Research Article   Open Access

Metacognitive Skills in Driving

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Abstract

Better knowing subjects' learning processes in driving entails knowing the strategies they adopt to acquire such learning. Sound metacognition knowledge as a fundamental learning strategy through the metacognitive skills (MS) that individuals use to drive allows us to further extend information on subjects' hard and complicated driving activity. Research was conducted with drivers (N=313) that measured their metacognitive skills, and their type and way of driving. The results showed significant differences between drivers who use more metacognitive skills and those who use them less frequently, despite both groups describing their type and way of driving as good and safe, which may not be true for those who employ fewer metacognitive skills. Finally, those drivers (N=82; 26.20%) who obtained a higher score for their way/type of driving, and who displayed sound MS, represented less than one third of the drivers in our study sample. To conclude, we found a profile for drivers who believe that their way of driving is suitable, and they classify their driving as good despite the differences found in use of MS (before, during and after driving). We conclude the need to implement training programs in metacognitive skills to improve driving.

Keywords: Metacognitive skills; Safe driving; Good driving

Introduction

Nobody doubts that driving a vehicle may be considered one of the highest risks taken in day-to-day life. Driving is defined as a complex task to control a mobile mechanism in a complex setting that constantly changes, and to perform subtasks at the same time, such as controlling direction or changing gears. From this driving conception, an approach is followed from a cognitive psychology perspective, which has been used to study driving according to different aspects (attention, perception, memory or motivation) [1,2].

From a cognitivism viewpoint, the limitations that a driver possesses to process information are considered due to human being's limited capacity. Several research works have taken into account how subjects have acquired knowledge in driving. Tudela (1992) employed driving to illustrate the differences between controlled processing and creating automatisms, by linking the differences between these two processes with the stages in which certain cognitive or motor learning is acquired [3]. The first learning stages are dominated by controlled processing, while automatic processes predominate this activity once we have well practiced a task. Hence driving has been defined by authors who work in the ergonomics field and in human factors as an automatic and self-regulated task [4,5].

Generally speaking, driving has long since been used as an example of automatic skill because it is a daily, repetitive and, quite often, a predictable, activity [4]. However, we should wonder if it is actually a completely automatic task. Throughout driving history, cognitive psychologists have considered driving, or the majority of driving, an automatic task. A series of studies have demonstrated that performing a second task lowers driving efficiency, so they doubt that this task can be done automatically [6].

Defining Metacognition and Driving

Metacognition is generally defined as knowledge about own thinking. For Flavell (1976), it refers to the knowledge one has about own processes and cognitive products, or to any matter related with them [7]. Metacognition is, among others, active supervision that regulates and organizes these processes in relation with the cognitive objectives on which they act with a specific goal or objective in mind. Such knowledge can be about the task, the subject him/herself or strategies. Crespo (2004) defines these three knowledge types:

Knowledge about tasks

It refers to the idea of an individual knowing what influence the nature of a task will have when it is undertaken. This may be related with the type of information that one finds, and that one has to deal with in any cognitive task. So it can be stated that memorizing a telephone number is much different from memorising a shopping list of 20 different items. This knowledge is related more specifically with the type of demands that a cognitive task requires. When faced with the same information in, for instance, a physics lesson, the subject knows it is much easier to remember the elements.

Driving is an active seeking process by which information is selected and transformed. This is a highly complex process as drivers must constantly select a whole series of stimuli, and of all kinds, during the journey, which will condition their behaviour.

As part of this conception, drivers are processors of information who adapt their behaviour to traffic circumstances at all times according to how they interpret the stimuli they perceive. Drivers constantly make decisions about their journey depending on how they interpret the situation and predict the future state of the controlling system. This decision is reflected in actions [1]. Driving implies regulating the driving procedure by paying attention and releasing resources when the task becomes automatic. When someone starts to

learn to drive, (s)he needs to pay attention to each and every component that forms part of this skill. With practice, arranging these components becomes more fluent and employing each component entails the driver paying less attention. So driving becomes more relaxed and comfortable.

Methodology

The main objective of the present research is to know some of the MS that drivers employ. To measure these skills, questionnaires on MS were devised for drivers.

The intention of the questionnaire was to verify the different kinds of MS that subjects employ when driving a vehicle. The questionnaire was divided into three clearly different parts. Regulating and controlling knowledge referred to the driver's active participation at three time points: before starting the driving activity (predicting, organizing, etc.), while driving (adjusting, revising, etc.) and after driving (evaluating, providing feedback, etc.).

