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Debiasing overoptimistic beliefs about braking capacity

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ABSTRACT

We investigated, using questionnaires, different strategies for removing drivers' overoptimism (Svenson et al., 2012a) about how fast their speed could be decreased when they were speeding compared with braking at the speed limit speed. Three different learning groups and a control group made collision speed judgments. The first learning group had the distance a car travels during a driver's reaction time for each problem. The second group had this information and also feedback after each judgment (correct speed). The third group judged collision speed but also braking distance and received correct facts after each problem. The control group had no information at all about reaction time and the distance traveled during that time. The results suggested the following rank order from poor to improved performance: control, group 1, group 3 and group 2 indicating that information about distance driven during a driver's reaction time improved collision speed judgments and that adding stopping distance information did not add to this improvement.

1. Introduction

An increased speed prolongs the stopping distance and leads to an elevated accident risk because it takes longer to reduce speed and reach a complete stop compared to a lower speed (Aarts and van Schagen, 2006; Cameron and Elvik, 2010; Nilsson, 2004). The risk of a fatal accident and personal injury increases if the speed at the time of collision is greater and it also results in greater physical damage (Nilsson, 2004; Cameron and Elvik, 2010).

Recent questionnaire studies have shown that drivers have difficulties in judging how fast a car can be stopped from different driving speeds if an unexpected event occurs, for example, an obstacle appearing in the road. When comparing braking from two different speeds, Svenson and colleagues (Svenson, 2009; Svenson et al., 2012a) found that drivers overestimated how fast they could bring down the speed from a higher speed compared with braking from a slower speed. To exemplify, drivers in Europe were given scenarios of the following kind. "*Imagine that you had driven a car outside a school at the speed limit speed of 30 kph (18.6 mph) when a child suddenly had rushed into the street. From this speed it was possible to stop the car just in front of the child after braking as quickly and forcefully as possible. Then, imagine that you were speeding and drove the same street at a higher speed of 50 kph (31.1 mph) and the child appeared at the same place as before. At what speed would the car hit the child after braking in the same way as before?*"

The judgments of the speed when hitting the child were systematically too low meaning that the drivers overestimated their braking capacity when they were speeding for all combinations of speed limits and speeding. This misconception was stronger for slower speeds as in the example above, which is particularly relevant for speeding in low speed limit driving contexts like roads adjacent to schools and for enforcement of speed limits (Elvik, 2010).

The speed when the child would be hit when braking at 50 kph in the above example is 50 kph (no retardation because of the reaction time of the driver–car system of 1 s, which is a very quick reaction for an unexpected event). An average driver who is aware of this, for many a counterintuitive fact, will have a different attitude to speeding in 30 kph speed limit areas than a driver who maintains the erroneous belief that the car can be slowed down much quicker than physically possible. Perceptual speed adaptation (Schmidt and Tiffin, 1969), the low frequency of such emergency situations and feelings of control are some of the possible factors that may prevent drivers from learning about their braking ability when unexpected obstacles appear in the road. In the following, we will call judgments of the speed at the point of collision with a suddenly appearing obstacle when speeding, described in scenarios like the above, *collision speed judgments*.

Misrepresentations of the laws of physics concerning driving lead to biased judgments and decisions (Svenson, 2009) and these biases are important for attitudes toward speed limits, preferred

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driving speeds and safe driving speeds among drivers, policy makers, politicians, lobbyists and citizens in general. The relationship between attitudes and behavior is well known and has been studied extensively (Eagly and Chaiken, 1993). Hence, when a driver is on the road attitudes toward speeds, braking, risks and speeding are important for how the car is driven and biases of this kind have been found when driving by Eriksson et al. (2012). For example, biased beliefs about how speeding affects braking capacity compared with driving at the speed limit may bolster a positive attitude toward speeding and, when possible, driving at higher speeds than the speed limit. Drivers self-reports of driving speed in questionnaires correlate with observed driving behavior and "indicate that self-reports of certain aspects of driver behavior can be used as surrogates for observational measures, thus providing a convenient extension to the researcher's methodological armory. One such aspect is speed which appears to play an important role in accident involvement" (West et al., 1993 p. 557).

The present study investigated different strategies for removing or modifying drivers' misconceptions about driving and braking. This was done to find out if and to what extent different teaching strategies could improve drivers' understanding of the relationship between speed and braking. There are different suggestions about how to improve judgments of a car's stopping capacity at different speeds and a search on the web gives several examples. Typically, the information provided refers to *stopping distances* from different speeds, exemplified by the University of Minnesota Traffic Safety Curriculum Unit (2012). Further, googling on "car braking speed" does not give retardation curves while braking but a multitude of references to braking distances from different speeds. But, if the stopping distance from a given speed is insufficient and an object or a person appears in the way a collision will follow. Then, it is the *collision speed* which is the most important parameter for the occurrence and severity of an accident. The present authors are not aware of any widespread information to the public about collision speeds when speed is too high and braking insufficient. But, to the best of the authors' knowledge, driver education in Sweden does not mention this as a specific problem with speeding and therefore Carlsson's computations and Svenson and colleagues have focused on this issue (Carlsson, 2004; Svenson, 2009; Svenson et al., 2012a).

