Neuroscience Letters 593 (2015) 78–82

Contents lists available at ScienceDirect

Neuroscience Letters

journal homepage: www.elsevier.com/locate/neulet

Research article

Covert effects of "one drink" of alcohol on brain processes related to car driving: An event-related potential study

Kazutoshi Ebe[a], Kosuke Itoh[b,*], Ingrid L. Kwee[c], Tsutomu Nakada[b,c]

[a] Toyota Central R&D Labs., Inc 41-1Yokomichi, Nagakute, Aichi 480-1192, Japan
[b] Center for Integrated Human Brain Science, Brain Research Institute, University of Niigata, 1-757 Asahimachi, Niigata 951-8585, Japan
[c] Department of Neurology, University of California, Davis, 150 Muir Road, Suite 127A, Martinez, CA 94553, USA

HIGHLIGHTS

- Consumption of a low dose (14 g) of alcohol did not affect behavioral performance in an easy car-driving task.
- However, the parietal P3 elicited by the preceding car's brake light was significantly reduced in amplitude.
- Alcohol begins to affect neural processes for car driving at a dose that is too low to explicitly modify behavior.

ARTICLE INFO

Article history:
Received 13 January 2015
Received in revised form 13 February 2015
Accepted 8 March 2015
Available online 18 March 2015

Keywords:
Drinking and driving
Ethanol
P300
Attention

ABSTRACT

The effects of a low dose of alcohol on car driving remain controversial. To address this issue, event-related potentials were recorded while subjects performed a simple car-following task in a driving simulator before and after consuming either "one drink" of beer (representing one standard alcoholic beverage containing 14 g of alcohol) or mineral water (control condition). Subjects who had consumed the determined amount of alcohol demonstrated no detectable outward behavioral signs of intoxication while performing the driving task, an observation in agreement with previous findings. However, the parietal P3 elicited by the brake lights of the preceding car was significantly reduced in amplitude, approximately 50% that observed under the control condition, likely indicating alteration of the neural processing of visual information critical for safe driving. The finding suggests that alcohol begins to affect neural processes for driving even at quantities too low to modify behavior.

1. Introduction

Moderate to high doses of alcohol are recognized as being deleterious to the normal brain processes that support safe driving. On the other hand, the effects of a low dose of alcohol on driving remain controversial, as underscored by the fact that the legal blood alcohol concentration (BAC) limit for driving varies widely among countries, ranging from zero tolerance to 0.1 g/dL [1].[1] Previous studies have shown that behavioral performances in tasks that demand a high degree of attention (e.g., divided attention tasks and distraction tasks) are affected by alcohol at BACs as low as 0.01 g/dL, but such effects become more difficult to detect as the task becomes less demanding [2–4]. Thus, the lack of outward behavioral indicators may account for the public's impression that a few drinks do not adversely impact one's car driving ability, which is an over-learned, automated skill that requires little cognitive effort for most. It is, however, important to consider the possibility that outward behavioral measures may fail to capture the entirety of the effect alcohol has on the brain processes related to driving, as the ethanol effects on the brain are known to be dissociable from behavioral measures [5,6].

Accordingly, we used event-related potential (ERP) to investigate whether ethanol affects brain processes related to driving in amounts too low to affect outward driving behavior. Subjects performed a highly simplified car-following task (with no other vehicles, traffic signs, distractors, secondary tasks, etc.,) in a driving simulator after having consumed one standard can of beer. For the control condition, subjects drank an identical volume of mineral water. The P3 component of visual ERPs elicited by the brake lights of the preceding car was recorded throughout the entire run, as this neurophysiologic index is well known to be reduced by alcohol to reflect altered central processing of task-relevant visual stimuli [7,8]. Additionally, several behavioral measures relevant to

* Corresponding author. Tel.: +81 25 227 0683.
E-mail address: itoh@bri.niigata-u.ac.jp (K. Itoh).

[1] Some countries do not have a BAC limit.