Subjects had to answer a series of statements and which correspond to the principles of MS. Each item scored on a scale of 1 to 6, where 1 represented always and 6 Never. They were also asked about their type of driving, whether it was safe or risky, and about how they drive, good or bad, which was also done on a scale of 1 to 6.

Participants

The study sample contained 313 drivers who, according to the research purpose, studies their use of MS. Their ages ranged from 17 to 70 years, and their years of driving experience ranged from 2 to more than 50 years.

Drivers did tests voluntarily and were asked to comment on their ideas and to provide their opinions when they had completed the questionnaires. It is noteworthy that there was barely any sample loss as only 5% of the questionnaires were not completed.

Results

The results obtained about the various MS were analyzed, along with their relation with the type/way of driving stated by drivers. The differences in most items were significant (Table 1).

	X2	Safe drivers	Risky drivers
Before driving			
Knowing where to go	82.24	61.70%	21.10%
Plan a long journey before driving it	46.85	53.35%	28.90%
Control what others will do	67.72	56.70%	16.70%
Think about my physical state	48.12	51.70%	16.70%
Think about my psychic state	63.37	46.70%	11.10%
I mentally solve problems	39.92	41.70%	17.80%
Think about not making mistakes	68.94	61.70%	36.70%
While driving			

Think about how I am driving	49.80	43.30%	12.20%
Evaluate the situation in detail	42.95	50%	14.40%
I know and control distractions	66.24	55%	10%
Think about my decisions	29.75	50%	23.30%
Remember rules	44.95	58.30%	30%
Try to control impulses	61.52	41.70%	8.90%
After driving			
I go over any mistakes made	39.28	25%	25%
I remember how I drove	55.14	25%	25%
I evaluated situations in detail	38.81	18.30%	18.30%
I mentally solve problems	41.90	26.70%	26.70%
I plan future actions	36.82	33.30%	33.30%

Table 1: Differences between risky drivers and safe drivers in their use of MS.

The subjects who stated that they used MS were classified as very good or very safe drivers, as opposed to those who stated using MS less frequently while driving.

After performing the descriptive analyses of drivers in relation to the different MS, and their type/way of driving, individuals were classified into homogeneous groups according to these variables. This was done by a cluster analysis; this analysis belongs to a series of techniques run to classify individuals. In research, drivers are classified according to several variables, in this case, they were classified according to the MS they used when driving, and their type/way of driving. With the SPSS program, a cluster analysis was used to obtain clusters because it allows the optimum number of groups to be created according to the similarity in different variables. The K means cluster analysis was used given the large number of cases. This method allows choosing the number of clusters beforehand that we wish to form. We opted to create three groups. A first group was known as high skills as the use of MS while driving was high. A second group was called medium skills, and a third group was named low skills. When this first phase had been completed, we went on to define/classify the three clusters more accurately. To do this, the mean scores out of 6 were calculated (i.e., using the level of the item scores) for the 21 MS, and for the type and way of driving, for all three clusters by an analysis of variance (ANOVA), and considering belonging to the corresponding cluster to be the independent variable, and the 21 strategies and type/way of driving to be the dependent variable. Table 2 reflects the means of these skills and the comparison made with the sample mean.

	High MS	Medium MS	Low MS	Sample mean
I know where I must go	1.59	2.01	2.47	2.03
I plan a long journey before driving	1.37	2.09	3.47	2.29
I control what I will do	1.54	2.12	3.18	2.27

I think about my physical state	1.57	2.47	3.17	2.43
I think about my psychic state	1.67	2.87	3.71	2.8
I mentally solve problems	1.7	2.35	3.39	2.48
I think about not making mistakes	1.17	2.21	2.48	2.02
I think about not breaking rules	1.37	2.02	2.55	2
I think about how I drive	1.5	2.5	3.93	2.49
I think about similar situations	1.77	3.1	3.9	2.99
I assess the situation in detail	1.55	2.44	3.57	2.53
I know and control distractions	1.63	2.23	2.92	2.27
I think about my decisions	1.28	2.13	2.8	2.1
I remember the rules	1.34	2.05	2.81	2.08
I try to control impulses	1.54	2.42	3.26	2.43
I go over any mistakes made	2.17	3.36	4.76	3.45
I remember how I have driven	1.94	3.04	4.88	3.27
I assess situations in detail	2.09	3.54	4.7	3.49
I mentally solve problems	1.78	3.15	4.63	3.21
I go over others' mistakes	2.46	3.44	4.31	3.43
I plan future actions	1.91	3.08	4.25	3.11

Table 2: Means of the metacognitive skills (MS) for each cluster and for the general samples.

