Cognitive Load Impairs Experienced Drivers' Judgments on Self-Reported Driving Superiority

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ABSTRACT

It seems reasonable that sooner or later, constantly overestimating one's driving skills may promote inappropriate driving and misjudgments of critical situations. However, it is very common for drivers to succumb to a self-perception bias by evaluating their own driving skills to be superior than the average [2]. A web-based between-subjects experiment was conducted to analyze drivers' inability toward accurate self-assessments. Using Cognitive Load Theory (CLT), we assessed whether this bias is further amplified when conscious deliberation is unavailable. First, the results clearly replicated the bias. Second, there was no difference between drivers' self-assessments under load and without load, although it is suggested that automatic processing promotes self-assessments which are even more favorable. Third, there was a significant effect of load on how experienced drivers perceived their superiority judgments. Those under load thought they rated their own abilities less superior to the average driver, while in fact their ratings were in line with the overall bias. This holds only for those driving at least the average traveling distance in Germany of approximately 1000 kilometres per month.

Categories and Subject Descriptors

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Keywords

Cognitive load, Driving skills, Self-evaluation, Web-based experiment

1. INTRODUCTION

Cognitive load plays an important role during vehicle control, there are numerous experiments highlighting this relationship. In a broader sense, the implications of CLT on human behavior can be applied to hypothesize about load effects on driving that currently lie beyond driving research interests. Those potential load effects might just as well be studied in a controlled driving environment. On top of load effects on driving as depicted by experimental driving research (e.g. [3], [7]), there is a large amount of unexplored findings, especially in the social psychology and cognitive science literature. Many of those findings show that CLT can be applied to driving beyond dual-task driving scenarios in order to paint a more thorough picture of how cognitive load not only directly affects driving performance, but also modulates related processes such as self-perception, prospective memory, and stereotypes. As a research paradigm, CLT can be a useful source of how cognitive processes that people seamlessly rely on are affected when their minds are busy. Interestingly, some of these processes are connected to driving. This is because driving involves an interplay of many bodily, cognitive, and social processes (e.g. motor control, experiencing distress, attention allocation between in-vehicle elements and objects outside the vehicle, multi-tasking, interacting with passengers and other drivers, empathy, performing hostile and aggressive driving). Other than driving, there are probably only few highly widespread types of human-machine interaction covering this many elements relevant for research. In this paper, we focused on how drivers assess their own driving skills under load. We present results of a web-based experiment and discuss the role of driving experience for this self-evaluation.

2. RELATED WORK

Put in general words, the benefits of CLT are based on the effects arising from a state of scant cognitive resources. In this state, conscious effortful thinking cannot be maintained. There are manifold consequences of cognitive load on different types of information processing. For example, under load, people are more likely to apply previously activated stereotypes [4] and to forget actions they have planned in the past because prospective memory is depleted [8]. Cognitive load furthermore modulates the sense of agency, that is, an individual's ability to identify effects caused by the self. Under load, this usually basic process of connecting a self-initiated cause and the related effect is inhibited [5]. Finally, people evaluate themselves more positively under load because in contrast to the complex process of self-verification (does the stimulus confirm my self-opinion?), self-enhancement (does the stimulus put me in a favorable light?) is performed automatically [12]. Swann et al. [12] argue that when resources are depleted, certain representations of self cannot be accessed from memory and compared with self-relevant stimuli. Furthermore, the positive automatic self is highly practiced, for example through repeti-

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tion over the whole lifetime [10]. To what extent are these phenomena possibly linked to behaviors which directly or indirectly affect driving related processes? In other words, why does cognitive load as a concept warrant more attention within the driving research domain?

Driving and Stereotypes. It is safe to say that for as long as vehicles will be controlled by humans, driver aggression will be an issue for road safety. Hostile and dangerous behaviors like honking and running red lights need to be explained by various reasons, such as personality, culture, context, and so forth [11]. Interestingly, some determinants of driver aggression can be linked to cognitive load. In the 1970s, hostile behaviors against female drivers were recognized to follow from a specific stereotype against them [1]. Drivers applying this stereotype, that is, letting their judgment and behavior be influenced by it, will honk at female drivers more often [1]. The overall tendency, then, to apply this or any other stereotype making assumptions about the driving performance of a specific group of people (e.g. elderly or novice drivers) is facilitated by cognitive load [4]. However, the stereotype must have been activated first. In fact, the effect of cognitive load on the imminent role of stereotypes is two-sided, as Gilbert and Hixon aptly explain [4], because on the one hand, load facilitates the application of a stereotype in terms of stereotype-conforming responses; on the other hand, though, load decreases the preceding activation of this stereotype. Generally, stereotype activation can be regarded as "finding a tool in the cognitive toolbox" whereas application can be thought of as "using the tool once it has been found" [p. 512]. Thus, performing under load increases the likelihood that a driver does not see a female driver in traffic and instead, just a driver.

