Effects of Ethanol and Auditory Distraction on Forced Choice Reaction Time

IIRO P. JÄÄSKELÄINEN,† KIMMO ALHO,* CARLES ESCERA,‡ ISTVÁN WINKLER,§ PEKKA SILLANAUKEE†† AND RISTO NÄÄTÄNEN

*Cognitive Psychophysiology Research Unit, Department of Psychology, POB 11, FIN-00014 University of Helsinki, Finland
†Biomedical Research Center, Alko Group Ltd, POB 350, FIN-00101 Helsinki, Finland
‡Neurodynamics Laboratory, Department of Psychiatry and Clinical Psychobiology, University of Barcelona, P. Vall d'Hebron 171. 08035 Barcelona, Catalonia, Spain
§Institute for Psychology, Hungarian Academy of Sciences, H-1394 Budapest, POB 398, Szozdiu 83185, Hungary
††Alcohol Related Diseases, Pharmacia AB Diagnostics, S-75182 Uppsala, Sweden

Received 24 April 1995; Accepted 11 August 1995

JÄÄSKELÄINEN, I. P., K. ALHO, C. ESCERA, I. WINKLER, P. SILLANAUKEE, AND R. NÄÄTÄNEN. Effects of ethanol and auditory distraction on forced choice reaction time. ALCOHOL 13(2) 153–156, 1996.—Effects of ethanol (0.55 g/kg) and auditory distraction on visual forced choice reaction time (RT) were investigated in 10 healthy social drinkers, using a single-blind, placebo-controlled, crossover design. Subjects were to respond by pressing a button either with their right-hand index or middle finger, depending on whether an odd or an even digit was presented on a PC screen. In control blocks, the digits were presented alone, whereas in distraction blocks they were shortly preceded by either a frequent “standard” tone of 600 Hz, or an infrequent tone that was either a 660 Hz “deviant” tone or a “novel” sound (e.g., telephone ringing). Alcohol reduced the hit rate by increasing the amount of errors, but had no effect on the RT, thus supporting the previous observations. In the placebo condition, the RT was prolonged by the deviant and novel sounds, and the hit rate was reduced by the deviant tones. During ethanol intoxication, however, the reduction in hit rate caused by the deviant tones was significantly smaller. This suggests that the attention-capturing effects of the deviant sounds were suppressed by ethanol, thus demonstrating a detrimental effect of ethanol on involuntary attention.

THE detrimental effect of acute alcohol intoxication on attention has been widely observed, and evidence suggesting a causal relationship between the alcohol-induced attentional impairment and increased accident risk has been reported (1,7). However, there appears to be considerable variability in the sensitivity of different attentional processes to acute ethanol; low doses of alcohol [producing blood alcohol concentrations (BAC) of less than 0.032‰] were reported to improve accuracy in choice reaction time (RT) tasks (9,14,15), thus suggesting that the ability to maintain attentional focus on a single task is relatively resistant to low alcohol doses. In contrast, performance requiring the ability to divide attention between two or several concurrent inputs was detrimentally affected with BACs as low as 0.015‰ (10).

Recent event-related potential (ERP) findings suggest that the cerebral mechanisms of involuntary attention switching to sound changes are suppressed by alcohol; the mismatch negativity (MMN) (11) component of the ERP, reflecting attention-independent change detection, was attenuated by low (0.5 g/kg) doses of alcohol (5,6). The P3a, a positive-going ERP component following the MMN in the chain of brain events reflecting an involuntary attention switch [see (11)], was also suppressed by ethanol (2,4). In contrast, the P3b, reflecting information processing within an attended channel, was not significantly affected by the same alcohol doses that impaired the generation of the MMN and P3a components (2,4,5). This tentatively suggests that the brain mechanisms of involuntary attention switching are more sensitive to low
alcohol doses than is the cerebral processing of voluntarily attended information. Behavioral evidence supporting these ERP findings, however, has not thus far been introduced.

