EVALUATION OF TRAFFIC CONFLICT TECHNIQUES

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1. Introduction

In practice, accidents are hardly ever observed by the traffic safety researcher. Therefore the analysis of traffic safety problems is difficult. One often uses historic data, information about accidents that took place in the past. From this information a reconstruction is made in order to explain the occurrence of the accident. Such a reconstruction is only partly possible, because the historic data is incomplete and in many cases distorted.

An alternative approach starts with the study of traffic behaviour, especially the kind of behaviour that is supposed to be dangerous. The traffic conflict technique is the best known representative of this approach, but certainly not the only one. The question in the first approach is whether or not the information given is reliable, here the question is whether or not the situation is relevant. The problem with the first approach seems to bother researchers less than that of the last one. The attention to the conflict technique is primarily concerned with the problem of validation. The applicability of the conflict technique is often measured completely in terms of predictive validity and the applicants of this technique are often forced into the defense, to demonstrate how valid there technique is.

From a theoretical point of view, it is rather curious to see how little attention is given to the foundation of the implicit or explicite explanation of accidents, and to the diagnosis and recommendations that result from safety studies, accident studies included. Evaluation studies are in most cases restricted to before and after studies of accident numbers. These studies are aimed at the justification of the amount of money invested more than to learn from the past for future work.

This article discusses a broader scope for the foundation of safety research and deduces from that a more comprehensive approach to the evaluation of traffic conflict techniques.

The basic assumption is that the object of traffic safety research is not the accident, but the critical event in the traffic system that results in any accident. As a consequence, traffic safety research should start with careful and systematic observation of the dangerous situations in traffic, in order to detect the factors that cause the accident. In order to reduce the number of accidents, one has to control the traffic system. Therefore it is necessary to study the traffic system itself and not only the outcome of the situations that run out of control. As a result of this approach, the traffic conflict technique is looked upon as a method for the systematic observation of conflicting traffic behaviour. These observations lead to the detection of deficiencies in the traffic system that increase the accident potential.

Therefore, the evaluation of this method should be primarily concerned with its use for the confirmation of traffic safety theory and not with the prediction of accidents.

If it is possible to express the amount of danger of a traffic conflict
situation in a severity score, deduced from the factors that contribute to that danger, we are not only able to improve the prediction of accidents, but also to recommend or evaluate safety measures from the analysis of these combined factors.

2. The definition of conflicts

The definition of a conflict is not easy to give. There are various definitions in use. A first aim in defining a conflict, is to describe the so called "universe of discourse". The definition indicates the kind of traffic behaviour that one is interested in. In this case the connotation of the concept is more important than the denotation. If an operational definition is given, one tries to describe a decision rule by which it is possible to distinguish between situations that are or are not conflicts.

During the first international symposium in Oslo, the following definition of a conflict was approved:

"A traffic conflict is an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged.

This definition was not only meant as a general demarcation rule for conflicts but must also be regarded as an attempt to define conflicts operationally.

Already in the investigations of Perkins and Harris, one of the first conflict studies that are carried out, an operational definition is used similar to the definition given in Oslo. Their definition is clear and easy to apply to car-car conflicts. In practice however, when the conflict technique is applied to different situations or to study various problems, various definitions are used. The reasons for this are:

- The research is related to a restricted safety problem, such as the safety of children crossing a street, the safety of pedestrians at intersections, the operational deficiencies of an intersection etc. Only those conflicts and behavioural aspects of these conflicts that are relevant for the investigation are taken into account.

- There are differences in observation methods. Subjective techniques make use of observations in the literal sense, using cues such as "sudden behaviour" or "avoiding behaviour", terms that need a judgement of the observer. Objective techniques use concepts such as "time-to-collision" (TTC, the time that remains until the accident will happen, if not evasive action takes place) or "post-encroachment-time (PET, the time that remains to react to an intruder entering the lane of a road-user). These concepts suppose the use of registration equipment instead of observers.

