE IMPLEMENTATION OF SUSTAINABLY SAFE ROAD PRINCIPLES IN THE NETHERLANDS IS AN ONGOING PROCESS. STUDY GROUPS ARE USING THE PRINCIPLES OF SUSTAINABLE SAFETY TO CREATE PRACTICAL DESIGN GUIDELINES, WHILE EXISTING GUIDELINES ARE BEING REVISED TO REFLECT THE SUSTAINABLE SAFETY REQUIREMENTS FOR ROADS LOCATED BOTH OUTSIDE AND INSIDE BUILT-UP AREAS. SINCE THE WORK ON GUIDELINES FOR ROADS IN RURAL AREAS IS PROGRESSING SMOOTHLY, THESE GUIDELINES SHOULD BECOME AVAILABLE IN MID-2001. INTERPRETING THE SUSTAINABLE SAFETY PRINCIPLES INTO RECOMMENDATIONS FOR MAIN ARTERIES IN URBAN AREAS, HOWEVER, IS PROVING TO BE MORE OF A CHALLENGE.**

Urban main roads connect residential areas to one another and are therefore used by relatively heavy flows of both rapid and slow traffic. Although local road authorities are responsible for urban street design in the Netherlands, the national government has provided them with general 'recommendations for traffic provisions in built-up areas'. These recommendations are currently being revised in order to implement the principles in a 'Sustainably Safe Traffic and Transport System.' Recent SWOV reports (D-2000-4; R-2000-5) have examined the consequences of implementing these principles.

Sustainably safe traffic is characterised by functionality, homogeneity and predictability. The objective of the sustainably safe concept is to create a traffic and transport system that is inherently safe. After all, it is better to prevent accidents before they occur. Applying these principles to residential street design is similar to what is already being done in existing design practice. The result will be a type of design in which streets have a speed limit of 30 km/h. Designing main roads (known in sustainable safety terms as "distributors"), however, will undergo major changes once sustainable safety principles start being applied. A study group made up of road authorities, practitioners and researchers drew up an extensive list of operational requirements for the design of these roads. These requirements include speed limit, the number of carriageways and lanes, markings, junctions, the mixing of different modes, parking on the carriageway, et cetera.

When this list of requirements is studied closely, certain problems are revealed. One of these is that it contains some redundant features. On the other hand, it lacks other major requirements for safety such as the ones pertaining to the the minimum sight distances at crossings and intersections. Furthermore, certain requirements such as the one pertaining to an obstacle-free zone do not always apply to urban distributors. Finally, the general rule that interpreting requirements into design recommendations or guidelines almost always leads to difficulties can be seen here as well. An example in this case is that the requirement to "separate driving directions" can be interpreted in many ways, ranging from a continuous white line to a barrier. At present, it is proving difficult to solve these issues since there is a lack of empirical knowledge relating to how the combination of these particular operational requirements will affect road safety. For this reason, SWOV research projects and experiments in the Netherlands will be devoted to filling these gaps in knowledge.

Another difficulty involves a basic difference between the existing design principles and those involved in the sustainable safety concept. In the existing system of design, most urban distributors combine a flow function with an access function, but according to the principles of sustainable safety, a road should serve only one function. This means that in certain cases, a choice favouring either one or the other of these existing functions will have to be made. This implies making a choice between flow and access, but always keeping safety as the number one priority. An example relates to the accessibility of shops and businesses located along a main road versus an efficient traffic flow along this same road. If, according to the principles of sustainable safety, the flow function is considered more important, the access function will have to be moved to adjacent streets. But realising alternatives for parking and loading zones (parking facilities in adjacent streets, either off-street or in garages) may not always be possible. So, will parking on main roads simply have to be accepted as inevitable even though this violates the principles of sustainable safety?

Before existing main roads in urban areas can be transformed into sustainably safe roads, these dilemmas will need to be resolved.

