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Driving Activity, Road Accidents and Attention Capacity among Ivorians Drivers

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Abstract: *In view of the various accident statistics, the problem of inattention and distracted driving is acute in Côte d'Ivoire, as in most sub-Saharan countries. The proposed study is therefore part of the studies on attention deficit driving. Its objective is to analyze the links between driving performance (indicated by the braking reaction time), road accidents and attention capacity in eighty-four Ivorian drivers, including the average age is 45 years old. These drivers are subjected to attention and simulated driving tests. The description of the evolution of attentional performance and driving performance shows the existence of a relationship between the level of attention and braking reaction time: a decrease in the level of attention induces an increase in braking reaction time and, conversely, a low level of attention leads to a reduction in braking time. In addition, it appears that the frequency of accidents is related to the top in attention.*

Key terms: *accident, attention, driving, distraction, inattention, reaction time*

1. Introduction

Driving involves several tasks simultaneously: the driver must manipulate the vehicle's on-board instruments, such as the steering wheel, brake and accelerator pedals, and gear lever; he must also control the lateral and longitudinal position of his vehicle while consulting his on-board instruments, and analyze the road environment. These actions are made possible by motor, sensory and cognitive functions.

The motor functions, grouping together the joints and the muscular system, allow the driver to act, in an often rather limited time, by coordinated gestures between them, within the framework of highly automated behaviors or following consciously elaborated strategies. Under these conditions, reaction time is a primary behavioral parameter and plays a majorrole in the evaluation of driving activity (Horrey&wickens, 2004; McKnight & McNight, 1993). It is referred to as “braking reaction time” and is thought to be related to perception; hence the terms "visual reaction time" or "auditory reaction time" or simply "detection time". Epidemiological studies, which include analysis of the reports of drivers who are victims of traffic accidents, have shown that the presence of motor deficiencies or deficits that may impair driver ability could be associated with increased risk of dangerous driving, traffic violations and collisions (Nanjui, Datié & Manou, 1998; Sauvignon, 1992). However, the mere presence of any of these facts does not automatically lead to the conclusion that a driveris at increased risk, since some studies show positive correlations, and others negative correlations, between these disorders and driving (Gresset & Meyer, 1994). Moreover, are view of some statistical analyses that have been conducted on perceptual disorders also suggests that these disorders may adversely affect driving (Evans, 2004; Loriot, 1990; Lovsund et al., 1991).

According to Groeger (2002), each sensory system initially processes information in a unitary manner, either through primary cortices or deeper cortices. A comparison and aweighting between the different sensory systems must then be carried out to arrive at the perception of the external world, particularly in the case of driving. In this perspective, Marin-Lamellet (2005) finds that managing the driving task mobilizes a certain amount of the driver’s perceptual-cognitive resources. The information gathered by the eyes is transmitted to the brain. The brain analyzes this information and makes a decision based on the knowledge recorded in it: meaning of signals, driving rules, learned behaviors, etc. The brain is then able to make decisions based on the information it receives. The information perceived by the eyes, analyzed and processed by the brain, is translated into driving gestures: accelerating, braking, changing direction or speed, etc. The information is then transmitted to the driver's brain. The model of the different psychological activities implemented by the driver can therefore be summarized in three levels of control: information gathering, information processing, action. Michon (1989), who talks about hierarchical models of driving, also finds three levels of control: a strategic level, which makes it possible to plan driving according to weather conditions, traffic density, the driver's condition, etc.; a tactical level, which consists of making appropriate decisions and adjusting to the demands of the environment (adapting speed, overtaking, etc.); and an operational level, which refers to the execution of basic driving actions, such as steering or braking.

With reference to these models that attempt to explain the process involved in driving, it emerges that driving a vehicle is a complex task that requires faculties of choice and reasoning, judgment, mental operations and continuous adjustments. In addition, driving a vehicle involves a variety of mnemonic processes. For Moll et al. (2000), episodic memory occurs when it is necessary to remember the destination of the trip. Procedural memory is very important in that it allows the vehicle to be handled. Semantic memory, on the other hand, enables the identification of traffic signs (illuminated, horizontal and vertical). The driving activity is therefore an exercise that requires a voluntary and methodical effort to acquire and fix information: the maintenance in memory of traffic rules (storage), the identification (decoding) and the implementation (recall) of these rules while driving

