Debiasing time saving judgements by manipulation of speed display

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Abstract

The time saving bias predicts that when increasing speeding from a high speed (e.g. 100 kph) the time saved is overestimated and underestimated when increasing speed from a slow speed (e.g. 30 kph). An alternative meter indicating the inverted speed (min/km) was used to debias time saving judgements in an active driving task. The simulated driving task was to first drive a distance at a given speed and then drive the same distance again at the speed the driver judged was required in order to gain exactly three minutes in travel time compared to the first drive. A control group performed the same task with a speedometer and saved less than the targeted three minutes when increasing speed from a high speed and more than three minutes when increasing from a low speed, as predicted by the time saving bias. Participants in the alternative meter group were closer to the target. The study shows that biased intuitive judgements can be affected by changing information format.

Introduction

Drivers often need to arrive at their destination at a specific time. If a delay occurs due to unforeseen circumstances such as a traffic jam, the driver needs to make judgements of how fast he or she has to drive in order to arrive on time. Previous research has shown a time saving bias in judgements of time saved when increasing speed ((Eriksson, Svenson & Eriksson, 2013; Fuller et al., 2009; Peer, 2010a,b, 2011; Peer & Rosenbloom, 2013; Peer & Gamliel, 2012, 2013; Peer & Solomon, 2012; Svenson, 1970, 1973, 2008, 2009). The time saving bias implies that the time saved when increasing speed from an already high speed is overestimated. Contrarily, the time saved by a speed increase from a low speed is underestimated.

The actual time saved can be obtained by the following formula:

\[
\text{Time gain} = cD \left( \frac{1}{v_1} - \frac{1}{v_2} \right)
\]

(1)

c is a constant used for conversion of the units of the distance measure, D is the distance travelled, v₁ is the original speed and v₂ the higher speed. According to the formula, an increase from a lower speed has a greater impact on the time saved than the same increase from a higher speed. Svenson (1970) investigated intuitive
judgments of the difference in travel time between two speeds, a high and a low speed, over the same distance. The study corroborated a time saving bias and the time saving judgements could be described with the following formula:

\[
\text{Time gain} = cD^e \frac{(v_2 - v_1)}{v_2}
\]  \hspace{1cm} (2)

in which \(c\) and \(e\) are constants describing the perceived distance as a function of the objective distance \(D\); \(v_1\) is the original speed and \(v_2\) the higher speed. A possible interpretation is that participants arrive at their time saving judgements by estimating the speed increase as a ratio or percentage of the faster speed which is a simplification of the physical curvilinear relationship between speed and time. An alternative description of the heuristic has been given by Peer and Gamliel (2012) who found that replacing \(v_2\) in the denominator with \(v_1\) provided a better fit to their data.

The miles per gallon (MGP) illusion is a bias that resembles the time saving bias. In a study by Larrick and Soll (2008), participants made judgements about the fuel consumption of different cars in the U.S. In the U.S., fuel efficiency is measured in miles per gallon, instead of litres per kilometres. The relationship between the amount of fuel consumed and a car’s fuel efficiency, when expressed in miles per gallon, is curvilinear. Larrick and Soll (2008) found that participants judged the relationship as linear and therefore made inaccurate judgements of fuel consumed over a given distance when comparing two cars. They also found that judgements were more accurate when the information about fuel efficiency was formulated in terms of amount of gas consumed per given distance.

Peer and Gamliel (2013) conducted a questionnaire study to investigate if the time saving judgements would be more accurate if information about the inverted speed (pace) was given, similarly to the MGP illusion example. In their study, participants were given information about the inverted speed (pace) in minutes per 10 miles and speed in miles per hour. The study showed that judgements were more accurate when pace data were presented alongside the speed. In their study, participants were presented to the information and the problems in an online survey when they were not driving.

In the present study, we wanted to investigate if time saving judgements can be debiased in an active driving task by using a technique external to the decision maker, such as an information display proposed by Larrick (2004). In this study, we use a pace display informing participants instantaneously of the inverted speed in minutes per kilometre. The present study differs from the online survey by Peer and Gamliel (2013) in that in their study participants were given speed information as well as pace data, but in the present contribution participants had to solely rely on pace information so that any effects can be attributed to the pace information alone.