# The effect of aggression, emotions and moods on road safety

**Not only aggression, but also other emotions and moods appears to have a major effect on traffic behaviour and thus on road safety. It is for this reason that SWOV is attempting to make aggression research part of a broad-ranging study into the effect of moods and emotions on safe and unsafe behaviour. Embedding aggression research in emotion theories can lead to new insights into the development of behaviour, and these new insights might be important keys for increasing road safety.**

Until now, the phenomenon of aggression in traffic has been studied in a fairly isolated way by means of two different approaches. In one approach, road users are asked what kinds of traffic behaviours they consider aggressive and how often they are confronted with this behaviour and display it themselves. The result of this kind of research is provided in the form of classified lists of aggressive acts as well as a limited insight into the frequency of these behaviours in terms of "the percentage of road users who have experienced this within the last year". A second line of research examines mistakes. Here, distinctions are made among errors, lapses, ordinary offences and aggressive offences before their relationship to accidents is examined. The aggressive offences in this line of research usually score highest in terms of frequency. This method of research, however, displays certain weaknesses. What needs to be established precisely, for example, is how often aggressive acts occur. Then the relevance of these acts for road safety can be determined. It is also necessary to have a more accurate picture of how this behaviour affects safety.

Certain other major disadvantages are still involved with the existing research into aggression. The usual correlation studies, for example, provide no answer to exactly how behaviour develops while such information would be necessary for being able to prevent aggressive behaviour. In addition, much research makes use of self-reporting, the value of which is still not entirely clear. What is more, the study of aggressive behaviour is isolated from other motivation research.

The existing research usually defines aggression as intentionally threatening or harmful behaviour. Researchers make a distinction between affectively aggressive behaviour and instrumentally aggressive behaviour. The first is elicited by anger; in the second, the aggressive person wants to obtain some kind of benefit by means of the aggressive behaviour, but not satisfaction. In studying aggression, the distinction between affectively aggressive and instrumentally aggressive is rather artificial. After all, instrumentally aggressive behaviour frequently has an affective background as well. An example is dangerous behaviour prompted by the fondness for the kick such behaviour elicits, or by extreme haste. Also lacking is research into aggression within emotion theories in which emotions other than anger play a role, and consequences of emotions other than aggression.

### Moods and emotions

Research into aggression has much to gain from embedding it into research into emotions and moods. This has been shown by such research as that conducted in the United States in which daily journals played an important role. Drivers were required to answer questions about their behaviour both before and after driving. These methods overcame many of the disadvantages associated with correlation studies. Also remarkable was that in addition to emotions, moods were studied as well. Researched showed, for example, that people who started driving in a more irritated mood drove faster.

Another development is illustrated by work done in the UK. Here, too, daily journals were kept, this time in the form of Dictaphone recordings made after driving. In this research, attention was devoted to anger and the reasons for it, as well as to courtesy. For the first time, it was possible to establish how often an event leading to anger occurred within a period of two weeks. It was then possible to infer how often such an incident occurred: in this case, once every 1600 kilometres. It also became clear that this anger develops primarily as a result of near misses. People experienced courtesy on the part of the other driver once every 1900 kilometres.
An initial validation of self-reporting also occurs in Finnish-British studies. This self-reporting even includes aggressive offences committed by the subjects themselves. Interim findings show that, remarkably, this self-reporting is scarcely distorted by self-deception and social desirability.

Recent research has also shed more light on the development of emotions and moods. An emotion develops by the subjective perception of an event, behaviour or an object evaluated as important in terms of values, norms or wishes. Grouped together, this is known as "interest of concern". If important, it will be sufficient to elicit neutral emotions such as surprise or curiosity. If it is also determined that the concern is harmful or advantageous, what develops is a negative or positive emotion. Also typical of emotions is the change in action readiness that follows. A person prepares himself to eliminate the potential harm or to perpetuate the positive situation. This action readiness, according to Dutch psychologist Frijda, possesses the character of "control precedence": all attention is aimed at that one thing: the object of the emotion. Moods, however,

lack this focus on an object. Although its cause can be an emotion, a mood itself is concerned with how one experiences life as a whole. Here, too, however, we see an action readiness: the elimination of a negative mood and the perpetuating of a positive mood.