- Some techniques distinguish between severity-grades of conflicts. The severity-grade is mostly related to the probability of an accident to occur, but sometimes also to the consequences of such an accident (e.g. whether or not injuries are probable if an accident would happen). The severity dimension is in general hardly specified, and only described in terms of a more or less sudden reaction or a longer or shorter TTC-value. Some times other aspects are mentioned such as velocities, distances, type of conflict, participants in conflict etc. However, in most cases it is not clear how these aspects must be combined to establish the severity-scores. The Malmo study shows that trained observers use one common severity scale to score the severity of conflicts. Furthermore, this score is not based on a simple cue but on a combination of cues.
In the introduction we state that the conflict analysis has to be developed into a method for the systematic observation of risky interactive traffic behaviour. Before it can be used for this purpose it is necessary to know in which situations, what aspects of this interactive behaviour are risky. In this respect, the validity of a conflict-technique should be evaluated by its power to discriminate between conflict situations with a high accident potential and those with a low one, on the basis of situational characteristics. Therefore, not only those conflicts that result in accidents are important, but also those conflicts are controlled by the road-user. There is no fundamental difference between general traffic safety research and conflict analysis as far as the confirmation of the theory of risky traffic behaviour is concerned.

3. Implications for the validation of conflict techniques

As said before, a conflict method is not only useful if it predicts the number of accidents, but primarily if it convincingly indicates which types of interactive traffic behaviour are dangerous. Convincingly here means that the analysis of traffic behaviour is based on an established traffic safety theory. The value of a conflict analysis technique for traffic safety research is therefore not determined by the validity with regard to the prediction of accidents, but especially by the verification of the severity that is attached to a conflict situation on the basis of a traffic safety theory.

It is a misconception to think that this verification is exclusively of importance for the conflict technique. For each type of traffic safety research that leads from the observation of safety phenomena to a safety diagnosis and consequently to the recommendation of safety measures, it is necessary to evaluate the assumptions. In most cases only the end product of measures is evaluated by means of before-after studies of accidents.

In order to check the validity of the assumptions behind the implementation of safety measures with regard to the intermediate effects of these measures on traffic behaviour, it is necessary not only to evaluate the reduction in accidents, but also the changes in the process. This process-evaluation tells us not only whether a certain measure is effective or not, but also why this is the case.

The severity grade of conflicts, in particular the change of conflict frequencies with regard to severity-grades can be used to check if assumptions about changes in the traffic system were correct.

We will describe some relations between severity scores and the predictive validity.

We assume that different types of conflicts are distinguished, and that there is a particular type of accident $A_i$ related to that type of conflict $C_i$ with probability $p_{i}$. For a given location, during a given period, we observe conflict frequencies $f_{i}$ for the various types $C_i$.

Model I describes schematically the relation between the conflict observations and the predicted number of accidents. Assume that the conflict types are ordered with regard to the increase in $p$-values.
Conflict type | Frequency $f_i$ | Probability of a particular accident $p_i$ | Expected number of accidents $A_i$ | Total number of accidents
---|---|---|---|---
$C_1$ | $f_1$ | $p_1$ | $A_1$ |
$C_2$ | $f_2$ | $p_2$ | $A_2$ |
$C_3$ | $f_3$ | $p_3$ | $A_3$ |
$C_n$ | $f_n$ | $p_n$ | $A_n$ |

$A = \frac{\sum_{i=1}^{n} f_i p_i}{\sum_{i=1}^{n} A_i}$

Model I: relation between conflicts and accidents.

With $p$ the severity of a conflict is given, with $f$ the number of conflicts. The product of $f$ and $p$ results in the expected number of accidents $A_i$ for a given time-period. The sum of these expected accident numbers gives the expected number of accidents in total.

We will not go into detail with regard to the nature of the $C$'s, which is of course the most important issue in the application of conflict techniques, but take the operational definitions of the $C$'s for granted. We will also neglect complicating factors such as the distinction in severity-grade of the accidents. In principle this problem can be solved by adding a weight-factor to the $A_i$'s before the final addition.

If we use the conflict analysis method to detect locations with a high accident potential, then we are primarily concerned with the prediction of $A$. If we use the method to analyse safety problems then the distribution of frequencies is of major concern.