The driving task also requires an optimum level of attention and vigilance to ensure road safety. All forms of attention seem to be involved in almost all tasks that underlie driving (Ducheck et al., 1997; Marin-Lamellet, 1993; Marottoti and Drikamer, 1993). Indeed, while driving, it is necessary at all times and with precision to make gestures adapted to the circumstances and the environment (sustained attention), to focus on selecting the information most relevant to driving (selective attention) and, finally, to detect at the same time the presence, speed and direction of an object in the environment (divided attention). Moreover, several studies show that impaired attention is as important a cause of accidents as speeding or alcohol impregnation (Lemercier & Cellier, 2008; Lee &Strayer, 2004). This impairment is thought to be due to several factors, including telephone use while driving and drowsiness, which limit psychomotor, cognitive and perceptual abilities, resulting in longer reaction times, slower information integration processes and, ultimately, a deterioration in driving performance (Atchley & Dressel, 2004; Consiglio et al., 2003; Prévot& Leger, 2000).According to several studies, including those by Gabaude (2010) and Chapon (2006), one of the main causes of road accidents is linked to attention deficits. Different types of accidents are characteristic of attention errors: collisions at intersections during a left-turn, collisions with stationary vehicles, collisions with vehicles arriving sideways due to failure to observe traffic signals (Larsen & Kines, 2002).

1.1. Issue

Several studies have looked at driving from a psychological perspective. Generally speaking, these studies have shown that driving is an organized and coordinated behavior which, in addition to sensory and motor functions, involves a cohort of cognitive functions (perception, intelligence, attention, memory...) resulting in a behavior which must be adapted to the various situations encountered in the road system. Admittedly, most of these studies did not relate, simultaneously, all these psychological components to driving. Nevertheless, when one considers several studies carried out from such a perspective, it is possible to grasp, in detail, their importance. It should be specified, without however reducing the whole of cognitive activity to any predominance of the attentional process that attention seems to be of primary importance. And for good reason, this process would be the key to other psychological functions: its action precedes and assists, without interrupting until the end of the task, that of other functions in the performance of cognitive tasks (Camus, 1996; Richard,2003); attention makes it possible to control, regulate or modulate almost all of our psychological activities (Camus, 2003; Richard, 1974) as well as the adaptation of human behavior to its environment (Broadbent, cited by Lachter, Forster &Ruth ruff, 2004). In away, "it reflects the idea of the predominance of one activity over all other possible forms at the same time" (Grau and

Amalberti, 1995). From this perspective, experimental studies conducted on driving simulators (Haraldsson et al., 1990) or in real driving situations (Khardi et al., 1995; 2000) establish a link between parameters indicating driver hypo vigilance and vehicle operation referring to kinematic cues (frequency and amplitude of steering wheel, brake or gas pedal inputs, etc.). In fact, this was done through an analysis of psychological processes, electro-physiological indices and/or behavioral indices objectivizing the driver's condition. In Côte d'Ivoire, there are currently to our knowledge few methodological approaches that take into account driving in simulated situations and that have linked at the same time attention, driving activity and road accidents. Yeboué-Kouamé's (1991) work focused on simple auditory and visual reaction times in bus drivers before and after starting service. However, these reaction times were measured using a stopwatch.

Thus, in line with the above, one could think that attentional processes condition driving activity, and their alteration could be a major source of accidents and incidents. The objective of the study is to explore the links between attention skills, braking reaction time and road accident rates.

2. METHOD

2.1. Participants

Eighty-four drivers between 20 and 60 years of age (m = 45.4 α = 18.1), with a minimum of 2 years driving experience and who frequently drive their vehicle, participated in the study. The total number of participants was 42 women and 42 men, who had no treatment that interfered with sleep and alertness and had regular schedules for three days prior to entering the study.

The statistical analysis covers 13600 drivers of light vehicles victims of accidents in Côte d'Ivoire and is based on the accident files of the Ministry of Transport (2013), which covers the annual balance of road accidents as of January 1, 2013. These files are based on data from the "Road accident analysis bulletins" of the Road Safety Office (OSER).

2.2. Materials

2.2.1. The Attention Test: Number Barrage Task

The attention test consists of a stopwatch, a pen and A4 (21x30 cm) number barrier sheets. The number barrier sheets come in four parallel shapes: A, B, C and D. Each shape has600 numbers from 1 to 5 digits arranged in 36 lines. The number of targets is 187 with 2 to 83-digit numbers randomly distributed per line. The numbers are separated by a dot, preceded and followed by a space. One point is given for each of the 187 targets correctly detected.

The jump-off test is a written test that can be taken individually or collectively. In this case, the passes are individual. Each participant has one minute to cross out all the 3-digitnumbers as quickly as possible.