In the present contribution, we tested the hypothesis that the drivers’ speed judgements would be debiased by presenting a pace meter indicating the inverted speed.
Method

Participants

There were twelve participants in the study. They were recruited from the participant pool of the Swedish National Road and Transport Research Institute in Linköping, Sweden. Participants were randomly assigned to three age groups with two men and two women in each group; 25-34 (M = 29.75 years, SD=3.40), 35-44 (M = 38.00 years, SD=2.16) and 45-54 (M = 49.50 years, SD=4.12). The majority of the participants had an average annual mileage of between 1500 and 2000 kilometres. All participants had a driver’s license, all of them had had their license for at least five years. The participants received 500 SEK (about € 50) for their participation.

Apparatus

Simulator

An interactive fixed-base driving simulator at the Swedish National Road and Transport Research Institute in Linköping, Sweden was used in the study. The visual system consists of three 40 inch NEC M40-AV TFT displays with 1920 x 1200 pixel resolution, providing a field of view of 180 degrees. The seat, steering wheel, pedals and dashboard are from a real car.

Pace meter

A pace meter that provided instantaneous information of the inverted speed in minutes per kilometre was used (Figure 1). As the speed increases, the pointer of the meter moves from left to right, but the numbers indicated on the meter decreases from left to right (as speed increases it takes less time to travel one kilometre). The numbers indicated on the meter ranged from three minutes per kilometre up to 0.5 minutes per kilometre and were presented with .5 intervals. The movement of the pointer decreases as the speed increases, illustrating that the time saved diminishes with higher speeds.

Figure 1. Pace meter indicating the inverted speed in minutes per kilometre.
Scenario

The simulated road environment presented to the participants was a two-lane rural road. There was no traffic in the participant’s lane and light traffic in the opposite direction. Two driving distances were simulated; one was 8.5 and the other 28.3 kilometres. The shorter driving distance was the first 8.5 kilometres of the longer distance, so both distances were parts of the same road.

Experimental design

A within participant design was used, each participant drove each of the two distances twice. Time was held constant so the driving distances were chosen so that the time spent on each of the two distances was the same. Half of the participants drove the shorter distance at the lower speed first and half drove the longer distance at the higher speed first. Age group and sex were balanced in both conditions (shorter distance/low speed first and longer distance/high speed first). A control group who performed the same task and drove the same distances in the same simulator with a conventional speedometer indicating speed in kph (Eriksson, Svenson, Eriksson, 2013) was used to allow for between groups comparisons.

Procedure

Participants first answered questions about background information such as age and years with a driver’s license. Then, they were given an instruction of the experiment in writing. Before the simulator task began, participants engaged in a practice run to adapt to driving in the simulator. The practice run lasted for 15 minutes and was driven on the same road as the one used in the driving task and at any speed chosen by the participant.

After the practice run, participants were first told to drive either the shorter or the longer distance at a given speed (30 kph for the shorter distance and 100 kph for the longer distance). Participants were then asked to drive the same distance again at the speed they thought necessary to gain exactly three minutes in travel time. Participants were then asked to answer a set of questions regarding the simulator drive such as how much time they thought they had saved and their average mean speed (in kph). The simulator task was then repeated with the second distance and speed and after the task was finished participants answered the same set of questions regarding time saved and mean speed.

After the simulator task, participants were given a questionnaire with further time saving problems. In order to compare the perceptual motor task of driving to paper-and-pencil studies of time savings, two of the problems corresponded to the two simulator driving tasks. Participants were given the distance (8.5 and 28.3 respectively) and initial speed (30 and 100 kph) and were asked to estimate the mean speed required to gain three minutes in travel time.
Results

Participants estimated how much time they thought that they had saved in both conditions. Their judged time saving and the actual time that they saved are shown in Table 1 (pace meter group) and Table 2 (speedometer group). The judged time saving when increasing speed from 30 kph was 3.38 minutes compared to the actual time saved, 4.42 minutes in the pace meter condition. When increasing speed from 100 kph, the judged time saved was 3.34 minutes compared to the actual time saved 3.47 minutes. In both conditions, participants judged their time saving as close to the targeted three minutes.

Table 1. Judged, actual and targeted time savings for the pace meter group.

<table>
<thead>
<tr>
<th>Original speed (km/h)</th>
<th>Judged</th>
<th>Actual</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>3.38 (.80)</td>
<td>4.42 (2.39)</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>3.34 (.94)</td>
<td>3.47 (1.44)</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. All entries are expressed in minutes. Standard deviations in parentheses.

Table 2. Judged, actual and targeted time savings for the speedometer group (Eriksson, Svenson & Eriksson, 2013).

