Accident Risk Modified by Passengers

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ABSTRACT

An extended evaluation of driving exposure and accident data showed that presence or absence of passengers considerably influences accident risk. This especially holds true when these factors are considered in combination with alcohol use and with respect to driver age. To understand the psychological and social processes at work, the factor “passenger” was introduced in a simulated driving situation. Following a repeated measurement design, 12 subjects had to drive twice under the conditions: alone, with a silent passenger, with a talking passenger, and while talking on the car phone with another person. The Würzburg driving simulator is the front seat of a real car with the original steering wheel and all pedals. The subject can manipulate a car icon at the front computer screen with regard to both speed and direction. The computer generates a road on this screen, which subjects must follow with the car icon as quickly and as safely as they can. In addition, they must react (slow down or brake) to obstacles that suddenly appear in front of the car. These obstacles either occur randomly or are announced by stimuli within the peripheral visual field of the subjects. The simulator allows for differentiation between processes of information input (focal vs. peripheral) and those of information processing (automatic vs. controlled). Presence of passengers was found to have no influence on information input and automatic actions. However, clear negative effect occurred in driving situations requiring controlled actions. These effects were discussed with respect to young drivers and alcohol.

INTRODUCTION

Since the 19th century it is known that a co-worker or observer modifies performance in a wide variety of tasks. Both, detrimental and facilitating effects of the presence of others are known. Zajonc (1965) integrated both aspects of social presence. He assumed that the presence of others increased in the performer the level of activation. Further, he argued that activation should make dominant or well-learned responses more likely to be emitted, and less dominant or newly learned responses less likely. His analysis implies that any increase in activation from presence of others will lead to improved performance on simple or well-learned tasks, but to worse performance on complex tasks.

Very little research has been done to investigate the role and the effect of passengers in cars. In some studies actual driving behaviour was observed to find behavioural differences between drivers with and without passengers (e.g. Baxter et al., 1990). Due to the complexity of real life situations and very mixed driving populations results were somewhat limited and, in part, contradictory. Only few studies described differences in the accident risk for drivers driving alone or with passengers.
First, we present epidemiological data that show clearly that accident risk is modified by passengers in a rather straightforward way. Second, for a more refined causal analysis of these findings we transferred the passenger situation into the laboratory. Thus, we used both approaches, epidemiological and experimental, in the sense of a rapprochement between epidemiology and experimentation (Perrine, 1993).

THE EPIDEMIOLOGICAL APPROACH

Accident risks were computed by comparing a representative exposure data set with a police recorded accident data set. The exposure data set was constructed by using representative surveys about driving in Germany (KONTIV/AUTOMOTIV) and combining them with the results of our German Roadside Survey (see Krüger et al., this volume).

Accident data were taken from the Accident Report System of the Bavarian Police from 1984 to 1991. We selected 92,039 accidents from this file. All non-car accidents, accidents with less than 3,000 DM damage, hit and run drivers and cases with missing values on any of the exposure variables were excluded from the analysis.

The following variables were included: age of driver (young=18-24 vs. medium aged=25-49 vs. older=50 and more), sex of driver, day of week (weekend [Fr 20h - Mo 04h] vs. weekday [Mo 04h - Fr 20h]), time of day (day [04h - 20h] vs. night [20h - 04h]), number of passengers (alone vs. one passenger vs. more than one passenger), breath alcohol concentration (BAC; sober; >= 0.08%). A logistic regression was performed to identify risk factors. The results are shown in Table 1.

Table 1

Results of the logistic regression. Only main effects were included. The odds-ratio for the first alternative was always set to 1. 95% CI gives the upper and lower limit of the 95% confidence limit. Example: The odds-ratio of females in relation to males is 0.768 indicating that the accident risk for female drivers compared to males is about 25% reduced.

<table>
<thead>
<tr>
<th>Term</th>
<th>odds-ratio</th>
<th>p</th>
<th>95% CI</th>
</tr>
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<tbody>
<tr>
<td>sex of driver</td>
<td>male vs. female</td>
<td>.768</td>
<td>**</td>
</tr>
<tr>
<td>age of driver</td>
<td>young vs. middle</td>
<td>.324</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>young vs. older</td>
<td>.313</td>
<td>**</td>
</tr>
<tr>
<td>day of week</td>
<td>weekdays vs. weekend</td>
<td>1.110</td>
<td>*</td>
</tr>
<tr>
<td>time of day</td>
<td>day vs. night</td>
<td>1.732</td>
<td>**</td>
</tr>
<tr>
<td>passengers</td>
<td>alone vs. 1 passenger</td>
<td>.743</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>alone vs. &gt;1 passenger</td>
<td>.824</td>
<td>**</td>
</tr>
<tr>
<td>BAC</td>
<td>sober vs. BAC&gt;=0.08%</td>
<td>12.17</td>
<td>**</td>
</tr>
</tbody>
</table>