In sober subjects, occasional changes ("deviants") occurring among unattended repetitive "standard" tones slow the RT to target sounds presented subsequently in an attended stimulus sequence (13). In addition, hit rate reduction by task-irrelevant deviant tones, and RT prolongation by "novel" sounds (e.g., phone ringing, glass breaking) have been observed in a visual forced choice RT task (3). These findings suggest that deviant and novel sounds have specific attention-capturing effects, and that these stimuli thus offer a way of investigating the properties of passive attention behaviorally. The aim of the present study was, therefore, to study the effect of ethanol on involuntary attention switching to deviant and novel sounds occurring in an unattended sequence of homogeneous standard stimuli. The specific hypothesis was that alcohol decreases the attention-switching effects of task-irrelevant deviant and novel sounds, an effect that might be related to increased accident risk during ethanol intoxication, due to dampening of the central " alarming mechanisms" of the brain (11).

**METHOD**

Subjects and Design

Ten healthy, right-handed, volunteers (four females; 24 ± 1 years, range 20–26 years), with self-reported weekly alcohol consumption for the past 6 months of 3–18 standard drinks (12 g of ethanol per drink), participated in the study twice in a counterbalanced order, thus serving as their own controls. Subjects had no history of substance abuse. They abstained from food for 3 h and from alcohol and all kind of drugs for at least 48 h prior to each experimental session.

The experiments were conducted in a sound-attenuated room with constant lighting conditions. In the alcohol session, subjects ingested a dose of 0.55 g/kg (10% v/v, flavored with lemon extract) in 25 min, followed by a waiting period of 5 min before the RT task began. After 25 min into the forced choice RT task their blood alcohol content was estimated with a Lion SD-2 breath analyzer (Lion laboratories Ltd., Barry, UK). Thereafter, the task was continued for additional 45 min. Subjects were then breathalyzed for a second time after the recordings were over. The mean BAC was 0.072 ± (SE) 0.008% 30 min after ingestion, and 0.052 ± 0.002% immediately after the RT task (i.e., 1 h and 15 min after the ingestion of the alcohol dose). The placebo session was identical to the alcohol session, except that the beverage contained no alcohol, a single-blind procedure being employed. The study protocol was approved by the Ethical Committee of the Biomedical Research Center of Alko Group Ltd, and an informed consent was obtained from each subject before their participation in the experiment.

Stimuli

Subjects sat on a comfortable chair facing a PC monitor set 90 cm in front of them at their eye level. Odd and even digits (1–8) were presented in the middle of the monitor screen with a constant interstimulus interval (onset-to-onset) of 1500 ms. In four control blocks each lasting for 5 min, subjects were presented only with the visual stimuli. In five distraction blocks each lasting for 10 min (including a short rest period in the middle), each visual stimulus was preceded, with a stimulus onset asynchrony of 300 ms, by an auditory stimulus of 200 ms in duration (including rise and fall times of 10 ms), which was either a standard (600 Hz, p = 0.80) or a deviant (660 Hz, p = 0.10) tone, or a novel sound (p = 0.10). The novel sounds were digitized environmental sounds (e.g., the sound of breaking glass, phone ringing). The auditory stimuli were binaurally delivered through headphones at an intensity of approximately 70 dSPL. The control and distraction blocks were presented in a balanced order.

Subjects were instructed to ignore the auditory stimuli (note that during control blocks, no auditory stimuli were delivered) and to press promptly a button with their right-hand index finger to an odd digit, and a different button with their right-hand middle finger to an even digit. Both buttons were located in a response pad that freely rested on the subjects' lap.

**Data Analysis**

Correct button press within 100–1200 ms from visual stimulus onset was considered a hit. An error was recorded when a wrong button was pressed within the 100–1200-ms temporal window. A failure to press any button within the designated temporal window was classified as a miss. The number of hits, the mean RTs for hits and errors, the number of misses, and the number of errors were calculated separately for the visual stimuli 1) when presented alone, 2) when preceded by standard tones, 3) when preceded by deviant tones, and 4) when preceded by the novel sounds. The overall effect of alcohol on the RT (separately for hits and errors), the number of hits, the number of errors, and the number of misses were tested with two-factor, repeated-measures ANOVAs. The distracting effects of deviant and novel stimuli, and the effect of alcohol on these distraction effects, were statistically analyzed with two-tailed, paired t-tests.