<table>
<thead>
<tr>
<th>Original speed (km/h)</th>
<th>Judged</th>
<th>Actual</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>3.56***(.90)</td>
<td>6.14 (1.86)</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>3.25*(.72)</td>
<td>2.21 (.85)</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. All entries are expressed in minutes. Standard deviations in parentheses. Significant deviation of mean (judged) from actual time savings *p<.05, **p<.01 and ***p<.001.

The average actual time saved in the low speed condition was 4.42 minutes and not significantly different from the targeted three minutes, $t_{11}=2.058$, $p = 0.064$, two-tailed. In the high speed condition, the average actual time saving was 3.47 minutes which was not significantly different from the targeted three minutes, $t_{11}=1.333$, $p = 0.281$, two-tailed. In the control study (Eriksson, Svenson & Eriksson, 2013), participants completed the same driving task with an ordinary kph speedometer and the actual time savings were significantly greater than three minutes when increasing from 30 kph ($t_{11}=5.853$, $p = 0.0001$, one-tailed) and significantly lower when increasing from 100 kph ($t_{11}=3.228$, $p=0.004$, one-tailed), which corroborates a time saving bias.

Figure 2 shows a comparison between the actual time saved in the control (speedometer) study and the present (pace meter) study. A Mann-Whitney U test was used to test the difference in actual time saved between the speedometer and pace meter group. In the high speed condition, the speedometer group saved significantly less time than the pace meter group ($U = 34$, $Z = -2.194$, $p = 0.014$, one-tailed). When increasing from the low speed, the speedometer group saved
significantly more time than the pace meter group ($U = 41$, $Z = -1.790$, $p = 0.039$, one-tailed).

Figure 2. Actual time saved (min) in both low and high speed conditions for the speedometer meter and the pace group.

Although the actual time savings differed depending on whether the speed was increased from a low or a high speed, the judged time savings did not. Figure 3 shows the judged time saved for both groups and conditions.

Figure 3. Judged time saved (min) in both low and high speed conditions for the speedometer meter and the pace group.
The mean speed estimates given in the questionnaire and the actual mean speeds chosen in the simulator tasks for both the speedometer and pace meter group are shown in Table 3. Mean speed estimates made in the questionnaire were similar to the mean speeds in the simulator task, except at the higher speed condition where participants in the pace meter group drove closer to the targeted mean speed in the simulator task.

Table 3. Participants’ questionnaire estimates of mean speeds, actual simulator driving mean speeds and correct mean speeds for the two distances.

<table>
<thead>
<tr>
<th>Type of meter</th>
<th>Speedometer</th>
<th>Pace meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5 km at original speed 30 kph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questionnaire estimate</td>
<td>49.46</td>
<td>40.33</td>
</tr>
<tr>
<td>Chosen speed in simulator task</td>
<td>45.51</td>
<td>42.26</td>
</tr>
<tr>
<td>Correct speed</td>
<td>36.43</td>
<td>36.43</td>
</tr>
<tr>
<td>28.3 km at original speed 100 kph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Questionnaire estimate</td>
<td>113.63</td>
<td>115.08</td>
</tr>
<tr>
<td>Chosen speed in simulator task</td>
<td>113.52</td>
<td>123.95</td>
</tr>
<tr>
<td>Correct speed</td>
<td>121.46</td>
<td>121.46</td>
</tr>
</tbody>
</table>

Discussion

A previous study by Eriksson, Svenson and Eriksson (2013) showed that participants make biased judgements of the time saved by increasing speed from a high and low speed in an active driving task. The present study showed that these intuitive biased judgements can be debiased by presenting a pace meter which shows the inverted speed in minutes per kilometre instantaneously. Although intuitive judgements of time savings have shown a robust bias (Eriksson, Svenson & Eriksson, 2013; Peer, 2010a, 2010b, 2011; Peer & Gamliel, 2012, 2013; Peer & Rosenbloom, 2013; Peer & Solomon, 2012; Svenson, 1970, 1973, 2008, 2009), the present study indicates that driving behaviour can be altered by providing in-car information adapted to the drivers’ shortcomings.

A driver who overestimates the time saved of a speed increase from a high speed may experience time pressure when he or she realises that time is running short. The driver may then be tempted to increase speed even further to reach the destination on time. Also, drivers who realise how little time that actually can be saved at higher speeds may be less motivated to choose a higher speed in the first place. Hence, drivers need to be aware of the effect of speed on time saved in order for them to make optimal choices about their mean speed over a journey and debiasing such judgements may lead to a decreased mean speed which has a positive effect on road safety.

References