If all types of interactive behaviour are scored and not just the dangerous ones, then the conflict method can be used to establish the distribution of particular types of desired and undesired behaviour. If the shape of the frequency distribution is unacceptable, safety measures that will change this distribution are needed.

In most cases however, no distinction with regard to the severity of conflicts is made. Interactive behaviour is binary classified into conflicts and non-conflicts. The limit between the two categories often differs in severity grade for different techniques. The binary classification results in a reduced model and accordingly leads to a loss of information:
Model II: binary classification into conflicts and non-conflicts.

A special case arises if $p_{cfr} = 0$ ("no accident without a conflict"). All information about $A$ is then stored in the total number of conflicts. This idea was behind the Oslo definition of a conflict. With this definition exposure to accidents is an important factor in the prediction of accidents. Not the seriousness of conflicts, but the number of conflicts is of major concern in this case.

Now the first question with regard to validity is to what extent the reduction of model I to model II results in a loss of information and therefore in a decrease in validity. The second question is to what extent a binary classification such that $p_{cfr} = 0$ is sub-optimal. With regard to the last question, safety measures will be proposed that result in riskless behaviour. It seems to be more realistic to aim at measures that change situations with a high degree of risk into situations with low risk, in other words to reduce the number of serious conflicts. A number of conflicts techniques only use serious conflicts to measure safety. The predictive validity of these methods is on the average higher than the methods that are based on the total number of conflicts as was to be expected. In this way the prediction of the number of accidents by means of the number of conflicts will become much more effective than the prediction by means of exposure (or traffic flows). The improvement of the severity rating will result in a better validity of conflict techniques.

Thus far, the classification of conflicts with regard to severity is taken for granted. This classification however, is the main issue for the improvement of the validity. The Malmo-study showed that the largest differences in scoring are given with the variation in detection and selection. It was also shown that the selection problem decreased with the severity of conflicts.

The agreement between teams in the severity rating of a given conflict once it is detected, is much higher. Trained observers agree to a large extent on the severity score of conflicts. A combination of cues is used to establish this severity score. The scoring rule however, is not yet made explicite. Teams that concentrate on time-to-collision as the major cue also use other aspects of the conflict situation. A careful study of the situations that are scored is needed to make this subjective evaluation operational. However, the operationalisation of the common scoring rule is only the first step to be taken. We then know that observers agree on the face-validity of the cues that are relevant for the severity-concept and how they score it. Whether this construct is also describing the real severity of the
conflict with regard to the occurrence of accidents or injury is still to be proven. The construct-validity of the technique is most essential. If we want to improve the technique, we have to check whether the aspects that are taken into account, indeed relate to real danger. Time-to-collision is important, because it measures the limit-conditions for control of the situation by the road-user involved. So far it fits in a general theoretic notion of safety control. However, ttc as such is not enough. It is shown that the ttc-curve is different for different situations. E.g. the fact that bicycles can be manoeuvred more easily to avoid a collision with another vehicle, is already demonstrated with the shape of the ttc-curve.

It is however yet unknown how this shape of the ttc-curve relates to lack of safety.

Furthermore, it is shown that the 1.5 seconds road-users seem to use as a margin for conflict avoidance, also appears to be used as a margin in other situations such as running of the road (time-to-line-crossing). A more fundamental study of this concept, e.g. with regard to car-following, gap-acceptance or overtaking may result in a better understanding of road-user behaviour in general and conflict-behaviour as a special case.

Also the PET-measure needs attention, as indicated in the Trautenfels study. But time alone is not a sufficient base to score severity. The speeds at the moment of impact, differences in mass between participants, the level of protection of road-users etc. also play an important role. The definition of critical traffic behaviour by means of ttc, pet, conflict type and other factors makes the concept of severity operational and suitable for falsification. From this, a more constructive approach to the problem of validity is possible than if the process as such is ignored as a basis for evaluation and only the end-product, the number of accidents, is used as a target for predictive validation of traffic conflict techniques and the scoring rule is left implicit.