2.2.2. The Driving Test: The Computer Reactiometer

The hardware consists of a Samsung Sens 700 microcomputer type 486 DX2 50, equipped with a passive matrix type color screen (display resolution: 640 x 350).

The system is also based on a non-interactive software program, called a "computerreactiometer", which attempts to reproduce driving situations involving emergency stops and braking at different speeds. In fact, the computer reactiometer measures drivers' reaction time to braking and displays reaction distance, braking distance and time, distance and total stopping time as a function of driving speed.

A brake pedal equipped with a USB TO RS232 key interfaced to the serial port of the computer is used to capture the subject's response.

2.3. Procedure

2.3.1. Familiarization and Configuration Phase of the Tool

Just before the driving test, the driver is first subjected to an attention test. Then, the driver is asked to sit in front of the computer, about sixty centimeters from the screen. The experiment begins with a familiarization and configuration phase. During this learning session, the device is introduced to the participant. He is informed that he will be confronted with simulated driving situations involving emergency braking, presented in a video sequence (5 consecutive tests). The experimenter shows the participant the brake pedal (juxtaposed at the level of the participant's feet) on which he will have to press as quickly as possible when itappears necessary to brake. Thus, to accustom each participant to the braking system, four stimuli, in particular traffic lights are successively presented and each time they appear, the participant presses the brake pedal. A video sequence involving a braking situation is then presented.

2.3.2. Experimental Phase

The experimental phase begins with the attention test. The instructions are as follows:"You have in front of you a sheet of paper with four series of numbers on the back. At the given signal, you must turn this sheet over and cross out all the 3-digit numbers as quickly as possible. You have one minute to complete this exercise. Attention! Are you ready? Go ahead! ». Each participant has one minute to perform a maximum number of roadblocks. A correctly crossed out number is scored a point.

The simulated driving test begins with the presentation of a video sequence. Each video sequence lasts 50 seconds. The video sequences each include five consecutive simulated driving tests involving attentional events (following vehicles, moving lane, moving in opposite directions, crossing animals) and emergency braking situations. During each trip, the reactiometer records the driver's braking reaction time. And at the end of the video sequence, i.e. after the five tests, the software displays all the results as well as the average reaction time. The reaction time can be measured according to several parameters: the speed of the vehicle, the stimulus, the state of the driver ("drunk", "very tired", "tired", "normal", "alert"), the state of the road (dry, wet, snowy).

At the end of the driving test, the driver is again subjected to an attention test. Finally, an exchange is made on the driving situation he has just experienced. It should be pointed out that during the experiment, each participant carried out four experimental sessions (at the beginning and end of the half-day sessions). For this purpose, four video sequences each comprising 5 simulated driving tests were used. In order to control a possible order effect of these video sequences, which would mask the variations in efficiency, a counter-balancing plan was necessary.

3. Results

3.1. Analysis of Daily Attentional and Driving Performance Profiles

We want to correlate attentional performance profiles with driving performance profiles at different times of the day. These two profiles have been highlighted from the average scores obtained in the attention tests and the average reaction times to braking, at8am, 11am, 2pm and 5pm.

Correlation results are presented in Table 1. In general, the relationship between average attentional performance and average braking reaction times is negative. Moreover, the two variables are significantly correlated in the late morning (11am) and early afternoon (2pm). This indicates that there is a relationship between the two variables at these times: drivers brake quickly (low mean reaction times) when they are attentive (high attentional performance) and conversely, drivers are less quick to react to braking (high mean reaction times) when they are less attentive (low attentional performance) (Figure 1).

However, the results of the regression analysis show a weaker relationship at these indicated times (11:00 and 14:00), indicating that a change in attentional performance at these times does not actually predict a change in driving performance: late morning [adjusted R^2 =.04, $p < .05$]; early afternoon [adjusted R^2 = .05, $p < .02$].

Table1. *Correlation between attentional and driving performance profiles*

		Braking reactiontime			
		8h	11h	14h	17h
Attention Performance	8h	- 0.14			
	11h	- 0.19	- 0.22*		
	14h	- 0.06	- 0.21	- 0.26*	
	17h	- 0.14	- 0.34*	- 0.30*	- 0.21