**SWOV research**

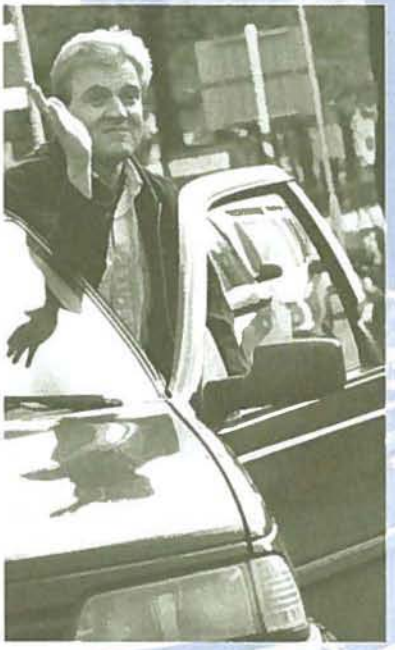
By now, a great deal of research has been conducted that has shown behaviour and thought (such as risk estimates) to be highly influenced by emotions and moods. Undoubtedly, this is also reflected in a person's participation in traffic.

Within this framework and as part of SWOV research, drivers were asked questions about their moods before and during their driving episode. They were also asked to respond to statements about the consequences of their behaviour: "If I am agitated, I start driving faster". Other statements involved emotions directly related to driving: "I enjoy driving a car" and "I enjoy driving fast". Yet other statements involved specific situations: "If I can't overtake a slow driver, I feel irritated" and "When I deliberately harm another road user, I feel guilty". In addition, questions were asked about offences, fines and near misses.

This research showed that moods could be described in combinations of extremes: calm-tense and energetic-tired with a factor being "agitation-irritation". The study found differences between various groups of motorists such as men versus women, drivers of their own cars versus drivers of company cars or lorry drivers, and among drivers of various ages. Lorry drivers, for example, score higher in both factors than others: they are more calm-energetic but also score higher on agitation-irritation. As age increases, so does the score for calm-energetic.
A considerable group of drivers admit that when they are irritated or agitated they start driving faster. This occurs less often among people with high scores for calm-energetic and low scores for agitation-irritation. This tendency to start driving faster as a result of negative moods also occurs more frequently among people who are involved in all kinds of traffic offences and who are fined.

Nevertheless, most drivers are in a good mood and enjoy driving. Twenty-five percent of the drivers also enjoys driving fast and is proud that they can drive safely at high speeds. Those who were proud that they did not allow themselves to be hurried to drive faster by others were less frequently involved in offences, fines and near misses. An alarming group of drivers, however, feels no regret for deliberately breaking the law and does not feel guilty for deliberately harming other road users. Worse still, many relationships were found between this group and offences, fines and near misses.

SWOV is intending to continue its research into the relevance of emotions and moods for road safety. This will be accomplished



along various lines. Currently, the reaction of lorry drivers to certain traffic situations is being studied. These traffic situations are related to traffic measures: the obligatory speed-limiting device or the no-passing ban on motorways. Step by step, questions are asked regarding the development of emotions for drivers: how annoyed do they feel, who do they think is to blame, what is their initial action readiness, and how do they react next. This should produce data about how traffic measures affect emotions, and about the possible unsafe consequences resulting from these emotions.

In the next phase, road users will be asked about the emotions and moods they have experienced while on the road. This will be done as soon as possible after having these experiences. Questions about reasons, about the development of emotions, and, toward the end, about the consequences to safety, will be asked. This research should provide insight into the relevance of moods and emotions for road safety. Next, some of the most relevant emotions will be investigated in more detail. Ultimately, insight into these processes is intended to lead to forms of prevention.