Driving and Prospective Memory. Completing intended actions in the future is guaranteed by prospective memory. A depleted prospective memory causes the forgetting of important actions, for example taking the right freeway exit. Marsh and Hicks [8] found that attention-demanding tasks play a key role. More specifically, inhibition was a function of simultaneous planning and careful performance monitoring. When the executive functions in charge of switching attention between planning and monitoring were heavily loaded, prospective memory performance decreased. The same decrement occurred when a demanding visuospatial task was involved. Accordingly, prospective memory decrements are to be expected when driving is no longer part of the set of routine behaviors because of environmental constraints, and when a planning task must be maintained simultaneously, for example wayfinding. Furthermore, the involvement of critical visuospatial tasks such as parking also increase the likelihood of forgetting to remember.

Driving and Agency. Being a good driver obviously requires good driving performance. Knowing to be a good driver requires the right perspective on events that occur during driving, for example whether dangerous situations were caused by the driver or not. Accordingly, people can only conclude they are (not) particularly good at driving if their sense of agency is not disturbed. Under load, there are not enough resources for accurately comparing the predicted effect with the actually occurring effect, because mental model construction for the prediction fails [5]. If the sense of agency is impaired as is the case under load, drivers are more likely to take credit on the road for outcomes that, in fact, were due to other drivers' actions or mere luck. Conversely, they might attribute critical situations they can be held responsible for to external sources, effectively neglecting their own responsibility.

Self-Evaluation of Driving Skills. Last but not least, relying on biased overly positive attitudes regarding one's driving skills may increase the likelihood of inappropriate driving. It is this aspect, the way how drivers usually assess their own abilities, that we focus on. The perceived superiority is strong, it holds for a wide range of driving skills, and it comes closer to a "positive-self" than a "negative-other" bias [9]. While it is still unanswered whether drivers' self-perceptions have an actual effect on relevant outcome variables like risk-taking and road safety ([2]), this may be easier to unveil if we can explore whether automatic processing modulates the perceived self-superiority. We expect an amplification effect because automatic processing predicts the need for self-enhancement in terms of choosing favorable evaluators and feedback [12]. Moreover, unconscious self-reflection, also called implicit self-esteem, is generally positive and corresponds to explicit self-evaluations, but only under time pressure or reduced cognitive resources [6].

Taken as a whole, load effects on these different aspects indicate how load may affect driving in terms of how drivers respond to external stimuli, how they process information, and how information is stored or accessed. Of course, this holds for other forms of human-machine interaction as well, but driving We thus hypothesize that when drivers are put under load and deliberate processing cannot be maintained, self-evaluations will be more favorable than in the absence of load.

3. METHOD

We conducted a web-based experiment in which we asked subjects to evaluate their own driving skills as well as their opinion on the average driver's skills on various dimensions. Half of them answered the questions while being deprived of cognitive resources (load condition); the other half answered the same questions under normal conditions (no-load condition).

The experiment consisted of four short blocks. (A) First, subjects were asked to enter their average driving distance per month in kilometres. (B) They then were required to rate themselves and (C) the average driver along 18 driving tasks, taken from McKenna et al. [9] and translated into German.[1] (D) Last, they were asked to indicate to what extent they thought they rated themselves worse or better than the average driver in the previous step and, in their eyes, how positive other people rate themselves compared

[1]The tasks were: Driving at appropriate speed for conditions, Paying attention to road signs, Changing driving to suit wet/icy/foggy conditions, Judging stopping distances for appropriate speeds and conditions, Attention to and awareness of other vehicles, Judging correct speed for bends/corners, Leaving motorways, Hill starts, Driving in busy town traffic, Changing lanes on motorways, Moving onto motorways, Parking, Judging the width of vehicles, Three point turns, Overtaking, and Changing traffic lanes.

to the average. All ratings were done using 7-point Likert scales.

The manipulation required subjects in the load condition to rehearse an 8-digit number while answering the questions. They were given 60 seconds for learning. This rather basic manipulation was successfully used in previous experiments to induce cognitive load (e.g. [4] [12]). After subjects were finished with the questionnaires, load condition subjects were asked to enter the number they had been rehearsing.

One hundred and seven subjects with a driver's license for automobiles participated in the experiment. We excluded those with a self-reported average driving distance of 0 kilometres per month from the dataset. We furthermore excluded one subject who indicated that he was substantially distracted during the experiment. We also excluded those with more than three errors in the rehearsing task. Thus, a total of 95 subjects remained in the dataset (32 females, 63 males). 45 were in the load condition, 50 in the no-load condition. Mean age of the sample was 29.56 years (SD = 7.38). On average, subjects drove 740.15 km per month (SD = 1459.12).