From physics we know that stopping distance depends on a linear component related to speed (during the driver's reaction time before she or he hits the brake) and a component that is depending on braking force, friction, and the speed squared (e.g., Carlsson, 2004). The formula for calculating the speed from the time of a stopping signal until a standstill of a car is the following where t_0 is the driver's reaction time and V stands for velocity at a given moment in time t, after the driver encounters a stop signal.

$$V = V_0 \qquad \text{for} \quad t < t_0 \tag{1}$$

$$V = (V_0^2 - 2g\mu(D - V_0 t_0))^{0.5} \qquad \text{for} \quad t \geq t_0 \tag{2}$$

The driver gets the signal to stop, at speed V_0. The second part $V = (V_0^2 - 2g\mu(D - V_0 t_0))^{0.5}$ describes the speed at distance D from the point where the driver first got a signal to stop, g is gravity and μ the friction between tires and the road surface. Eq. (2) is valid for a road without any shifts in elevation. A friction coefficient of $\mu = 0.8$ for hard braking on a dry asphalt surface describes good braking conditions and it is reasonable to assume a driver braking reaction time of at least $t_0 = 1.0$ s in this applied context with an unexpected object suddenly appearing.

To solve the problem in the example with a successful stop from 30 kph and a collision from 50 kph it is first necessary to determine the stopping distance, D_L for braking from the lower speed, V_{0L}. Developing Eq. (2) gives

$$D_L = t_0 V_{0L} + \frac{V_{0L}^2}{2g\mu} \tag{3}$$

If $(D_L - V_0 t_0) \leq 0$ or in words, if the lower speed stopping distance is shorter than the distance covered at the higher speed V_0, during a driver's reaction time, t_0 then the collision speed will be the same as the higher speed.

From a cognitive perspective the functions in Eqs. (1) and (2) are complex and difficult to estimate. Still, most people do not hesitate to give a more or less rough estimate when asked. Biased judgments call for debiasing and a number of researchers have addressed this issue and we will continue in this direction and investigate different ways of improving collision speed judgments. Fischhoff (2002) listed different reasons for biases in categories of tasks, judges and mismatch between task and judge and suggested a number of debiasing strategies. In the present contribution, the participants were well informed about the tasks. We assumed that the systematic errors made by people when they judge collision speeds are not a result of not understanding the situation or what to judge. In his review of studies on how to improve biased judgments, Larrick (2004) emphasized reinforcement of prescriptive strategies that individuals themselves can adopt. In the case of biased collision speeds, the errors are likely to depend on difficulties of adapting adequate judgment strategies to the task and the lack of feedback. There are different ways of improving judgments of this kind.

An associative way of learning is based on response feedback and includes association based processes that link problems with responses (Estes, 1959). This kind of learning may activate relationships and judgment rules that may not be open to introspection to the judges themselves. Strategy based learning tends to be more conscious to the learner than associative learning. If the normative rules linking problems to their solutions are too complex to follow for unaided cognitive strategies, approximated rules of thumb can be learned in strategy based learning. In the present study we investigated associative learning (collision speed response feedback) and learning the same problem with additional information that may enable more strategic heuristic solutions. It is evident from the above that the prevalent strategy to instruct drivers about speed and braking is via stopping distances. Therefore, we will add information about stopping distances when we attempt to teach drivers about collision speeds at impact if a driver drives too fast and an obstacle suddenly appears.

A strategic approach to learning can be illustrated by a problem like the one given in the introduction with driving at a low speed of 20 mph and at a high speed of 40 mph. The stopping distance from 20 mph is 46 feet including a "thinking" reaction time distance of 26 feet. The stopping distance from 40 mph is 126 feet. This is the kind of information one finds in most traffic safety contexts and it illustrates the strategy development approach to learning about speed and braking. This is also the information needed to solve this kind of problems in a normatively correct way. A corresponding associative based approach was induced by giving the participants the correct stopping distances and collision speeds after each problem and judgment.

As mentioned above, the applied relevance of the present research concerns speed limits and attitudes toward exceeding speed limits, in particular in areas where there are pedestrians and other unprotected road users. When drivers, the public and politicians form their norms and opinions about driving, speed limits and traffic planning, they typically base their initial and often final views on attitudes and implicit or explicit judgments of travel time and risks at different speeds etc. In some cases, the initial unaided judgments are later revised by formal calculations and facts, but often preliminary judgments prevail as foundations