	High SM	Medium SM	Low SM	Mean sample
Type of driving	1.87	2.29	2.51	2.28
Way of driving	1.95	2.26	2.83	2.39
N (%)	82 (26.20%)	89 (28.43%)	142 (45.37%)	

Table 3: List of clusters with type of driving and way of driving.

After describing the internal configuration of each cluster and the clearer differences among them, it was considered worthwhile analyzing how the three groups behaved when they compared themselves to these variables: subjects' type of driving and way of driving. To make this comparison, an ANOVA was run by taking the cluster to which subjects belonged as the independent variable, and the

type and way of driving as the dependent variables. This variable scored as skills from 1 for safe or good drivers to 6 for more risky and not as good drivers (Table 3).

Although the mean use of SM was high (2.28 and 2.39) in relation to the type of driving and way of driving, we checked how subjects with high SM (N=82; 26.20%) obtained the highest scores for these variables (type of driving and way of driving, with 1.87 and 1.95, respectively). A second group (N=89; 28.43%) showed medium SM. Finally, those individuals in the low SM group (N=142; 45.37%), obtained lower indices for both variables (2.51 and 2.83), and were above the general mean use of SM. In any case, the scores from 1 to 6 for the three groups (1 meaning good driving) indicated that they considered themselves to be good drivers. It can be concluded that a driver profile was found, one who thinks that his/her type of driving is suitable, and who classifies his/her driving as good, despite the differences found in use of MS (before, during and after driving).

Discussion

As mentioned earlier, most cognitive psychologists conceive driving to be an automatic task type [9-15] because it is repetitive, habitual and predictable. However, driving is also considered a self-regulated conduct [9,11,16] as drivers regulate their performance. According to the results obtained in research works, most drivers use MS as they allow them to regulate their performance in the three driving phases: before, during and after.

To better understand these results, it is necessary to bear in mind that driving learning processes entail attentional states controlled by the subjects themselves until automatic processes are achieved [3]. As verified from the questionnaire about MS for drivers, most of the participants stated that they plan their driving before they start driving, consider their physical and psychic states, and control what they will do. All this allows them to face the task of driving with certain safety guarantees and, in turn, to automatically perform some behaviours and to self-regulate others. So this work is in line with the research related to the S-R-K model (Rasmussen, 1983), which has demonstrated that the many tasks involved in driving are not completely automatic because some conducts have to adapt to different traffic situations that the subject has to constantly perform [6,17].

Driving becomes automatic when, for example, we drive along a series of daily routes. However in such driving, we can make a series of mistakes or perform some actions sloppily. In order to correct these conducts, it is necessary to impose control over mental processes [1]. As the present research indicates where most drivers used a large number of MS to drive. In planning processes (before driving), the obtained results indicated a series of skills related with the driver's own actions [5]; that is, with routine tasks carried out to better cover a journey. Knowing where to go, planning a route, trying not to make mistakes, mentally solving mistakes, controlling what drivers will do, and respecting traffic rules are all skills that most of the drivers in our sample plan. So we found that subjects correctly plan their task and that they normally do many of these tasks, a matter that has been considered in other research works [18-21]. These are the MS of tasks and strategy, as defined by Flavell (1981). Thinking about one's physical and psychic state, which would be the person's tasks, are not such widely used skills used by drivers as the previous ones are.

When subjects are driving (while driving), regulation processes of cognition come into play [9,11,22,23]. These processes allow drivers to control tasks. The data obtained in the present research work

demonstrate how the control tasks that subjects perform of their own person-related self-regulation processes are those they use the most. Knowing and controlling distractions, thinking about their decisions and attempting to control their impulses are skills that allow them to better regulate their conduct [24,25].

The participants in the present study also used skills related with certain strategies, like remembering rules and evaluating situations in detail. With the post-driving skills (evaluation) used by subjects after driving, we generally highlight the actions taken, such as mentally solving problems and planning future actions; that is, strategy-related skills [26-28], which allow conducts to better adapt to reality.

Our research indicates a correlation between safe driving and using MS [29], and drivers generally use these skills to better control their driving performance.

These results demonstrate that those subjects who stated that they drive in a less risky way are those who use more MS. In turn, those who state that their driving is good or very good are those who state they use more skills.

So the type and way of driving seem to be related with use of MS. These results were explained by psychology some time ago to explain how human capacities are organised into three very different areas that correspond to the triple human nature: an individual's willingness, understanding and actions [30-32]. Behaviour while driving includes will, feelings, motivation, requirements, values, preferences and meta-directionality of actions. From a cognitive-conduct perspective, use of thoughts, strategies, judgements, decision making, and analytical aspects of people's actions, are included. Thus more thoughtful drivers are those whose driving is less impulsive and is, therefore, less risky. As the present research verified, such these subjects are, in turn, those who show more MS in the three driving phases.