**: p<0.01; *: p<0.05
The well-known influence of the risk factors sex, age, time and alcohol was replicated by this analysis. Hence, these odds-ratios give a reference for the passenger effect under study. When one or more passengers are present accident risk is reduced (approx. 25%). The size of the passenger effect is about the same as the sex-of-driver effect. Essentially, the reduced accident risk was found for both passenger situations (e.g. one passenger vs. two or more passengers) although dyadic and group situations are known to be quite different from each other.

Further analyses were done to search for significant interactions between the risk factors and passengers. Two significant interactions that include the passenger effect will be discussed:

- passenger and age of driver
- passenger and BAC of driver

Figure 1 shows the interaction between the passenger and age of driver factors: For medium aged or older drivers the presence of an additional passenger is beneficial, while for young drivers the situation is reversed. Especially the presence of two and more passengers increases accident risk for this group sharply.

**Figure 1**

Accident risk modified by passenger and age of driver. The effect of passengers is different for young vs. medium old and older drivers. For young drivers, one or more additional passengers lead to an increased accident risk, while medium old and older drivers show a decrease in accident risk when passengers are present.
Figure 2 presents the interaction between BAC and passengers. For illustration purpose the “pure” BAC and passenger effects were removed by setting the risk in each BAC-category (sober vs. >=0.08%) for the driver without passengers to 1. For drivers with BAC of 0.08% or higher accident risk was increased when one passenger was present. This does not hold true with two or more passengers. Up to now, we can not explain this finding. One apparent problem is sample size. Although we used 9627 trips to estimate the alcohol effect, only 8 cases showed the combination of a BAC higher than 0.08% and more than one passenger. However, for sober drivers the already known passenger effect was found.

**Figure 2**
Accident risk modified by passenger and BAC of driver. The main effects of BAC and passenger were removed in this illustration by setting them to 1. While sober drivers have a lower accident risk with one or more passengers present, drivers with a BAC of 0.08% and higher have a higher accident risk when one passenger is present.

**EXPERIMENTAL ANALYSIS OF PASSENGER EFFECTS**

For a refined causal analysis of passenger effects we used an experimental approach. We developed a driving simulation task designed to combine a tracking task with a divided attention task.
METHOD

Driving Simulation

Subjects are seated in a real car seat in front of a steering wheel and pedals. The simulation is presented via a computer screen in textmode. Subjects are instructed to drive as “far” as possible. To achieve this, they have to drive at a moderate speed, because barriers that block the street occasionally have to be avoided. A barrier stays visible for exactly one second. The subjects can either drive slowly enough, so that the barrier vanishes before they reach it, or they can reduce speed by braking as quickly as possible. If the subject causes an accident, he has to drive backwards for 20 seconds at a fixed medium speed. This procedure induces a motivation to avoid accidents. Subjects are fully aware of these task characteristics.

Three different kinds of barriers are realized, thus implementing three markedly different situations:

1. Periodically the car reaches a “foggy” area in which it is very probable for barriers to appear almost immediately before the car. The subjects task is to maintain a low speed to prevent accidents.

2. Peripherally warned barriers: On the left and right edge of the screen horizontally oriented bars move up and down independently from one another. The task is to monitor the bars and to slow down when they approach each other. If the bars are at the same horizontal level a barrier will appear in front of the car. If the subject does not reduce speed it will be impossible for him to avoid an accident.

3. Occasionally, barriers appear at random in the “freeway”. The task is to brake as quickly as possible to prevent an accident (only subjects with moderate speed can achieve this).

Table 2
The experimental design

<table>
<thead>
<tr>
<th>Passenger factor</th>
<th>speaking factor</th>
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<tbody>
<tr>
<td>presence</td>
<td>speaking</td>
</tr>
<tr>
<td></td>
<td>passenger trip</td>
</tr>
<tr>
<td>absence</td>
<td>silence</td>
</tr>
<tr>
<td></td>
<td>silent passenger trip</td>
</tr>
<tr>
<td></td>
<td>alone</td>
</tr>
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Design

In this experiment we used

1. a passenger factor: presence vs. absence of passengers and
2. a speaking factor: conversational speaking vs. silence

as independent factors. 12 subjects participated in the experiment. Each subject had one exercise and three experimental sessions. Each experimental condition was realized twice. A trip lasted for 15 minutes. The condition absence of passenger and speaking was realized
using a car phone. Table 2 illustrates the design: From each subject we analysed two passenger, silent passenger, telephone and alone trips.

