New representation of GADGET's matrix for a driver typology

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Abstract

The GADGET acronym that stands for "Guarding Automobile Drivers through Guidance Education and Technology" is an European project about road safety. Its overall objective is to assess traffic safety measures on driver behavior. We use this method as a basis for a new modeling of the driving activity by enriching the GADGET's matrix and adding a meaningful representation of all the variables in the matrix. Our new representation of the GADGET's matrix relies on STONE engine. STONE structures knowledge in a hierarchy of categories (Galois Lattices). It starts from input descriptors and relations between descriptors and builds a tree of descriptors that are a structured set as a semantic set of dimensions and categorize objects in a hierarchical lattice. For several drivers, the STONE Engine has a unified viewpoint and takes into account the whole set of the driver’s properties. This paper complements the Brezillon & Brezillon study about the diagnostic and remediation of driving errors. It shows how the levels of the driving activity can be unified in a same description.

Résumé

Le projet GADGET ("Guarding Automobile Drivers through Guidance Education and Technology"), est un projet européen sur la sécurité routière. Son objectif global est d'améliorer les mesures de sécurité routière concernant le comportement du conducteur. Nous utilisons cette méthodologie et réalisons une nouvelle modélisation de l'activité de conduite, en enrichissant la matrice GADGET et en choisissant une représentation qui a du sens pour toutes les variables de la matrice. Notre nouvelle représentation de la matrice se base sur STONE. STONE structure le savoir en une hiérarchie de catégories (treillis de Galois). Il se base en entrée sur les descripteurs et leurs relations et construit un arbre de descripteurs qui structure l’ensemble des dimensions sémantiques. Pour plusieurs conducteurs, STONE présente un point de vue unifié et prend compte toute la variabilité d'un conducteur. Ce papier est complémentaire de celui de Brézilon & Brézillon qui diagnostique les erreurs et propose une remédiation. Nous présentons dans ce papier comment STONE unifie dans une même description les niveaux de la conduite automobile.

Introduction

Car driving is a complex activity that needs to be practiced to be safe. Young drivers particularly, but all drivers in general case, do not know how to contextualize learned procedures in effective practices. The major problem is that they do not develop an efficient (and personal) driving awareness. This corresponds to the driver's Situation Awareness discussed by Endsley (1995):"*The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future*". This mental representation is "action-oriented" (i.e. the driver is an actor not a witness). Mental representations are a key element of the driver's cognition. An erroneous representation means, potentially, decision-making errors and unsafe driving actions. It constitutes an Operative Image (i.e. a functionally deformed view of the reality (Ochanine, 1977). Once built, such mental models generate perceptive expectations, guide the road environment exploration and the new information processing, orientate decision making and, lastly, determine all driving behaviors carried out by the driver (Bellet et al., 2005). (Bailly et al., 2003) illustrate the potential effect of inexperience at different levels of situation awareness, including information perception, driving situation understanding, and anticipation.

Our project is to improve driver's Situation Awareness (Brezillon, 2007). We start from two projects: the GADGET project (Siegrist, 1999) and the work of Young et al. (2006). The GADGET, acronym for "Guarding Automobile Drivers through Guidance Education and Technology", is a European project about safety road. It aims to assess traffic safety measures on driver behavior; analyze the influence of in-car safety devices, various road environments, education and training programmes, safety campaigns, and legal measures (including enforcement) on driver behavior (see part one for more details). The work of Young et al. (2006) shows that it's easier to learn from people's errors rather than from their successes. That is the main result of the study in which two training methodologies were compared and evaluated. One group of persons were trained using case studies that containing errors of management (error-story training) while a second group was exposed to the same set of case studies except that the case studies had not errors of management (errorless-story training). Thus, we consider good behaviors as well as bad behaviors of drivers and propose a driver's typology based on driving errors.

This paper presents the first results of this work. First, we present the GADGET project in details and we present TR-CAD, our new representation of driving activity, based on GADGET. We then present our driver's typology, which is errors-based, and then discuss this driver errors-based typology.

The GADGET Project

The GADGET, acronym for "Guarding Automobile Drivers through Guidance Education and Technology", (Siegrist 1999), was an European project about safety road. GADGET method describes the driving activity by splitting driving tasks and driving behavior into three hierarchical levels, (Michon 1985; Van der Molen & Bötticher, 1988):

- Strategic level: Tasks and behavior at the uppermost level are linked to, for example, planning and preparing for a journey, which route to take, and the chosen departure time;
- Tactical level: At this intermediate level, the tasks and behavior are linked to situations connected to the driving itself;
- Operational level: At this highest level, the tasks and behavior are connected to situations at a given moment.