# Whiplash: a growing problem

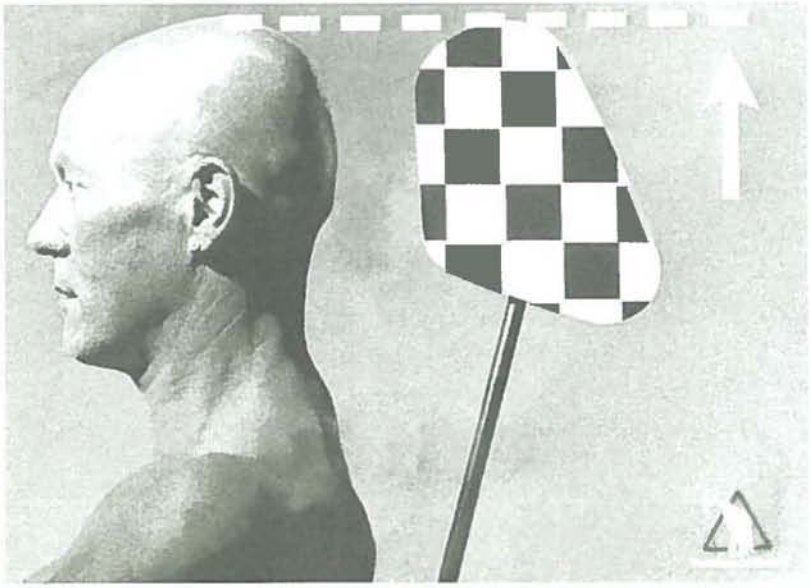
**In a recent publication of a national Dutch survey it is estimated that, every year, around 25,00 Dutch people incur whiplash complaints following car accidents. These neck injuries cost society considerable sums of money since insurance companies pay up to a third of their annual damage payments to whiplash patients. The tremendous extent of the problem, the high costs involved, and the impact of whiplash injuries on the victims' quality of life are good reasons for devoting more attention to these neck injuries. This attention should focus both on the registration and the prevention of whiplash cases, most cases of whiplash being caused by rear-end collisions.**

**The figures and their sources**

About 7,000 whiplash cases, nearly all involving car occupants, are registered annually in a system that obtains its data from a representative sample of A&E departments in Dutch hospitals. Recent results of periodically held telephone surveys, which cover most of the various types of accidents, including those occurring in road traffic, point to a total number of about 25,000 whiplash cases. This includes whiplash injuries that were treated at A&E's. Since persons suffering from whiplash were rarely admitted to hospital (fewer than 200 admissions a year as opposed to a total of 19,000 road casualties), the remainder (some 18,000 whiplash cases) must have been treated by GPs (general practitioners).

A proper registration of casualties treated by GPs is not available in the Netherlands. Nevertheless, such a system would be very useful for all sectors involved with accidents and accident registration the Netherlands, including the sectors involved in road traffic accidents.

These Dutch registration activities are based on initiatives taken by the Dutch Ministry of Health, Welfare and Sport and the Netherlands division of the European Consumer Safety Association. They are focused on taking preventive measures in regard to public health. SWOV and other interested parties in the various sectors that deal with accidents are continuously involved in the development of these activities.



Generally speaking, however, these registration systems often lack the kind of relevant data about the accidents that is actually needed.

Another registration system primarily focused on road traffic accidents, the National Register on Road Traffic Accidents, is maintained by the Ministry of Transport and Public Works. This very important registration is based on police data. It is a well-known fact that this kind of registration is far from complete, and worse still, far from representative: accidents not involving motor vehicles and accidents resulting in less serious injuries are insufficiently reported. Since rear-end collisions (the most common cause of whiplash injury) do not usually result in serious injuries, they may well fall within the category of cases that are insufficiently represented in the registration. However, despite these shortcomings, the registration still yields sufficient data in regard to the development of the number of rear-end collisions. Rear-end collisions have increased enormously, both in terms of their sheer numbers and in terms of their percentage of accidents, over the last 10 years. They now account for 11% of all road traffic accidents: about 4500 of the road traffic accidents involving cars. These figures are expected to increase as traffic concentrations continue to rise.