**RESULTS**

Alcohol significantly decreased the number of hits, F(1, 9) = 5.98, p < 0.05; it increased the number of errors, F(1, 9) = 6.16, p < 0.05, but had no significant effect on the number of misses. In addition, there was a weak overall tendency for shorter RTs for hits with alcohol, compared to placebo. The RT for errors in the control blocks, and in trials preceded by standard tones in distraction blocks, was somewhat shorter in the alcohol condition than in the placebo condition, t(9) = 2.27 and 2.31, p < 0.05 (for absolute values, see Table 2). In addition, the RT for errors was shorter than that for hits in both the placebo and alcohol conditions, F(1, 9) = 7.67 and 10.52, p < 0.001.

The deviant tones significantly decreased the number of hits for the subsequent visual stimuli both in the placebo, t(9) = 7.84, p < 0.001, and alcohol, t(9) = 2.71, p < 0.05, conditions, compared with the standard tones. However, the hit rate decrease caused by the deviant sounds was significantly smaller in the alcohol than placebo condition (Fig. 1), t(9) = 2.51, p < 0.05.

The RT was prolonged upon the presentation of a deviant sound in the placebo, t(9) = 5.11, p < 0.001, and alcohol, t(9) = 4.29, p < 0.01, conditions, as well as upon the presentation of a novel sound in the placebo condition, t(9) = 2.70, p < 0.05, compared with the standard tones. The hit rates were unaffected by the novel sounds in both the placebo and alcohol conditions.
ETHANOL, DISTRACTION AND REACTION TIME

TABLE I
EFFECT OF ETHANOL ON THE AMOUNT OF HITS, ERRORS, MISSES, AND RTS (FOR HITS AND ERRORS) IN THE VISUAL FORCED CHOICE RT TASK

<table>
<thead>
<tr>
<th>Distractor</th>
<th>Hit (%)</th>
<th>Error (%)</th>
<th>Miss (%)</th>
<th>Hit RT (ms)</th>
<th>Error RT (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Placebo</td>
<td>87.4 ± 3.3</td>
<td>6.4 ± 1.0</td>
<td>6.3 ± 3.0</td>
<td>458 ± 19</td>
</tr>
<tr>
<td></td>
<td>Alcohol</td>
<td>82.1 ± 2.8</td>
<td>10.3 ± 2.2*</td>
<td>7.6 ± 3.4</td>
<td>448 ± 22</td>
</tr>
<tr>
<td>Standard sound</td>
<td>Placebo</td>
<td>87.6 ± 3.1</td>
<td>5.7 ± 0.9</td>
<td>6.7 ± 2.7</td>
<td>444 ± 15</td>
</tr>
<tr>
<td></td>
<td>Alcohol</td>
<td>84.0 ± 2.7*</td>
<td>10.1 ± 2.1*</td>
<td>5.9 ± 2.0</td>
<td>435 ± 17</td>
</tr>
<tr>
<td>Deviant sound</td>
<td>Placebo</td>
<td>82.8 ± 2.8</td>
<td>9.3 ± 0.6</td>
<td>7.9 ± 2.9</td>
<td>454 ± 16</td>
</tr>
<tr>
<td></td>
<td>Alcohol</td>
<td>81.6 ± 2.4</td>
<td>12.8 ± 1.7*</td>
<td>5.7 ± 1.9</td>
<td>447 ± 19</td>
</tr>
<tr>
<td>Novel sound</td>
<td>Placebo</td>
<td>87.7 ± 2.4</td>
<td>6.7 ± 0.9</td>
<td>5.6 ± 2.2</td>
<td>453 ± 17</td>
</tr>
<tr>
<td></td>
<td>Alcohol</td>
<td>84.3 ± 2.8†</td>
<td>11.5 ± 2.4</td>
<td>4.3 ± 1.7</td>
<td>446 ± 22</td>
</tr>
</tbody>
</table>

Values are mean ± SE.
*<p < 0.05.
†<p < 0.01.

DISCUSSION

The hit rate was significantly lower after alcohol than placebo ingestion; this effect was mainly due to the increased number of errors with alcohol, whereas the RT for hits tended to be slightly shorter with alcohol than with placebo (for the absolute values, see Table I). Similarly, the RT for errors was shorter in the alcohol than in placebo condition, but this effect was significant only when either standard tones or no tones (in the control blocks) preceded the RT trials. It thus seems that although the subjects tended to respond more quickly, they also made more errors, after alcohol ingestion. Corroborating results (i.e., increased amount of errors and lack of RT prolongation) have been observed in previous choice reaction time studies with similar, moderate BACs (8,12,14). With slightly higher BACs, however, a RT prolongation was observed in addition to an increased error rate (8,9).

