ANALYSIS OF THE DRIVING TASK: SYSTEM ANALYTICAL POINTS OF VIEW

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1. SYSTEM-ANALYTICAL VIEWPOINTS

1.1. Introduction

Much road safety research so far has been done from a differential point of view. It was mainly concerned with demonstrating the relevance for accident liability of general and permanent differences between drivers (such as personality, character, and physiological, biological or anatomical characteristics). This research has little demonstrable relevance for countermeasures, especially for driver selection. A main reason is the low stability of accident liability as a driver characteristic.
Replacing driver selection by measures for influencing driving behaviour by means of safety promotion, education, etc., differential research was aimed at more specific and time dependent variables, like alcohol, age, driving experience and their effect on accident liability.

In the field of general driving behaviour research, at this time, at least three directions can be distinghuised:
1. A compilation of the sensori-motor, perceptive and cognitive functions relevant to driving ability.
2. Development of driving simulators and instrumented vehicles.
3. System-analytical research into the driving task, in which driver, road, vehicle and traffic components are represented.

1.2. Hierarchical relations in the driving task

The driving task can be analysed at four different levels:
1. Choice of destination and means of transportation.
2. Choice of route (once destination and vehicle are decided).
3. Choice of manoeuvre, related to vehicle guidance along the road and relatively to other road users (given the route).
4. Vehicle operation (acting out the manoeuvre).

The level of analysis indicates the extent of the loop (see Figure 1.1.). Some remarks are:
Every level of analysis involves specific tasks (positioning the destination on a map, the route in a network, the road in a route, the vehicle in a track) which do imply specific activities. This also implies the possibility of overlap of different activities (for instance overtaking another vehicle and turning off at an intersection).
A more extensive loop is a higher hierarchy of control. Positioning the route incorrectly in a network (9) necessitates a fresh choise of route (2), choise of manoeuvres (3) and so on (9). The more extensive the loop, the less specific and time-dependent the information will be. Concerning the most extended loop, information can be obtained by consulting maps. The relation between vehicle operation and response, however, is determined by characteristics that are specific (to make and type) and is also time-dependent (sensitive to vehicle load, wind force, etc.). Consequently in the case of higher ordered control the information can be based on more abstract codes (for example a road number (9) against the distance perceived between the vehicle and the roadedge (7).

1.3. Criterion problems

The purpose of using the road can be formulated in terms of reaching a destination or providing activity. In the former case costs, time and effort of covering the distance between origin and destination can be evaluated negatively as they exceed those of alternative means of travel (public transport). In the latter case the activity inherent in travel (as driver or as passenger) can provide the opportunity for a positively rated effort and pastime and is a means functionally unrelated to the objective of reaching a destination. The two objectives, however, are not mutually exclusive.
In the following decisions regarding travel, choise of destination and means of transportation will be disregarded. Their

treatment is assumed to require a decisional-oriented sociological approach.

There are a number of distinct aspects to reaching a destination:

1. Routes can differ in distance (D) between origin and destination.
2. There may be a difference in average speed ($\bar{V}$ = journey time) per route.
3. Given the average speed for the route, there may be a variation in speed during the route (sd_v).
4. For each change in speed, a difference in average acceleration or deceleration (a) is possible.
5. Given the average acceleration or deceleration for change in speed, there may be a variation in acceleration or deceleration with such change in speed (sd_a).
6. And so on.

The succession of aspects reflects an increase in differentiation (distance, speed, acceleration/deceleration, etc.) and greater susceptibility to time-dependent variation. Figure 1.2. illustrated this. Some remarks are:
Traffic flow stability increases if variation in movements of the component elements can be described with the help of lower derivatives.
The consequence of this is that manoeuvres for guiding the vehicle, along the road and relatively to other road users, decrease in number and complexity, i.e. they can be selected by reference to fewer and simpler position references.
Manoeuvring leads to a change in the vehicle's lateral position and/or its speed. These changes can be described with greater or less differentiation (direction, distance, speed, etc.). Given the control dynamics of the vehicle (see Figure 1.3.), the movements follow from the operation of the vehicle. (The relation between vehicle operation and response will be disregarded as yet. It requires a control-oriented vehicle-engineering approach.)