Several studies have been done to collect the psychological characteristics of people who have committed driving offences [33,34] have analyzed different theoretical conceptions related with aggressive driving and stress; e.g., "poor social adjustment conduct". This theory sustains that people drive the way they live. Another relevant theory talks about not controlling one's impulses, which is related with the careless driving type. Evidently, there is the theory that refers to aggressiveness in general, where aggressive driving is another sign of such conduct. Finally, there is the frustration-aggression theory, in which aggressive conduct is triggered when several environmental factors interact with internal factors, like stress, physiological activation, thoughts learned, and disinhibition signs like anonymity and potential escape. As we can see, aggression is related with not regulating conduct and drivers rarely using thought strategies and skills. All these questions are reflected by the results of the present study. It is worth stressing that the drivers who use less MS while driving describe their type and way of driving as suitable, which does not quite reflect reality, and do not use learning strategies, MS in particular, more frequently.

Years of driving experience and drivers' age are related with users employing more MS. Subjects with driving experience; both in number of driving hours and miles driven, are drivers who use more self-regulation thinking processes while driving. The more experience subjects acquire, the more MS they employ, which means taking fewer risks and driving more safely. These data coincide with studies into personality traits open to experience and their relation with aggressive conducts while driving Dahlen et al. (2006)[35].

The young drivers in the present research, that is new drivers, indicated that their driving was riskier and less safe, which is related with them using fewer MS. This finding is in line with Tasca (2010) and Vassallo et al. (2008) [36,37], whose studies related aggressive driving with relatively young men drivers for a series of conditions; e.g., anonymity, sensation seeking or aggressiveness in social situations, being in an angry mood, believing they possess superior driving skills, and being in traffic congestion conditions. All these characteristics denote lack of control of mechanisms of thought regulation.

The subjects who use skills that help them take fewer risks while driving, like respecting rules as opposed to careless conduct, or who control their impulses, denote risk control thinking and, therefore, acquire knowledge that better matches reality. Another series of authors, based on risk homeostasis theories [38,39], explained drivers' safe behaviour and their thought control while driving. Striking a balance between the risks that one wishes to take and levels of safety while driving is conditioned by maintaining a constant subjective sensation about the risk in question. So driving will depend on the safety strategies that subjects adopt. Indeed those drivers who use more processes to control certain behaviours drive more safely.

In general terms, we see that when drivers define their driving as very good and safe, it is because they normally use many MS before, during and after driving. These results can help to improve driver training, especially for younger drivers who have still not acquired the necessary experience in this complicated task.

Acknowledgement

Author contributions

All the authors contributed to the conception and design of the work; organized sample collection and data preparation, and performed data collection, analysis and interpretation. All the authors critically reviewed its comprehensive content and finally approved the version to be submitted for publication.

The authors declare that they have no competing interests

References

1. Castro C, Durán M, Cantón D (2006) La conducción vista por los psicólogos cognitivos. Boletín de Psicología, 87: 35-60.

2. Sommer M, Herle M, Häusler J, Risser R, Schützhofer B, et al. (2008) Cognitive and personality determinants of fitness to drive. Transportation Research Part F 11 5: 362-375.

3. Tudela P (1992) Atención. En J Mayor & Pinillos JL (editors.), Tratado de Psicología General. 3: 119-162.

4. Anderson JR (1993) Rules of the Mind. Hillsdale. Erlbaum NJ (editor).

5. Brown AL (1981) Exposure and experience are a confounded nuisance in researchon driver behaviour. Ergonomics 14: 345-352.

6. Groeger JA (2000) Understanding driving. East Sussex: Psychology Press.

7. Flavell JH (1976) Metacognitive Aspects of Problem Solving. En Resnick LB (editor). The Nature of Intelligence. Hillsdale, N. Y.: Lawrence Erlbaum.

8. Crespo N (2004) La Metacognición: Las Diferentes Vertientes de una Teoría. En Revista Signos 33: 97-115.

9. Anderson JR (1995) Learning and memory: An integrated approach. New York: Wiley & Sons.

10. Baddeley AD (1990) Human Memory: Theory and practice. Welshpool, Wales: Lawrence Erlbaum Associates.

11. Brown I (1982) Exposure and experience are a confounded nuisance in research on driver behaviour. Ergonomics 14: 345-352.