In the GADGET matrix, later also referred to as the GDE matrix (Peräaho, Keskinen & Hatakka, 2003) a fourth level was added above the three levels. This uppermost level became known as "Goals for life and skills for living" (hereafter the "Political level"). This level does not actually contain any driving tasks or deal with driving behavior, but is concerned with the more lasting driver characteristics such as personality, group identification, age, etc. This level has been included because these drivers' characteristics can influence how a driver solves the tasks and influence driver's behaviors at lower levels. How a driver behaves as a person can have an influence on how he/she solves tasks at the strategic level, such as how well trips have been planned. Poor planning can thus have an influence on tasks and behaviors at lower levels. At the superior level, this means knowledge of those personality traits that can influence decisions at lower levels. As far as the other levels are concerned, this implies knowledge and skills relevant to the ability to deal with the tasks at each level. The GDE matrix also emphasizes that the driver must know how incorrect and missing information and/or skills can lead to increased risk. At the highest level, a risk seeking personality can be not favorable from a traffic safety viewpoint. At the strategic level, driving while drunk can result in increased risk, while driving too fast is an unfortunate choice at the tactical level, and a lack of technical driving skills at the operational level.

Our work relies on the assumption that GADGET methodology must be revisited at the light of the notion of context. We suppose that all the variables in the GAGDET matrix can be used to describe the context of the driving activity. Context is what constrains a focus without intervening in it explicitly (Brezillon and Pomerol, 1999). If the focus is on the car-driving task, then some information in the GADGET matrix like traffic regulation and road planning are contextual elements that may constrain the focus (e.g. drive quietly because not in a hurry). We think to give by this way a coherent picture, thanks to the notion of context. Another assumption is that a decision supports system would benefit of drivers' experience by incrementally record, when in position of failure, drivers' practices. However, conversely to other systems, the system would records good and bad practices. Thus a system will be later able to identify a bad behavior as well as a good behavior, determine a path in the situation space to allow the driver to return to a normal situation and correct driver's behavior, and propose a scenario to support the training of the driver.

TR-CAD

This part aims to present our methodology to obtain TR-CAD (Tree Representation of Context Awareness for Drivers' behavior) which has to step: GDE matrix was improved upon by definition of new variables and we reorganize the variables by sense instead of by levels.

Supplement of the GDE matrix

Our claim is that the GADGET matrix is incomplete and the hierarchical structure of the matrix insufficient. Our first step was to complete the GADGET's matrix with additional variables. In our viewpoint, the missing variables concern several aspects of driving. First, there are variables concerning the driver, personal variables (sex, age, work, etc.) as well as variables describing his personal driving practices (if he had his driving license from the first examination or not, how many time he had his license, if he drives daily, etc.). Second, there are variables concerning driver's preferences (if the driver drives to the saving in gasoline or not, if he always drives as quickly as possible or not, if he always trying to avoid damaging the car or not, if he drives to decompress, if he likes races of cars, etc.). Third, there are variables describing driver's mental condition (tired, stressed, etc.). In addition to the variables concerning the driver, there are additional variables concerning the driving situation like the climatic conditions (rain, fog, snow, and glaze). We also added variables concerning others persons inside in the car (kids, animals, adults, etc.). Then we added variables concerning the car (color, mark, type and the relationships between the driver and his car, etc.).

All these variables were not included in the GADGET's matrix, whereas we thought they are important to describe the driving task. For example, the variable "sex" was not present to describe the driving task; however woman and man do not drive in the same way. Such personal variables describe the driving's experience and the social background of the driving task. They were not taking into account whereas a person who drives every day for his job for example does not drive in the same way when the person drives in vacations.

Reorganization of the GDE matrix

We found in literature that most of the studies based on the GADGET's matrix are lead generally at one level of the matrix. For example, a study concerns driver's time reaction is at the operational level. Another study tries to model driver's mental representation on the road at the tactical level. In our work, we make the assumption that modeling the driving task requires to take in account simultaneously all the levels of the GADGET's matrix because the highest levels have an influence on the lower levels. For example, the driver that is much stressed will not drive as usual, and maybe he will take some risks that he wouldn't have taken in normal time. If we model this case at the tactical level only for example, we just model the fact the driver is driving by taking serious risks, so we will say that he is a dangerous driver, and we will have no idea the fact that he is stressed or has personal reasons.