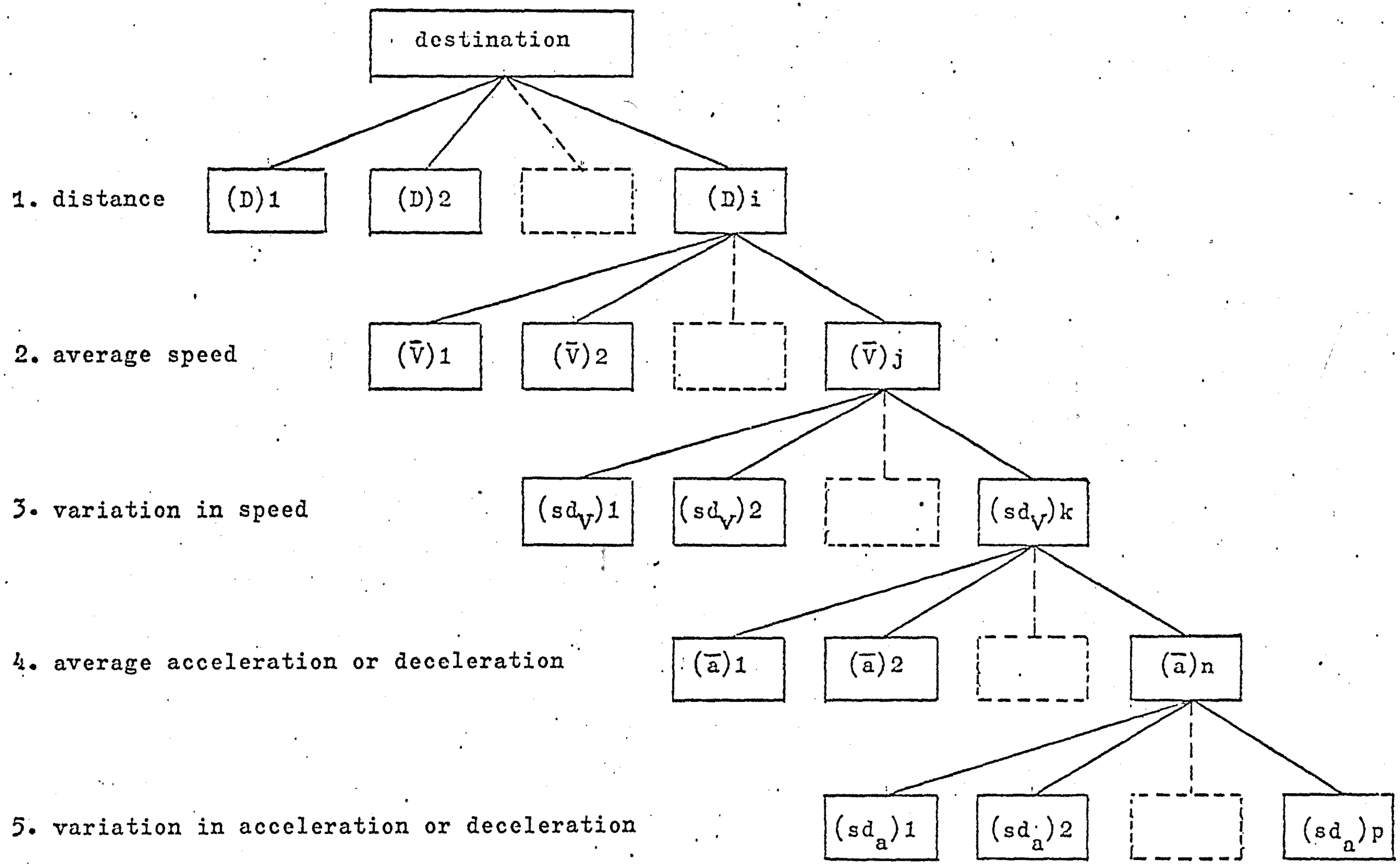

Figure 1.2. Hierarchy of movements

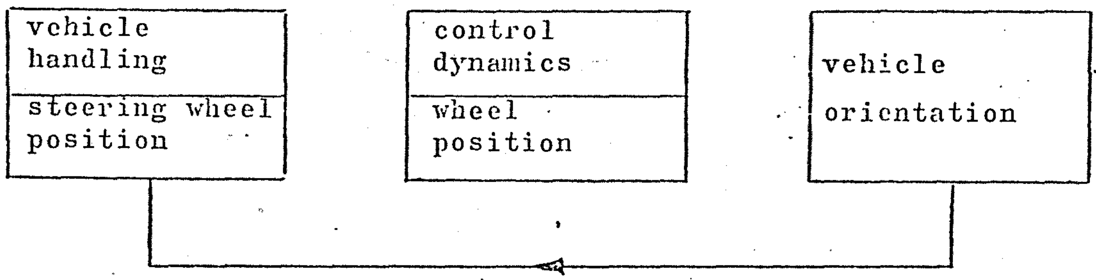

Figure 1.3.

Given the route, a shorter journey time implies a bigger average number of decisions per unit of time and hence a bigger number of wrong decisions per unit of time. The ratio with the total number of decisions, however, is determined by the discriminability and the perceptibility of possible manoeuvres (both of them depending on the structure of the driving situation).
Wrong decisions, unless corrected, result in collisions. Wrong decisions can be corrected if there is enough spare space available (for instance reservations) and/or spare response capacity (of driver and vehicle) (for instance in acceleration). The correction of wrong decisions requires additional driver effort and results in an additional movement variation (acceleration or deceleration laterally and/or longitudinally).

1.4. Journey time, driving effort and control level

The higher the turnover rate, the shorter the time within which feedback information should be available. This may lead to:
1. Greater perceptive-motor effort (governed by the driver's perceptual and response capacity and by the control characteristics of the vehicle).
2. Stronger anticipation of the input (preview control) (limited by the irregularity of the input, for instance wind gusts, track of road).

3. More efficient selection and coding of information (limited by the way in which the information is presented to and processed by the driver).
4. A lower-order control system, by selection of a less differentiated input (for instance a change of distance relative to the roadedge and/or relative to other vehicles, instead of speed and/or acceleration of the relative change in position; this results in lower manoeuvring accuracy).