12. Goleman G (1995) Emotional Intelligence. Nueva York: Bantam.

13. Michon JA (1985) A critical view of driver behavior models: what do we know, what should we do? En L. Evans y R. Schwing (Eds.), Human behavior and traffic safety. New York: Plenum Press.

14. Schmidt RA (1982) Motor control and learning: A behavioural emphasis. Champaign, IL: Human Kinetics Publishers.

15. Welford AT (1986) Note on the effects of practice on reaction times. Journal of Motor Behaviour 18: 343-345.

16. Shiffrin RM, Schneider W (1977) Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. Psychological Review 84: 127-190.

17. Pastor M, Monteagudo J, Pollock D (1999) Conceptualización y análisis psicológico del error humano en la conducción de vehículos a partir de los desarrollos recientes del modelo de habilidades, reglas y conocimiento. Anuario de Psicología 30: 39-64.

18. Brown AL (1987) Metacognition, executive control, self-regulation and other mysterious mechanisms. Hillsdale: Erlbaum.

19. Nelson TO, Narens L (1994) The Role of Metacognition in Problem Solving. In Metcalfe & Shiminura (Eds.), Metacognition (207-226). Cambridge: MIT Pres.

20. Nickerson R (1988): On Improving Thinking through Instruction. In E. Z. Rothkopf (Ed.). Review of Research in Education, 15 (3-58), Washington, DC: American Educational Research Association.

21. Wellman H (1985) The origins of metacognition. In Forrest-Pressley DL, MacKinnon GE, Waller TG (editors.). Metacognition, Cognition and Human Performance (1-31). Orlando, FL: Academic Press.

22. Schraw G (1998) Promoting general metacognitive awareness. Instructional science 26: 113-125.

23. Schraw G, Moshman D (1995) Metacognitive theories. Educational Psychology Review 7: 351-371.

24. Liang Y, Lee JD, Reyes ML (2007) Nonintrusive Detection of Driver Cognitive Distraction in Real Time Using Bayesian Networks. Transportation Research Record: Journal of the Transportation Research Board. Transportation Research Board 2018: 1-8.

25. Zuckerman M, Kuhlman DM (2000) Personality and risk-taking: Common biosocial factors, Journal of Personality 68: 999-1029.

26. Flavell JH (1987) Speculations about the nature and development of metacognition. Hillside, N. J.: Lawrence Erlbaum.

27. Mayor J, Suengas A, y González-Marqués JG (1995) Estrategias metacognitivas. Aprender a aprender y aprender a pensar. Madrid: Síntesis.

28. Nisbet JP, Shucksmith J (1987) Estrategias de Aprendizaje, Madrid: Santillana.

29. Devlin A, McGillivray J, Charlton J, Lowndes G, Etienne V (2012) Investigating driving behaviour of older drivers with mild cognitive impairment using a portable driving simulator. Accident Analysis & Prevention 49: 300-307.

30. Bloom B, Englehart M, Furst E, Hill W, Krathwohl D (1956) Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain.

31. Geller ES, Ludwig TD (1990) A Behavior Change Taxonomy for Improving Road Safety. In Proceedings of the OECD International Road Safety Symposium, Copenhagen, Denmark.

32. Krathwohl DR, Bloom BS, Masia BB (1964) Taxonomy of Educational Objectives: Handbook 2: The Affective Domain. London: Longmans, Green and Co Ltd.

33. Herraiz F, Chamarro A, Villamarín F (2011) Psychosocial Predictors of Traffic Crimes: A Study with Inmates in a Penitentiary Centre. Clínica y Salud 22: 87-100.

34. Galovski TE, Malta LS, Blanchard EB (2006) Theories of Aggressive Driving. Road rage: Assessment and treatment of the angry, aggressive driver [Internet]. American Psychological Association 27-44.

35. Dahlen E, White R (2006) The Big Five factors, sensation seeking, and driving anger in the prediction of unsafe driving. Personality and Individual Differences 41: 903-915.

36. Tasca L (2000) A review of the literature on aggressive driving research. Recuperado el 8 de enero de 2011, de: http://www.aggressive.drivers.com/papers/tasca/tasca.pdf

37. Vassallo S, Smart D, Sanson A, Cockfield S, Harris A, et al. (2008) Risky driving among young Australian drivers II: Co-occurrence with other problem behaviours. Accident Analysis and Prevention 40: 376-386.

38. Summala H (1988) Risk control is not risk adjustment: the zero-risk theory of driver behavior and its implications. Ergonomics 31: 491-506.

39. Wilde G (1994) Risk homeostasis theory and its promise for improved safety. Styx Publications.