ATTENTIONAL COMPETITION BETWEEN TASKS AND ITS IMPLICATIONS

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ABSTRACT: Attentional processes are necessary for any complex activity, such as driving. When driver's attention is not at its optimum, it can induce driving errors. The aim of this study is to highlight the involvement of attentional problems and their weight in accident production, using data from in-depth analysis of accidents. Three attentional defaults are distinguished according to the task that competes with driving activity: inattention, attentional competition, and distraction. Inattention is the default the most represented (74,5%) by comparison with attentional competition (19,1%) and distraction (6,4%). Overall, attentional defaults lead mainly to perceptual failures (45%). In more than half of the cases, it requires other factors for a driving error to emerge. The interest of the study of human failures linked to attention defects is that it allows defining driver's needs in help and thus identifying which systems are the most relevant and, on the opposite, which are those possibly lessening attention capacity required for driving.

1 INTRODUCTION

Attention plays an essential role within driving activity. It can be defined as “control, orientation and selection by a person of one or several forms of activities during a period of time that can not be maintained a long time” [1]. It permits not only to select information relevant for driving situation and to inhibit irrelevant one, but also to manage various tasks performed simultaneously by the driver. Indeed, driving is a complex activity that involves the implementation of many tasks necessary for its successful achievement: navigation, vehicle control and hazards identification (e.g. [2]). Moreover, in addition to tasks underlying driving, it is common for a driver to perform an additional task which is unconnected with the primary activity. It can be: tune the radio, discuss with a passenger or just be in his thoughts. Stutts and al. (e.g. [3]) showed that, even if discussion with another passenger is excluded, drivers make a potential distracting activity 16% of the actual driving time. Furthermore, with the introduction of new technologies into the vehicle, potentially distracting activities continue to increase. In other terms, driving activity places the driver in a situation of attentional sharing all the time, whether to perform tasks inherent to driving or secondary tasks.

Among crash risk factors, studies have widely investigated vigilance problems, dealing with organism's arousal problems, linked to diverse variables such as drowsiness, alcohol, drug or medicine. With the emergence of mobile phones and new technologies introduced in vehicles, the issue of attention problems has taken a greater expansion. Many studies have shown that this is one of the most important causes of accidents. For example, for Stutts and al. (e.g. [4]) at

least 25% of police-reported crashes involve some form of driver inattention. Sussman and al. (e.g. [5]) estimate that inattention is responsible for 35 to 50% of accidents. However, attentional perturbations deal with phenomena that can be quite varied and the variation in the results found in the literature reflects it. These questions are also subject to various classifications. Thus, we can find some classifications which are strictly based on cognitive process so as to differentiate attentional disorders (e.g. [6]). But in an ergonomic perspective, we will rely on the classification by Van Elslande and al. (e.g. [7]), which allows distinguishing attentional problems according to the task that competes with the driving task. Three categories of attentional dysfunction are defined:

- 'Inattention', resulting from interference between a driving task and personal concerns.
- 'Attentional competition', resulting from interference between several tasks relevant for driving (e.g. guide a vehicle and follow an itinerary).
- 'Distraction', resulting from interference between a driving task and an external stimulation without link with driving (e.g. guide a vehicle and tune the radio). This secondary task can be gestural or visuo-cognitive.

The aim of this study, based on an in-depth analysis of accidents, is to identify the type of drivers' errors induced by each of these attentional perturbations: Are there differences in the disturbed driving functions according to the attentional perturbation? Secondly, we evaluate the influence of attentional defaults in the emergence of driving errors. Indeed, the mere presence of attentional problems is not always a sufficient condition to cause a failure. As in any complex events, the deterioration of the situation is often led by a combination of several variables, attentional and other. It is therefore essential not to limit the analysis to the sole detection of a factor as inattention, but also to establish its role in the genesis of accidents.

2 METHOD

In order to investigate attentional problems, we relied on data issued from the in-depth study of accidents (EDA) performed at INRETS-MA, and we focused on the cognitive mechanisms involved. The advantage of working on accidents is to focus the research on human errors that pose a real safety problem, without confusing them with 'normal errors', benign and/or controlled by the driver. Data are collected by multidisciplinary teams, consisting of a psychologist whose role involves interviewing drivers about the circumstances of the accident, and a technician, specialist of infrastructure and vehicle, whose mission is to record the traces and to diagnose physical conditions of the accident. The advantage of this method is in its systemic approach, taking into account the three components of the road system: human, vehicle, infrastructure, and their interactions. Compared to police reports, EDA offers a far more precise data collection, permitting notably to emphasize the explanatory mechanisms dealing with drivers' errors production as well as the factors that originate these errors.