4. RESULTS

Paired-samples t-tests comparing self-evaluations and evaluations of the average driver once more replicated the fact that drivers perceive almost each and every aspect of their driving abilities as superior. Of the 18 items, only 2 ('Reversing' and 'Navigating and driving in unfamiliar area') did not yield significant differences. With respect to the 16 other items, subjects thought they generally perform these tasks better than the average. For one of those items, $p < .05$, otherwise $.001 < p < .01$.[2]

Independent-samples t-tests comparing self-evaluations of load and no-load subjects did not yield any significant results, $.15 < p < .98$ for all 18 items. Thus the hypothesis stating depleted cognitive resources would lead to a stronger self-reported superiority was not supported. A closer look at the data in the no-load condition which, according to our hypothesis, had to be surpassed in the load condition, reveals that for 15 items, the means were considerably large, $5.00 < M < 6.26$ ($.83 < SD < 1.48$). Next, we looked at how accurate subjects under load reflected their ratings and whether they assumed self-reported superiority for other drivers as well. For both aspects we found no differences, $.38 < p < .39$.

In the last step we focused on those with a quantitative driving experience at average level or higher. We therefore excluded all subjects with a monthly average driving distance below the average value recently found in the German Mobility Panel: 1055 km/month.[3] Nine subjects remained in the load condition, 10 in the no-load condition. The average driving distance in this sub-sample was 2336.84 km/month (SD = 2707.49). The mean age grew slightly higher compared to the total sample (M = 33.53, SD = 6.11). There were 2 females and 17 males.

Again, there were no significant differences between both conditions, $.05 < p < .95$ for all 18 items. However, subjects under load (M = 5.22, SD = .97) now thought their previous self-evaluations were less above average compared to subjects withoud load (M = 6.30, SD = .68), $t(17) = 2.83$, $p < .05$, although in fact, there was no difference for superiority between both conditions since the hypothesis was not supported.

5. DISCUSSION

We attempted to show that drivers deprived of cognitive resources would in an offline situation exaggerate their favorable self-evaluations because automatic self-evaluations are generally more positive. Upon success, it would have been interesting to analyze which forms of load (working memory, perceptual, communicative) affect the current, not overall self-evaluation in an online situation. We chose an offline setting because our concern was to explore the potential of two inter-related aspects for driving research: A feasible methodology using a basic, low-effort load manipulation, and the diverse responses under depleted cognitive resources. However, with respect to automatic versus controlled self-evaluations, there was not much left to disentangle. Even when drivers had sufficient resources to correct overly positive self-evaluations along the presented tasks, the self-evaluations were still very positive. There was simply no more potential for an increase in the load condition.

Instead, we found that in this offline situation, some drivers under load were less aware of how superior they actually evaluated their own abilities. Although load did not affect actual evaluations, it had an effect on meta-evaluations for those driving as much as or more than the average German driver. While this result should be explored further with a larger sample, it indicates how cognitive load modulates the assessment of driving skills if driving is performed with certain experience. Acquiring experience in an activity means to perform it more automatic and mindless. It becomes an activity that requires abilities one does no longer cast doubt on. Experienced drivers may lose practice in effortfully reconsidering their self-image, especially when they rarely encounter critical situations. Under load, they are deprived of the possibility to accurately reflect upon their evaluations. It becomes too effortful to align their evaluations to reality. For less experienced drivers, this effort may be smaller. More data is needed to support this possible explanation. Furthermore, future studies need to clarify whether the difference in meta-evaluations for experienced drivers under load versus not under load are caused by idiosyncrasies of driving, or whether there is a general underlying tendency not particularly related to driving. This can be accomplished by a comparison with self-evaluations of other skills.

The result suggests there may be a large amount of drivers which, in certain situations, become less aware of the fact that they are likely to overestimate their own abilities. Even if we assume this erroneous meta-evaluation has no effect

[2]Since this finding is not very surprising and detailed information is not of value here, the specific dimensions will not be mentioned.

[3]The panel is produced on order of The German Federal Ministry of Transport, Building and Urban Development. The document for the 2011/2012 version can be found at this location: http://mobilitaetspanel.ifv.uni-karlsruhe.de/de/downloads/mop-berichte/index.html (German version only)

on actual driving because the exaggerated self-evaluations also might not, it would be hard to ignore how experienced drivers could sometimes fail to realize their self-view as being highly biased. Generally, succumbing to biased thinking rarely is a desirable state of mind. This is, for instance, the reason why it would be important to overcome stereotypes against drivers belonging to a specific social category.

6. LIMITATIONS

It is important to note the limitations inherent to a web-based experiment on cognitive load. First, even in a laboratory study it is sometimes hard to verify whether subjects in the load cognition were in fact under load and those in the control condition were not [4]. This holds all the more for the approach presented here. Second, web-based experiments are not set within a controlled environment. Although the instructions being provided stressed the need for full concentration, subject distraction may still have occurred. We tried to address this issue by excluding all subjects which indicated they were substantially distracted during the procedure. Of course, being slightly or substantially distracted is rather subjective. In fact, subjects in the load condition are expected to have been distracted to a minimum degree or not at all because otherwise, they were most likely excluded after failing to rehearse the 8-digit number. Last, it is possible that subjects cheated and wrote down the number instead of rehearsing it mentally. However, as an indicator of validity of the present study, drivers' self-perceived superiority was replicated and emerged on a multitude of dimensions.

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