RESULTS AND DISCUSSION

Two dependent variables are discussed: speed and accident risk. Speed was analysed by an ANOVA including the factors: speaking, presence, subjects and session. Accident risk was analysed using a logistic regression with speaking, presence, subjects and session as independent variables.

Table 3 shows the speed and accident risk for the three different event types. It is obvious, that both speed and accident probability is mediated by the situation the subject is in. “Foggy” area leads to slow driving and lower accident probability. Peripherally warned barriers leads to moderate speed and high accident probability, while “freeway” results in high average speed and medium accident probability.

Table 3
The average speed (in lines per second), standard deviation of speed, accident probability and frequencies of events for the three different event types

<table>
<thead>
<tr>
<th>Event type</th>
<th>speed</th>
<th>accident probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m</td>
<td>sd</td>
</tr>
<tr>
<td>“foggy” area</td>
<td>1.5</td>
<td>.76</td>
</tr>
<tr>
<td>Peripherally warned barrier</td>
<td>3.2</td>
<td>1.3</td>
</tr>
<tr>
<td>“freeway” barrier</td>
<td>4.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

The presence or absence of another person showed no significant effect on driving performance, while the effect of speaking was significant at the 5% level. Thus only the effect of the concurrent speaking task will be discussed further.

The bars in Figure 3 show the reduction of speed in the speaking condition (e.g. the difference in speed between the non-speaking and the speaking condition) for the three driving situations (“foggy” area with low average speed, peripherally warned barriers with medium average speed and “freeway” with high average speed). The speed reduction is greatest in the “freeway” situation and minimal in the “foggy” area situation, while in the peripherally warned situation speed reduction is medium.

Obviously only in situations with moderate to high average speed a speed reduction is an efficient countermeasure to the strain augmented by concurrent speaking. In this simulation setting speed adaptation can be described by the simple rule:

Reduce speed in situations with high average speed to cope for an extra strain.
Figure 3
Observed speed reduction due to speaking in situations with low, medium and high average speed. Especially in situations with high speed a compensation in speed due to the extra speaking task was found.

Correspondingly, the bars in Figure 4 represent the modifications in accident risk in the speaking condition expressed as odds-ratio for the three different situations. Accident risk clearly increases in the “foggy” area, a situation with low average speed and slight speed adaptation. Accident risk in the peripherally warned barrier situation is essentially unchanged, while on the “freeway” we find a decreased accident risk.

Therefore, accident risk due to speaking is increased in situations with low average speed and very little speed adaptation. Speaking has no effect on accident risk while driving at a medium speed, whereas in situations with high average speed the additional strain of speaking leads to decreased accident risk, mediated by an overcompensation in speed.

CONCLUSION
Our epidemiological study revealed that passengers modify accident risks in a rather straightforward way: Accident risk with passengers is reduced as compared to driving alone. But characteristics of the driver and the driving situation modify the general passenger effect strongly. Both, in difficult situations or for unexperienced drivers, accident risk increases with passengers present. The social facilitation approach offers a possible explanation for these findings: Accident risk depends on an interaction between driving difficulty and passengers, with detrimental effects of passengers in difficult situations.
Observed in-/decrement of the accident risk of the speaking condition in situations with low, medium and high average speed (refer to Table 3). Especially in situations with low speed a increment in accident-risk was found because subjects can not compensate by adapting their speed, while in situations with a typical high speed overcompensation was found, that lead to decreased accident risk. The dependent variable (odds-ratio) is on a logarithmic scale.

Our reconstruction of the passenger effect in the laboratory showed that speaking is a promising factor towards a further understanding of the passenger effect. Speaking is resource demanding and thus interacts with numerous simultaneous tasks. Hence, drivers try to compensate for this extra strain by reducing difficulty in the driving task: They slow down whenever possible. This reduced speed diminishes accident risk and causes the “beneficial” effect of passengers. However, this “beneficial” effect is only a reaction to increased task demands.

In difficult traffic situations linked with low speed a compensation by a further reduced speed is not possible. Hence, increased task demands by passengers lead to increased accident risk in such situations.

The rapprochement of epidemiology and experimentation proved to be successful. We could show that the passenger effect found in epidemiology can be reproduced in an experimental driving simulation setting. The epidemiological data suggests further that the state of the driver (e.g. alcohol) modifies the passenger effect. Thus, the passenger as a secondary task might be a promising approach to study effects of alcohol or drugs. The compensatory behaviour typically shown by drivers under the influence of alcohol or drugs might be grossly impaired when interaction with a passengers is demanded as a secondary task.
REFERENCES