Human error is discussed here in terms of functional failure (e.g. [8]). This concept characterizes the momentary inability of a human function (sensory, cognitive or motor) to handle with a difficulty, which leads to a breakdown in the handling of a situation. There are six categories of human functional failures. The first five correspond to the different stages of information processing: perception, diagnosis, prognosis, decision and execution. The last one is an alteration of the functional chain in its entirety, called 'overall failure'.

This methodology allows us to highlight the explanatory elements at the origin of these functional failures, that is to say: the factors of errors. Generally, none of these factors can explain by itself the emergence of a failure. They usually combine with each others. These elements can be endogenous (directly related to driver status and its internal conditions for achieving the task) or exogenous (related to infrastructure, vehicle or environment). Among endogenous elements, some of them concern driver's attention. So, eight explanatory factors related to attention have been highlighted thanks to accidents data, and distributed depending on the specific type of attention problem that they generate: inattention, attentional competition, or distraction (Table 1).

Table 1: explanatory elements related to attentional defaults

Types of attentional defaults	Explanatory elements derived from EDA
Inattention	- Low level of attention (e.g. leisure journey) - Thoughts, concerns - Road over-familiar/monotony - Manoeuvre over-familiarity
Attentional competition	- Navigation problem - Identification of a potential risk on one part of the situation
Distraction	- External distraction (phone, conversation with a passenger…) - Secondary task (tune the radio, pick an object…)

In order to clarify the role of attentional problems in the genesis of driving errors, the degree of impact of attentional variables was estimated using three levels:

- **Impact 1**: the variable has a major, 'decisive', influence on the production of driving error. The suppression of this variable would have sufficed to avoid the problem: the functional failure wouldn't have occurred, and the accident wouldn't have happened.
- **Impact 2**: intermediate level which reflects a participatory, 'co-determinant', influence of attentional problems and other kinds of variables in the apparition of the failure.
- **Impact 3**: these variables have not a strong influence upon the onset of the functional failure; their influence is only 'contributory'. It promotes the malfunction, but in their absence, the failure would

have occurred anyway due to the weight of all other factors involved.

The sample consists of 251 drivers involved in a traffic accident, these drivers having at least one attentional factor explaining their functional failures. As we can see below, inattention is the attentional default that has the highest occurrence rate (74,5%) in accident apparition, compared with attentional competition (19,1%) and distraction (6,4%). Only drivers who have had one particular attentional problem are concerned in our sample.

3 RESULTATS

Overall, the results indicate that attentional defaults often lead to perceptual failures (45%) and that they have rather a co-decisive influence in the genesis of failures (58,3%). However, further analysis of the distribution of errors shows differences according to the type of attention defaults, both for the failures that generate these defaults and for the contexts in which these failures occur.

Table 2: distribution of driver's functional failures according to the attentional default

	perception	diagnosis	prognosis	decision	execution	overall
Inattention	39%	20,3%	22,5%	8%	9,1%	1,1%
Attentional competition	66,7%	8,3%	4,2%	14,6%	4,2%	2,1%
Distraction	50%	6,3%	12,5%	0%	31,3%	0%

Inattention is, overall, the attention default the most widely represented (Table 2). In 39% of cases, a problem of inattention led to perceptual failures and in 42, 8% of case, to failures in the assessment of the situation (diagnosis and prognosis failures). In both cases, the main attentional variable is "over familiar road". The difference lies rather in the combination of these explanatory attentional elements with other variables of a different nature. When a problem of attention leads to perceptual failures, in 58,9% of cases there is the explanatory element "lack of visibility", linked to infrastructures (buildings, vegetation…) or temporary lack of visibility (sun, truck…). At the origin of diagnostic failures, we find drivers who know the route very well but who drive a little too fast for the driving conditions such as curves or when overtaking. In other cases, knowledge of the route reinforces the drivers in their priority feelings. Especially at intersections, they do not anticipate any dangerous behaviour from other drivers. This results in prognostic failures. The weight of inattention within the accident rate seems to be moderate, this factor having especially a co-decisive impact. Moreover, this is the default which has the highest rate of contributory influence (33,3%). Therefore, in most cases a problem of inattention alone does not lead to driver error. Other factors (speed, lack of visibility…) are necessary to impede the driving situation. Only one specific inattention variable does not fulfil these conditions: driver's concerns. In 41,7% of cases, this factor has a decisive influence (figure 1).