We take simultaneously into account all the variables of the matrix, at all the levels, whatever the level at which they appear, and rather we meet them by type. There are two kinds of grouping: the variables appearing several times in the matrix (this is a directed influence from the highest level) or the variables describing the same parts of the driving task. Figure 1 shows some repeated variables in the matrix.

For example, variables common to the "Operational" and "Tactical" levels are: "if the driver manages to drive in difficult conditions or not," "if the driver adjust its speed at the driving situation or not," “if the driver has insufficient automatism or not,” "if the driver has strong and weak points of the basic traffic skills," "if the driver has strong and weak points for random situations," "if the driver has an realistic self-evaluation of his driving." These variables appear in both levels since a driver, once he decides to reduce speed (which is "Tactical" information) he does it further by braking with his foot (which is" Operational" information).

A variable that is common to the "Tactical" and "Strategical" levels is "if the driver has competences for planning." The driver has plan his way, before taking the car, by looking a map for example (which is a "Strategical" information) and once in his car he looks the road signs to follow his way (which is a "Tactical" information).

A variable that is common to the "Strategical" and "Political" levels is "if the driver complies with social pressure or not." The variable shows that maybe a driver who plans his way would be able to change his mind if his children ask for stopping.

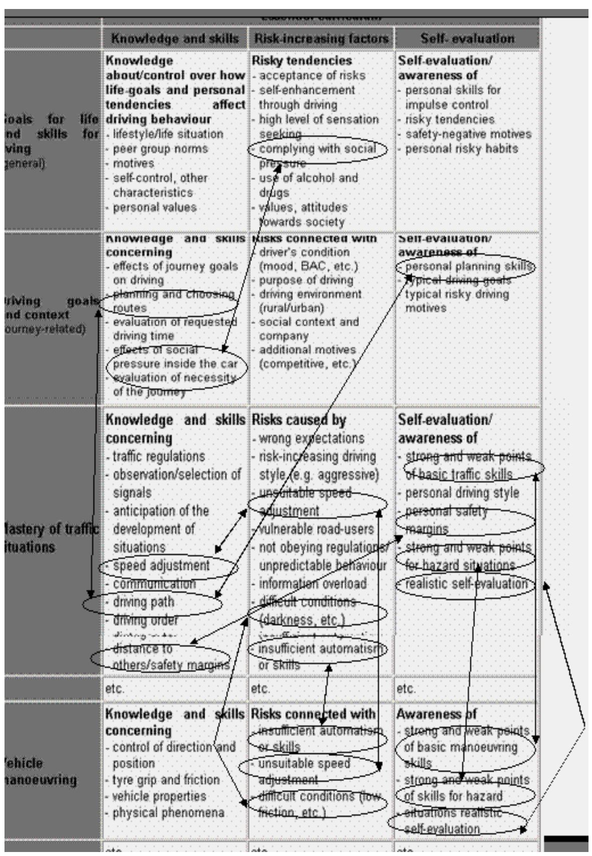

Figure 1: The repetition of variables

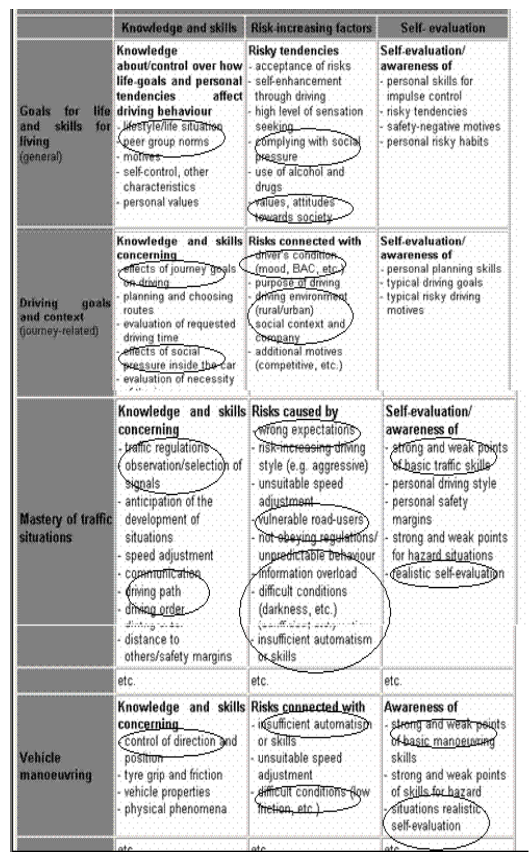

Figure 2: The lifestyle's variables

Figure 2 shows the variables that describe the lifestyle of the driver. All these variables describe the way the driver perceives his driving context. This concerns the variables which describe how the driver could comply with social pressure and may be sensible at it (peer group norms, complying with social pressure, values of attitudes towards society, for the social part). For example, a driver may not drive the same way if he has children inside the car, he would be more careful. It concerns the variables which describe if a driver has self-control or not, can be patient or not (e.g. at traffic lights). For example the driver's behavior in case of bad conditions for driving, if the weather is not good, and the fact that the driver can slow down to be more careful. These variables describe insufficient automatism, wrong expectations, information overload, strong and weak points of basic traffic skills, realistic self-evaluation, control of direction and position for the driver's behavior. Globally, these variables describe strong and weak points in the driving task.

	Knowledge and skills	Risk-increasing factors	Self- evaluation
Goals for life and skills for living (general)	**Knowledge about/control over how life-goals and personal tendencies affect driving behaviour** - lifestyle/life situation - peer group norms - motives - self-control, other characteristics - personal values	**Risky tendencies** - acceptance of risks - self-enhancement through driving - high level of sensation seeking - complying with social pressure - use of alcohol and drugs - values, attitudes towards society	**Self-evaluation/ awareness of** - personal skills for impulse control - risky tendencies - safety-negative motives - personal risky habits
Driving goals and context (journey-related)	**Knowledge and skills concerning** - effects of journey goals on driving - planning and choosing routes - evaluation of requested driving time - effects of social pressure inside the car - evaluation of necessity	**Risks connected with** - driver's condition (mood, BAC, etc.) - purpose of driving - driving environment (rural/urban) - social context and company - additional motives (competitive, etc.)	**Self-evaluation/ awareness of** - personal planning skills - typical driving goals - typical risky driving motives