So far research has been concentrated on manoeuvring behaviour related to guiding the vehicle along the road and relative to other vehicles.
In analising driver's manoeuvring behaviour, it must be borne in mind that information is not always coded in signals but must be obtained by the driver from direct perception of stimuli, such as road markings, vehicle lights. Hence, variation is possible in the selection and coding of (input) information which forms a complication in a cybernetic closed loop approach.

1.5. Analysis of the driving task: summary

The "Analysis of the driving task" can be regarded as a link between general theories of human functioning and the design of specific vehicle, road and traffic characteristics.
For road safety measures the part dealing with manoeuvring seems to be of most direct importance.
Even with this limitation the relevant theories cover almost the entire range of human functioning, while knowledge is also required of road, traffic and vehicle engineering aspects.
Before arriving at usefull models that take into account perception, information and decision processes at the one hand and vehicle operation and control at the other, much future analytical and empirical work appears to be done. In the meantime intermediate criteria have to be chosen. This applies also to the evaluation of driving aids and other improvements of driving conditions.

Research going on in the Netherlands is aimed at perceptual and information processing aspects of the drivers task in manoeuvering his vehicle along the road and relative to other vehicles.
Some of the results of this cooperative project (Institute for Perception and the Institute for Road Safety Research), which bears significance for the design of vehicle and road lighting, signalling and marking systems, will be presented at this symposium.

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