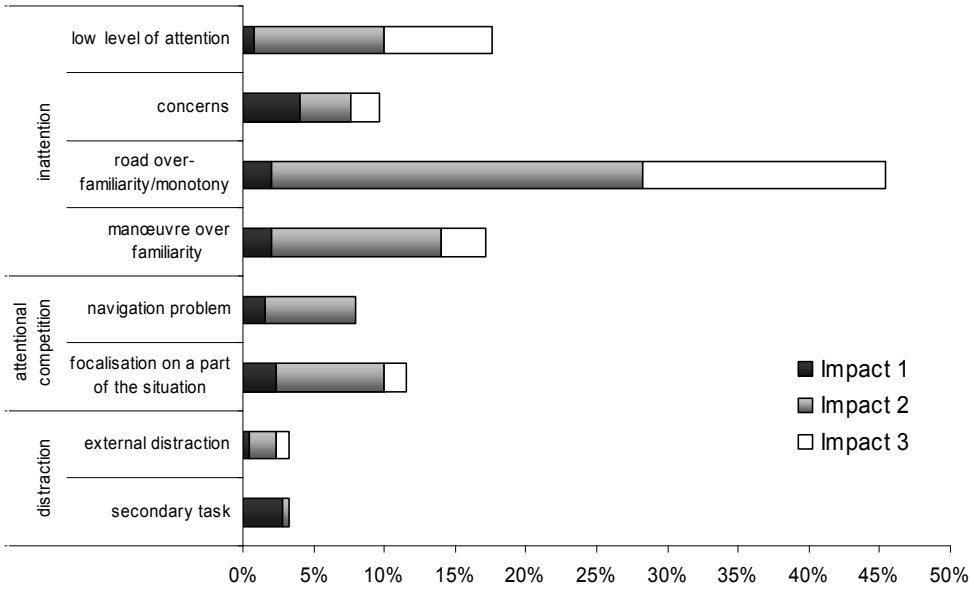

Figure 1: Distribution of attentional explanatory elements and their impact

The attentional competition represents 19,1% of accidents. It leads to a large majority of perceptual failures (66,7%) and more specifically to failures such as “focusing on part of the road scene”. Drivers mobilize their attentional resources on an element identified as a source of risk (62,5%) or on searching for a direction (40,6%), at the detriment of detecting an important element of the road scene. We find such accident scenarios at intersections or during specific manoeuvres such as changing direction. Ignorance of the route contributes to the emergence of perceptual failures in 43,8% of cases. Whether the source of attentional competition is a problem of navigation or identification of a danger, the impact will be co-decisive in 71,4% of cases.

Distraction is poorly represented in the accident rate (6,4%). It leads mainly to perceptive failures due to drivers interrupting their information gathering, or executive failures because of problems of vehicle guidance. Distraction occurs less frequently than inattention and attentional competition, but it is the default which has the strongest impact in the production of a failure. Its influence is decisive in 47,1% of cases and co-decisive in 41,2%. However, the two explanatory factors at the origin of the distraction do not have the same weight. In the case of a 'materialized' additional task, the influence is decisive in 87,5% of cases (figure 2), whereas for a cognitive distraction by an external element (telephone, children…), the proportion is only of 11,1%.

4 DISCUSSION

This study allows several conclusions. At first, we can notice that different attentional defaults are dissimilar on two points: their consequence and their influence. Primary, although these defaults generate a majority of perceptual failures, there is also a significant proportion of diagnosis and prognosis failures when considering inattention, and a high percentage of executive failures when considering distraction. Moreover, whereas inattention has the highest accidents rate in which the attentional variable had only a contributory influence, distraction has the greatest impact in the emergence of the failure, its influence being decisive in 47,1% of cases.

From these results follows the second observation: it is necessary to take into account not only the presence of a factor, but also its weight in the appearance of the error. Indeed, distraction is a default that occurs rarely but in half of cases it is sufficient by itself to lead to the accident. Conversely, in most cases, a problem of inattention requires other factors to degrade the driving situation.

New technologies could be a way to solve some attentional problems, but they have also the potential adverse effect to arouse others. To promote the adaptation of systems, we must establish exactly what the driver's needs are and define, as a consequence, the driving functions the most appropriate to these needs. These needs correspond to something that has failed in the driving system in its defence and/or its protections. Thus, crashes can be seen as the symptom of these lacks, and functional failures like a more precise indication on what has lacked to drivers to compensate the difficulties they met. So, the drivers functional failures observed diagnosed from in-depth accident analysis will enable us to establish more precisely the needs associated with each attentional default.

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