http://dx.doi.org/10.1016/j.neulet.2015.03.020
0304-3940/

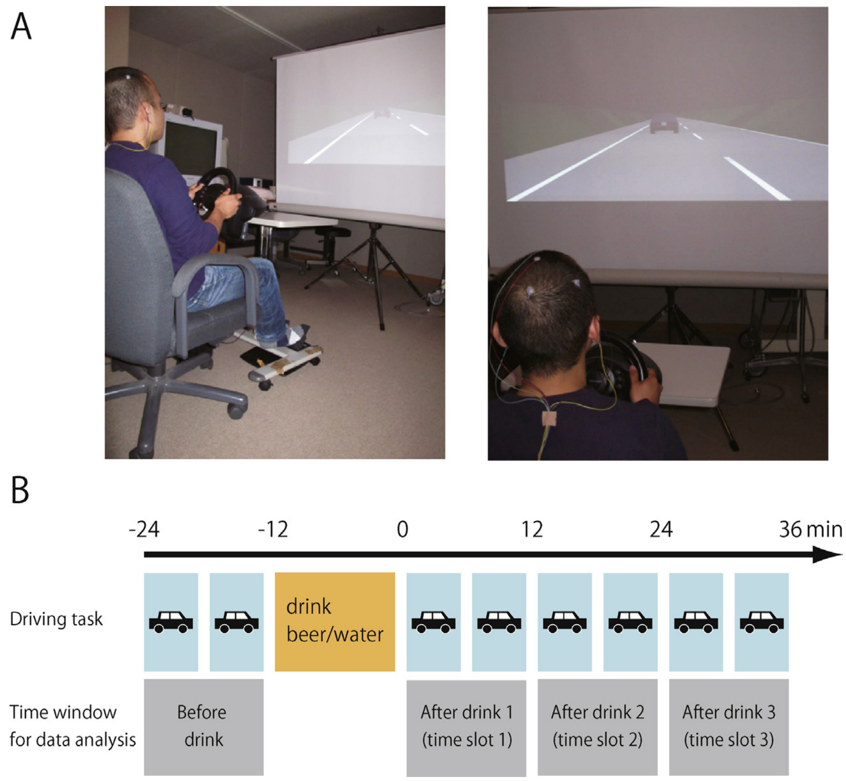

Fig. 1. Driving simulator (A) and the time schedule of the experiment (B). The pictures in (A) were taken using a strobe light, while the experiment was performed in darkness.

safe driving, namely, distance headway, coefficient of variation in distance headway, lateral deviation from the lane's center and reaction time for braking, were also examined. Fig. 1 summarizes the experimental procedure.

The amount of beer consumed by the subjects corresponded to one standard drink, or 14 g of alcohol.[2] As a rough practical guide, one can of beer (350 ml), one glass of table wine (150 ml), and one shot of 80-proof liquor (45 ml) all represent one standard alcoholic beverage. For the average American male, weight 80 kg, behavioral intoxication can be seen after a little over three standard drinks, an amount that generally correlates to a blood alcohol level that is above the legal BAC limit for driving in the United States (0.08 g/dL). For the average Japanese man, weight 65 kg, Japan's legal BAC limit for driving (0.03 g/dL) can be reached after consumption of one standard drink, according to the Widmark formula [9,10].

2. Methods

2.1. Subjects

The study was carried out in accordance with the human research guidelines of the Internal Review Board of the University of Niigata. Twelve neurologically normal social drinkers (21–35 years old, 2 females) participated in the study after giving their written informed consent, but one subject did not complete the entire study due to personal reasons. All subjects possessed a valid driver's license and had normal or corrected-to-normal vision. Mean (±s.d.) body weight of the (remained) eleven subjects was 62.8 (±7.7) kg. The subjects' mean estimated peak BAC's during the driving task was 0.036 (±0.006 s.d.) g/dL, using the Widmark formula [9,10]: BAC [g/dL] = {alcohol weight [g]/(body weight [kg] × r)} × 0.1055 [kg/dL], where r (the rho factor) was 0.7 for men and 0.6 for women.

2.2. Stimuli and procedure

Subjects performed the study task on two separate days, either after consumption of a can of beer (350 ml, 5% alcohol by volume) over 12 min; or after the ingestion of the identical volume of mineral water over the same amount of time. Six subjects performed the water condition first, and the other six the alcohol condition first. (However, one subject who started from the alcohol condition did not come back for the water condition, leaving eleven subjects for analysis.) Before data recording, subjects underwent two practice runs of the driving task on the first day of participation, and one additional run on the second day so that they were adjusted to their driving positions and were acquainted with the task.

An original driving simulation system was used for the interactive presentation of visual stimuli and for behavioral recording (Fig 1a; Toyota Central R&D Labs., Inc., Nagakute, Japan; see also [11]). This system was comprised of a computer, a steering wheel, two foot pedals (brake and gas), a digital light processing (DLP) projector, and a projector screen. Subjects were instructed to follow the preceding car and to maintain a constant distance from it. The simulated terrain was a flat road with occasional gentle curves. The preceding car drove in the center of the lane, and subjects were instructed to do the same. The speed of the preceding car ranged between 40 and 80 km/h, and its rear brake lights were lit whenever it decelerated. In order to keep the task simple, there were no other vehicles, pedestrians, traffic lights, crossroads, or any other distracting elements. One uninterrupted run lasted 4.5 min, and was followed by a 1.5 min break between runs. The preceding car decelerated 31 times during each run, thereby providing 31 chances per run for recording visual ERPs in response to the preceding car's brake lights. Subjects performed a total of eight runs according to

[2] The definition of standard drink varies across countries [24]. This study uses the definition applied in the United States of America (USA).