* Significantly marked correlations at $p < .05$

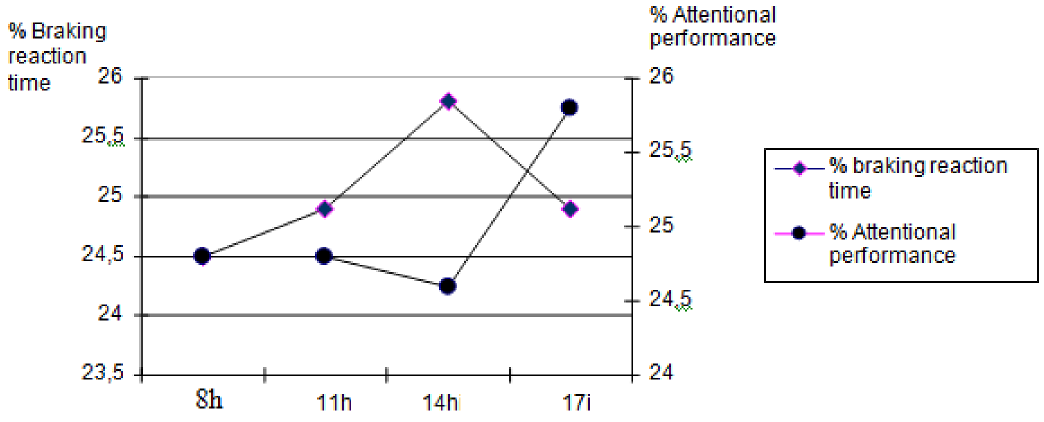

Figure1. *Variations inattentional performance and braking reaction time*

3.2. Analysis of Attentional Performance and Accident Profiles

For practical and methodological reasons (different participants in the study from accident victims, calendar variations in traffic patterns and composition, etc.), a correlational study could not be carried out. Consequently, for reasons of readability and comprehension, the daily profiles of accidents and attention performance are respectively established from the daily evolution of, on the one hand, the percentages of accidents and, on the other hand, the percentages of average scores obtained in the attention tests at the beginning of the morning (8 am) and afternoon (2 pm) and at the end of the morning (11 am) and afternoon (5 pm) (Table 2).

Table2. *Tends in average attentional performance scores and road accidents on January 1st 2013*

	8h-11h	11h -14h	14h -17h
% drivers victims of accidents $X^2(1)$	6.23 **	5.08*	12.5***
% attentionalperformance F(1,82)	0.01	0.10	6.99**

* p<.05 ; **p<.01 ; ***p<.001

Analysis of changes in attentional performance showed an increase in late afternoon performance (4) after stability from early morning (1) to early afternoon (2) [F (3.76) = 2.88, $p<.04$], while the accident rate increased gradually until late afternoon [$X^2(ddl=7) = 514.35$; $p<.001$] (Figure 2).

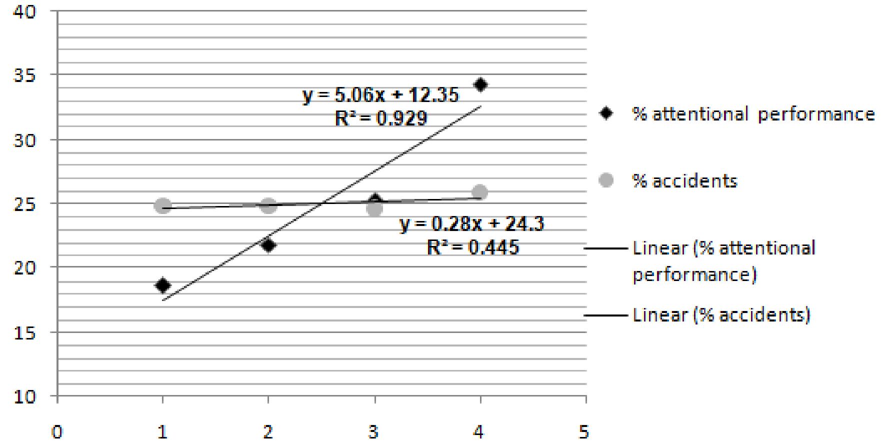

Figure2. *Trends in average scores for attentional performance and road accidents (in percentage)*

4. Discussion

The objective of this study was to study the correlates of attention capacity with, on the one hand, braking reaction times and, on the other hand, road accident rates.

