



## Effects of a front-seat passenger on driver attention: An electrophysiological approach



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### ABSTRACT

The human attention system is limited in capacity, and when performing two concurrent tasks there is competition for cognitive resources. This is particularly important in dangerous scenarios, such as driving on sharp curves where deficits in performance can be caused by various sources of distraction, including the presence of a passenger in the vehicle. In the present study, a dual-task paradigm was employed to examine the nature of attentional limits while operating a driving simulator in the presence of a passenger. The primary driving task had two levels of difficulty and event-related potentials (ERP) were collected from a secondary auditory task. In addition to several driving performance measures, our main ERP of interest was the P300. In dual-task studies, increases in primary task difficulty have been shown to reduce the amplitude of the P300 elicited by a secondary task. This presumably occurs because attentional resources initially dedicated to the secondary task are consumed by the primary task. The present results showed that compared to driving solo, the presence of a passenger was associated with a decrease in P300 amplitude in the more difficult driving conditions. These results suggest that in-car passengers may consume valuable resources in difficult driving situations that require more attentional focus in the first place.

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## 1. Introduction

Driver distraction is a major contributing factor in motor vehicle crashes. In 2013, 18% of all crashes and 16% of fatal crashes in the U.S. were associated with distracted driving (National Highway Traffic Safety Administration [NHTSA], 2015). Drivers under 40 years of age made up the largest proportion of those involved in distraction-related fatalities, with those in the age group of 20–29 years contributing to 27% of these fatalities (NHTSA, 2015). Recent observational studies report that nearly 17% (Sullman, Prat, & Tasci, 2015) and 33% (Huisinigh, Griffin, & McGwin, 2015) of the drivers observed were involved in distracting activities.

Driver distraction has been defined as a form of inattention that occurs when attention is diverted “away from activities critical for safe driving toward a competing activity, which may result in insufficient or no attention to activities critical for safe driving” (Regan, Hallett, & Gordon, 2011, p. 1776). The competing activity may be from inside the vehicle (e.g., talking to a passenger) or outside the vehicle (e.g., looking at a roadside billboard). It has been estimated that 84% of distraction-related fatalities involve carelessness and inattentiveness due to cell-phone use, interacting with a passenger, eating, looking at

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something outside the vehicle, etc. (NHTSA, 2009). As human operated motor vehicles remain the primary means of transportation in many countries, it is important to identify the potential sources of driver distraction and have an understanding of its impact on driver behavior in order to improve road safety.

### 1.1. Effects of passengers on drivers

According to a recent study, the most common distractions among drivers were interacting with a passenger (53%), talking on a cell-phone (31%), looking at something outside the vehicle (20%), and texting/dialing a cell-phone (17%) (Huisingsh et al., 2015). Another study also found that talking to passengers was the most frequent distraction among drivers (Sullman et al., 2015). The American Automobile Association (AAA) Foundation for Traffic Safety (2015) reported that, among teenage drivers, interacting with passengers was the leading cause of distraction-related crashes (15%), followed by cell-phone use (12%). While several experiments have examined the effects of cell-phone use (e.g., Strayer & Johnston, 2001) and roadside billboards (e.g., Chan & Singhal, 2013) on driving performance, the impact of in-car passengers is less well understood. Within this body of work, previous research has focused on the influence of passengers on teenage drivers (e.g., Pradhan et al., 2014; Williams, Ferguson, & McCartt, 2007), rather than college and university student drivers. This is an important population as distracted driving is highly prevalent among post-secondary students. In a recent study by Hill et al. (2015), 18% of college students (mean age = 21.8) reported having been in a motor vehicle crash due to distracted driving. 24% cited interacting with passengers as a contributing factor in crashes.

The role of passengers is an important issue as having a passenger in the vehicle can change the driver's social environment. Compared to driving solo, a passenger can induce two types of social influence – direct social influence through interaction between the driver and passenger or indirect social influence associated with the mere presence of a silent passenger (Liu, Saito, Oi, & Pelowski, 2012; Ouimet et al., 2013). This latter form of social influence on the driver may be due to perceived social norms or expectations conveyed by a passenger (Ouimet et al., 2013). A number of studies have indicated that driving with a passenger can have a profound impact on driver behavior. Drivers can also be affected by various attributes associated with the passenger, such as the passenger's relationship to the driver, whether the passenger is silent or communicating with the driver, and the nature of the interaction occurring between the driver and passenger (Williams et al., 2007).

Studies evaluating crash risk have come to inconsistent conclusions about the effects of passengers. Some studies suggest that passengers may be a source of distraction and are associated with increased crash risk (Williams et al., 2007), while others suggest that passengers may have a positive (i.e., protective) effect on drivers and are associated with lower crash risk (Vollrath, Meilinger, & Kruger, 2002). These contradictory findings are likely due to different characteristics of the driver and passengers, such as their relationship to one another, age and gender, as well as varying driving conditions.

Doherty, Andrey, and MacGregor (1998) found that teenage drivers were more likely to be involved in crashes in the presence of passengers compared to older drivers. Lee and Abdel-Aty (2008) reported that younger drivers were at a higher likelihood of being involved in a motor fatality when accompanied by younger passengers compared to older passengers. In Ouimet et al. (2013), teenage drivers showed greater inattention to driving hazards in the presence of a passenger compared to driving alone. Centifanti, Modecki, MacLellan, and Gowling (2014) found that teenage drivers displayed more risky driving behaviors in the presence of a high risk-inclined peer compared to a low risk-inclined peer. This effect was observed even when the driver and peer were not directly communicating, suggesting that peer passengers can exert social influence just by being near the driver. In Hing, Stamatiadis, and Aultman-Hall (2003), drivers over 75 years of age were more likely to be involved in crashes when accompanied by a passenger compared to drivers between 65 and 74 years of age. Furthermore, it was found that this negative effect was greater when driving on curved or graded road conditions. Together, these studies suggest that passengers may act as social stimuli and provide a source of distraction from within the vehicle. Attention may be diverted away from the driving task to the passenger, resulting in insufficient or no attention to the road ahead. In driving situations that require higher driver workload and attention, such as making turns as opposed to driving straight (Hancock, Wulf, Thom, & Fassnacht, 1990), the distracting effects of passengers may be more detrimental.

On the other hand, passengers may have a protective effect on drivers by warning them of potential hazards, helping with navigation, and encouraging safer driving behaviors. Vollrath et al. (2002) found that, for the majority of the driving population, passengers were associated with a reduced rate of accidents compared to driving solo; however this positive effect was smaller in driving situations where high attentional demand was required, such as when passing another vehicle. Lee and Abdel-Aty (2008) found that, with the exception of younger drivers with younger passengers, the presence of passengers was generally associated with safer driving behaviors, such as wearing seatbelts and not driving after alcohol use.

Together, these findings suggest that the social environment, relating to the presence of passengers in the vehicle can alter driver behavior (e.g., through indirect social influence such as perceived social norms). Depending on certain driver and passenger characteristics (e.g., age) and the driving situation, passengers can have positive or negative effects on road safety. However, to date, no study has used an electrophysiological approach to study the effects of a passenger on driver attention. Past research has shown that the human attention system is limited in capacity, and when performing two concurrent tasks there is a competition for cognitive resources (Kahneman, 1973). This is particularly important in more demanding driving scenarios, such as negotiating sharp curves, where performance deficits can be caused by various sources of distraction, including the presence of a passenger in the vehicle.

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