Mastery of traffic situations	**Knowledge and skills concerning** - traffic regulations - observation/selection of signals - anticipation of the development of situations - speed adjustment - communication - driving path - driving order - distance to others/safety margins	**Risks caused by** - wrong expectations - risk-increasing driving style (e.g. aggressive) - unsuitable speed adjustment - vulnerable road-users - not obeying regulations/ unpredictable behaviour - information overload - difficult conditions (darkness, etc.) - insufficient automatism or skills	**Self-evaluation/ awareness of** - strong and weak points of basic traffic skills - personal driving style - personal safety margins - strong and weak points for hazard situations - realistic self-evaluation
	etc.	etc.	etc.
Vehicle manoeuvring	**Knowledge and skills concerning** - control of direction and position - tyre grip and friction - vehicle properties - physical phenomena	**Risks connected with** - insufficient automatism or skills - unsuitable speed adjustment - difficult conditions (low friction, etc.)	**Awareness of** - strong and weak points of basic manoeuvring skills - strong and weak points of skills for hazard - situations realistic self-evaluation
	etc.	etc.	etc.

Figure 3: The motivation's variables

	Knowledge and skills	Risk-increasing factors	Self- evaluation
Goals for life and skills for living (general)	**Knowledge about/control over how life-goals and personal tendencies affect driving behaviour** - lifestyle/life situation - peer group norms - motives - self-control, other characteristics - personal values	**Risky tendencies** - acceptance of risks - self-enhancement through driving - high level of sensation seeking - complying with social pressure - use of alcohol and drugs - values, attitudes towards society	**Self-evaluation/ awareness of** - personal skills for impulse control - risky tendencies - safety-negative motives - personal risky habits
Driving goals and context (journey-related)	**Knowledge and skills concerning** - effects of journey goals on driving - planning and choosing routes - evaluation of requested driving time - effects of social pressure inside the car - evaluation of necessity	**Risks connected with** - driver's condition (mood, BAC, etc.) - purpose of driving - driving environment (rural/urban) - social context and company - additional motives (competitive, etc.)	**Self-evaluation/ awareness of** - personal planning skills - typical driving goals - typical risky driving motives
Mastery of traffic situations	**Knowledge and skills concerning** - traffic regulations - observation/selection of signals - anticipation of the development of situations - speed adjustment - communication - driving path - driving order - distance to others/safety margins	**Risks caused by** - wrong expectations - risk-increasing driving style (e.g. aggressive) - unsuitable speed adjustment - vulnerable road-users - not obeying regulations/ unpredictable behaviour - information overload - difficult conditions (darkness, etc.) - insufficient automatism or skills	**Self-evaluation/ awareness of** - strong and weak points of basic traffic skills - personal driving style - personal safety margins - strong and weak points for hazard situations - realistic self-evaluation
	etc.	etc.	etc.
Vehicle manoeuvring	**Knowledge and skills concerning** - control of direction and position - tyre grip and friction - vehicle properties - physical phenomena	**Risks connected with** - insufficient automatism or skills - unsuitable speed adjustment - difficult conditions (low friction, etc.)	**Awareness of** - strong and weak points of basic manoeuvring skills - strong and weak points of skills for hazard - situations realistic self-evaluation
	etc.	etc.	etc.