With regard to driving performance indexed by braking reaction times, the hypothesis that here is a link between the profiles of attentional performance and driving performance is partially verified. According to the results of the statistical tests, late morning and early afternoon are the times when changes in attentional and driving performance are significantly related. Furthermore, this relationship is negative, indicating that periods of high attentional capacity correspond to periods when driving performance has a minimum value and, conversely, periods of peak driving performance coincide with times when drivers have poorer attentional performance. Specifically, in the late morning and early afternoon, drivers are willing to brake early (low average reaction times) when they are attentive (high attentional performance) and, conversely, drivers are less willing to react to braking (high average reaction times) when they are less attentive (low attentional performance). Our data thus confirm the experimental studies, carried out in particular on driving simulators or in real driving situations, showing a relationship between the decrease in alertness and motor behavior (voluntary action of the lower limbs on a command, in this case) (Grau et al., 2000; Haraldsson coll., 1990). Our results are also similar to accident logical studies (Horne and Reyner, 2001). Sauvignon (1995) who, based on the proportion of accidents caused by lack of vigilance, had found links between vigilance, driving safety and road accidents; times of occurrence were on average in the intervals from 1:00 p.m. to 4:00 p.m.

Although the results obtained seem to shed light on the previously highlighted results, namely the certain importance of attentional capacities in the driving task and their inextricable link with this activity, this link is however much more predictable at times when traffic is less intense: in the late morning and early afternoon. This seemingly weaker relationship is probably influenced by other environmental and vehicle variables. Thus, the weak linkage found at these times may reflect the fact that driving is a complex activity, which is not exclusively a matter of chronobiological and chronopsychological phenomena. Moreover, the statistical study of road accidents, which eloquently illustrates this complexity, shows a daily accident peak in the late afternoon, a time that corresponds to a period classically considered to be favorable for maintaining the level of alertness (Folkard, 1997).This weak correlation could, moreover, be explained by exogenous factors, notably the environment (the road and its surroundings, weather conditions, etc.) as well as the vehicle being driven (component wear, grip capacities, etc.).

Methodologically, it should be noted that the reaction test and the number barrage test are tests with "sensory and motor components". They are, as Gates (1916) pointed out, tests involving perceptual-motor tasks because they require speed and accuracy (reaction time, accuracy and speed of movement). This could undoubtedly explain the observed relationship between attentional performance and reaction time.

Furthermore, the evolution of road accident rates and of attentional capacity seem to indicate that the time of occurrence of accidents is in phase opposition to the attentional performance of drivers, so that it is tempting to say that these two profiles evolve in opposite directions. These results are fairly consistent with those of laboratory correlational studies (Philip et al., 2005; Orselli, 2003), although a correlational study could not be conducted for methodological reasons. These data are also consistent with those of Méité and Gaymard (2015), who were able to show statistically significant associations between daily patterns of attentional performance and crashes among bus drivers.

This close link between the evolution of road crashes and the evolution of attentionalcapacity is essentially linked to a driver's attention disorder (Lee &Strayer, 2004), i.e., driver inattention and distraction. While driving, the driver may be distracted or be inferred from other tasks (exogenous redirection of attention) or, immersed in his or her thoughts, be inattentive to the road scene (endogenous redirection of attention) (Posner, 1980). Thus, the higher the level of distraction, the less the driver will pay full attention to the road environment; since according to the Psychological Refractory Period (PRP) procedure, when two tasks are performed simultaneously, a deterioration in performance on one or both of the tasks is observed, due to sequential processing of information at the central level of the information processing system (Carrier & Pashler, 1992).

5. Conclusion

This study of the correlates of attentional capacities with braking reaction times and road accident rates, on the one hand, and the importance of attentional capacities in driving activity and road safety, on the other hand, is important. Since driving activity itself involves different forms of attention (sustained attention or vigilance, selective attention, divided attention), it remains to be determined which type of attention is most involved in the driving situation. Moreover, the relationship between accident frequency and attention deficit also highlights the significant proportion of accidents in Côte d'Ivoire due to a lack of attention: driver carelessness accounts for 24.44% of all vehicle accidents and is the cause of 1,487 accidents per year, resulting in 36 deaths (Ministry of Transport, 2013). Given this undeniable role of attention capacities, it is necessary to focus future research on the various terms related to the deficit of attentional control, including inattention and distraction. Thus, we could contribute to the organization of awareness campaigns on gestures and manipulations that divert attention and prevent concentration on the road.

In addition, the major interest of this study lies in the use of a non-interactive driving simulator (the computer reactiometer). If this software does not allow the driver, on the one hand, to control his speed and trajectory and, on the other hand, to reproduce the noise of the vehicle's engine, it offers the advantage, at the very least, of appreciating the ability to react to urgent and unforeseen situations. In this respect, with a view to future investigations, major methodological efforts seem necessary. It is quite possible to replace the simple treatments used here with other more advanced and effective treatments, particularly with regard to driving simulation: experimentation on a driving simulator could, in fact, offer the advantage of reproducing driving conditions as faithfully as possible.

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