**Preventive measures**

Various studies in other countries have confirmed that 70% to 80% of whiplash cases are caused by rear-end collisions. The remaining cases have occurred in other traffic situations or in other kinds of accidents (e.g. home accidents). One obvious way to prevent whiplash injury, therefore, would be to prevent rear end collisions. There are a number of measures that might help to reduce the risk of such

accidents. Examples are infrastructural measures that involve the redesigning of roads and junctions where rear-end collisions commonly occur, the use of advanced transport telematics (e.g. devices installed in cars that automatically maintain car speed and the distances between cars so as to help prevent cars from colliding) and the addition of preventive features in vehicles. In regard to these devices and features, however, thorough research is still very much needed to make sure that they will be safely designed for the purpose of creating a road traffic system that will be safer in all respects.

Since traffic concentrations are expected to keep increasing (and rear-end collisions will therefore continue to occur more frequently), other preventive measures are needed as well. Head restraints, the logical answer to the problem, are installed both in front and rear seats in almost all cars on Dutch roads. But because Dutch people are the tallest on average of all Europeans, and because existing EU requirements for vehicles still fail to take this phenomenon into consideration, at least 35% of the Dutch male population are not being fully protected by the head restraints that comply with current legislation (i.e. a minimally 80 cm above the hips). Despite negotiations in regard to vehicle regulations on the part of Dutch representatives, this EU requirement for the minimum height of head restraints is still five centimetres too low to protect many drivers in the Dutch population.

Current legislation concerning other aspects of head restraints could also stand improvement. An example is their horizontal distance from the back of the head (which should be minimal) and their energy-absorbing properties. Hopefully, incorporating the rear-end impact testing of cars in EuroNCAP, a European programme testing the injury-preventive capabilities of new cars using criteria that exceed legal requirements, will soon become a reality. Whether this will be done depends on the outcome of other European testing projects (collision tests using anthropometric dummies) being conducted for this purpose.

# Publications

Most SWOV reports are written in Dutch but include an English summary. Below is a selection of reports that have recently been published by SWOV. Reports can be obtained by completing the SWOV order form that can either be found on the website, or that can be sent to you by Patrick Rugebregt of the Department of Information and Communication (Patrick.Rugebregt@swov.nl). The price of each report (in Dutch guilders) is mentioned in the following list, as well as the language in which the report is written. Reports can be paid by credit card. For bank transfers, we will charge an extra Dfl. 15,- per transfer. After SWOV has received your payment, the reports will be sent to you by mail.

**Heading in the wrong direction**
Descriptive research on wrong-way driving on Dutch motorways: background, causes, liability and measures.
M. de Niet & A. Blokpoel. D-2000-6. 110 pp. Dfl 36,- (in Dutch).

**Wrong-way drivers and head-on collisions on motorways**
Number and development of their threat to road safety, in the period up to 1998. A. Blokpoel & M. de Niet. R-2000-16. 113 pp. Dfl. 37,- (in Dutch).

**Compatibility of cars in the Netherlands**
Statistical analysis of frontal collisions in the framework of the European research project 'Improvement of crash compatibility between cars", Workpackage 2a. L.van Kampen. D-2000-8. 41 pp. Dfl. 20,-.

**Opting for measures based on traffic risk**
Results of a pilot project and a discussion of the use of risk indicators. F. Bijleveld. R-2000-18. 52 pp. Dfl. 22,50 (in Dutch).

**Regional tests for sustainably safe road categorising, part 2**
J. van Minnen. R-2000-13. 117 pp. Dfl. 35,- (in Dutch).

**Knowledge made to measure for region and country II**
Available and necessary information for supporting road safety policy in 1999. M. Brouwer. R-2000-17. 64 pp. Dfl 25,- (in Dutch).

**The National Road Database and road safety research**
Experiences with the NRD and a design for a linked database containing the most important road and traffic characteristics.
F. Poppe & A. Blokpoel. R-2000-15. 76 pp. Dfl 25,- (in Dutch).

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**Colophon**

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