Figure 4: The personal values' variables

Figure 3 shows the variables that describe driver's motivations: speed adjustment, anticipation of the situation evolution, personal driving style, risk acceptance, respect of the driving's rules, risk tendency, strong and weak points of random situations, safety margin, high level of sensation seeking. These variables are related to a risky behavior of the driver; the driver may overestimate his competences and take risks. These variables describe also the fact that the driver likes competition and wants to be better than other drivers.

Figure 4 shows the variables that correspond to the personal data, like personal skills for impulse control for the self-control of the driver, (such variables describe how the driver can be able to control himself in a driving situation particularly stressing for him); self-enhancement though driving, use of alcohol or drugs (such variables describe the fact that the driver may like to drive and see in his car); the driver may think that it is not dangerous to drive while being drunk before, that he thinks that for him, he can resist more than others to alcohol's effects, and that he has all it has all its capacities and its reflexes of driving even if he drinks beyond the legal limit.

The last group of variables describes the properties of the driver's vehicle like tire grip and friction vehicle proprieties and physical phenomena.

Result : TR-CAD

We start from the 4 classes of variables described in the previous section and we refine them. The new representation shows that instead of having a hierarchical structure, the variables can be categorized by type, as shown in the previous section.
We found variables about:

- Life style, which concerns the attitude towards society, driver's competences about the direction checking, the automatism, the basic competences, the information overload, the trajectory of the vehicle, the social driving context, the driver condition, etc.
- Driver's motivations, if he has risky motivations, looking for strong sensations, the driver's competences in unpredicted situations, or risky situations, the speed adjustment, the anticipation of the evolution of a situation, the risk acceptance, etc.
- Personal data of the driver, which concerns his driving experience, his age, his activity, if he already drives under the effect of alcohol or drugs, if he has self-control, etc. Some variables about his vehicle concern the fact that the driver takes care of his car, if his car is expensive, etc.

Our GadText matrix is used to make an error-based typology of drivers that aims to identify a driver's behavior and specially his drawbacks for after, being formed by scenarios adapted to his drawbacks. Our Gadtext's matrix can be seeing at www-poleia.lip6.fr/~jbrezillon/typology.html

Collecting data: an error-based typology of drivers

Method

The typology has been elaborated from a questionnaire on the web (at www-poleia.lip6.fr/~jbrezillon/questionnaire). This questionnaire is based on our GadText matrix and concerns 61 variables and has 162 questions. There are some reformulations in the questions for the skew of the morality of the driver and to determine if the driver lies or not. To stage this skew, we also guided the questions about the facts while trying to ask for the least most often possible the opinion of the driver about his own behavior.

The results are based on 419 relevant answers to that questionnaire. We found 15 classes, by doing a principal composant analysis that reduces the 61 variables to 3, and we classify new data, thanks to agglomerative methods.

We then identify for each class the variables which have a specific value in this class and another value in the others classes (we call these variables "specific", as they have a specific value for one class). After, we determine in each class the specific variables that are related to risky behaviors. We then obtain a driver typology based on the errors observed by drivers.

Finally, we analyze driving behavior evolution according to the drivers' age. We wanted to know if young drivers present specific errors different from those of old drivers.