In the placebo condition, the deviant and novel sounds preceding the RT trials significantly prolonged the RT, and the deviant tones also decreased the amount of hits, thus supporting the previous observations (3,13) according to which unattended deviant and novel sounds distract concurrent RT performance, most probably due to their attention-capturing effects. Somewhat surprisingly, the novel sounds seemed to be less distracting than the deviant sounds in the present investigation. Escera et al. (3) obtained similar results with the same paradigm, and thus it is unlikely that this result is a chance finding. The explanation offered by Escera et al. (3) for this, on the basis of their ERP data, was that the distraction effect induced by the novel sounds occurred at a shorter latency than that of the deviant tones. Thus, it is possible that although the novel sounds produced stronger attentional captures, the attention switching caused by the deviant tones coincided better with the RT trials, thus causing stronger distraction effects on the hit rate.

The amount of decrease in the number of hits induced by deviant tones was significantly smaller in the alcohol than placebo condition (Fig. 1). This result suggests that the attention-capturing effects of the deviant sounds were suppressed by ethanol, thus demonstrating a detrimental effect of ethanol on involuntary attention. This is consistent with the recent results according to which alcohol, from doses of 0.5 g/kg, suppresses the MMN component of the ERP (5,6), which is associated with involuntary attention switching to sound changes (3,11,13).

No such effect was observed for the novel sounds, however. In searching for an explanation for this, it might be relevant that the suppression of MMN response was stronger for 5% than 10% deviations in tone frequency with a 0.55 g/kg dose (6). Thus, considering the fact that the novel sounds constitute a larger change than the deviant tones, it is possible that the lack of alcohol effect on the distraction induced by novel sounds was due to the relatively low dose of ethanol used. Consistent with this hypothesis, the P3a induced by novel sounds has been observed to be suppressed by ethanol with larger doses of 0.74 and 0.85 g/kg (2,4).

Nevertheless, the attenuation of the deviant-induced distraction effect by ethanol in the present study yields novel behavioral, converging evidence to support the previous ERP findings suggesting that the mechanisms of involuntary attention switching to sound changes are sensitive to ethanol. In fact, the BAC used in the present study was in the 0.05-0.07% range, which is similar to the BACs at which the MMN suppression was previously observed (5,6). Moreover, the behavioral result for the deviant tones found in the present study

FIG. 1. The amount of hit rate (%) reduction caused by the deviant auditory stimuli in the placebo and alcohol conditions. In the placebo condition, the deviant tones significantly reduced the hit rate in the subsequent visual forced choice RT task. This distracting effect of the deviant tones was, however, significantly lower after alcohol ingestion, thus suggesting alcohol-induced suppression of the attention-capturing effects of the deviant tones (n = 10; *<p < 0.05).
and the previous ERP results appear to be of quite a similar magnitude (i.e., 40–60% reduction in response strength) (5,6). Consequently, it may be that the same preperceptual change detection mechanisms (11) account for both the alcohol-induced attenuation in the behaviorally observed distraction effect and the previous ERP observations. Such a hypothesis, of course, has to be tested in future experiments with simultaneous recording of ERP and behavioral data.

In addition, the suppression by alcohol of the involuntary attention switching, observed in the present study and in the previous ERP studies (2,4–6), may be linked to the increased accident risk during ethanol intoxication due to disturbed reorienting of the attentional focus on changes in the acoustic environment. For instance, the contribution of alcohol to traffic accidents where the driver is engaged in a secondary task prior to meeting a hazard (1) might in part result from the transiently impaired ability to notice and respond to changes occurring outside of the attentional focus.

ACKNOWLEDGEMENTS

Supported by the Finnish Foundation for Alcohol Studies, the Academy of Finland, and the National Scientific Fund of Hungary (OTKA T006967). Dr. Escera’s stay in Helsinki was supported by the Generalitat de Catalunya (CIRIT BE94-3/505).

REFERENCES