Main results

Here, we only present the evolution with the age of the drivers' behaviors. We found four steps in the evolution of the driving behaviors with the age (see figure 5):

- Discovering step: it's the step in which drivers discover what driving is, thus errors made at this step concern mainly a lack of competence for driving (as information overload, no evaluation of the necessity of a trip, no respect of the safety margins, etc.)
- Risk step: the driver becomes experimented in driving, and looks for the limits of his competences by taking risks, thus errors made at this step concern mainly risks (as personal driving style, the no respect to driving rules, etc.)
- Stable step: the driver has found and kept his driving style, and the errors made in this step are quite similar to the previous one.
- New driving style step: driver's competences decrease with the age; The driver becomes less and less self-confident: the errors made at this step concern the new way to drive (e.g. stressed, not realistic self-evaluation and drive for another reason than go somewhere – which appear at this step).

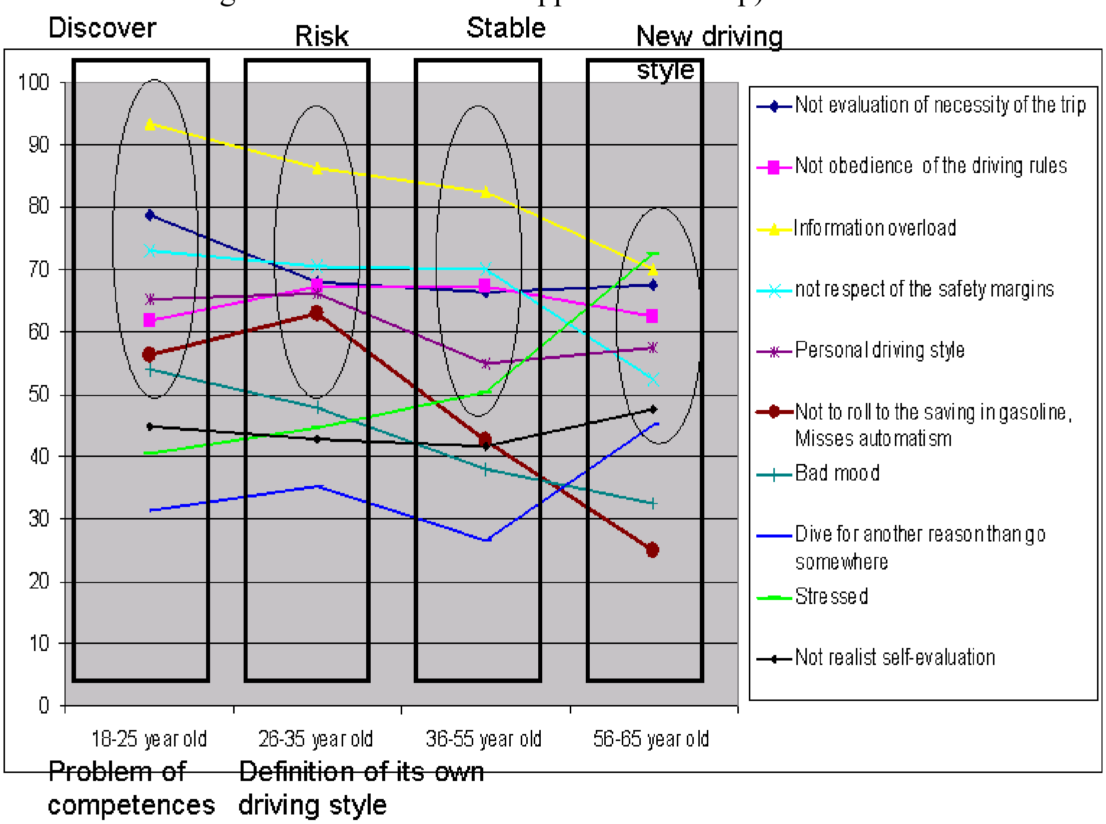

Figure 5: Evolution of the driving behavior among time

Figure 5 show that there exist specific errors according to the age of the driver. Young drivers make competence errors by their lack of experience. Later, drivers make risky errors, searching their personal driving style. After, their behavior stays stable. Once older, drivers make errors because there is a shift between their previous style of driving some years ago and the current one. The main problem is a problem of information processing.

Conclusion

GADGET analyzes the influence of: in-car safety devices, various road environments, education and training programmes, safety campaigns, and legal measures (including enforcement) on drivers' behavior. The work presented in this paper is based on this project, but we propose a new modeling of the driving task by completing the GADGET matrix and changing its hierarchical representation of drivers' behaviors. Our TR-CAD allows us to propose a driver typology that is based on driving errors and is organized in 15 classes. We further analyze the evolution of the driving behavior according to the age of the driver, in order to determine specific errors related to driver's age.

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