Absinthe: Attention Performance and Mood under the Influence of Thujone

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ABSTRACT. Objective: The aim of this study was to determine whether the impacts of absinthe on attention performance and mood were different from those experienced with beverages that contain only alcohol. The ingredient causing absinthe's toxicity is believed to be thujone. **Method:** A total of 25 healthy subjects participated in the study. An attention performance test and two questionnaires testing different mood dimensions were used. Three drinks with an identical amount of alcohol but with different amounts of thujone were offered. **Results:** The results of the present study showed that the simultaneous administration of alcohol containing a high concentration of thujone had a negative effect on attention performance. Under this condition, the subjects tended to direct their attention to signals in the central field of attention and to neglect peripheral signals; the number of correct reactions decreased significantly in the peripheral field of attention, and reaction time and the number of "false alarm" reactions increased significantly. The effects were most prominent at the time of the first measurement. When the subjects were under the influence of alcohol or were administered both alcohol and a low thujone concentration, these effects were not observed. The assessment of mood state dimensions showed that the anxiolytic effect of alcohol was temporarily counteracted by a high thujone concentration. **Conclusions:** As they are apparently opposed to the effect of alcohol, the reactions observed here can be explained by the antagonistic effect of thujone on the gamma-aminobutyric acid receptor. Similar alterations were observed for the other mood state dimensions examined. (*J. Stud. Alcohol* **65:** 573-581, 2004)

ABSINTHE IS AN ALCOHOLIC BEVERAGE composed of extracts of a variety of herbs such as wormwood (Artemisia absinthium, L.), to which a particular psychedelic effect is ascribed. This effect is attributed to the terpenoid α-thujone that is abundant in wormwood oil. Beverages fortified with extract of wormwood were already consumed during the 4th through 2nd centuries B.C. (Papyrus Ebers) (Arnold, 1989; Dehal and Croteau, 1987). The selection of wormwood, however, was based on taste rather than on its ability to intoxicate because the oil can be dissolved only in highly concentrated alcohol. Distillation procedures, moreover, became available only at a much later time. The first official recipe for absinthe was published in Switzerland in 1792 by the French physician and exile Dr. Pierre Ordinaire (Huckenbeck, 2001). Only a few years later, the Swiss major, Dubied, and his son-in-law, Henri-Louis Pernod, opened the first large distilleries, and the production of absinthe turned into a flourishing business (Huckenbeck, 2001). In the 19th century, the consumption of absinthe virtually turned into a cult in Paris. The so-called *l'heure verte* (the green hour) was celebrated with great enthusiasm (Vogt and Montagne, 1982), and absinthe inspired both painters and poets. Bad grape harvests at that time led to a drastic increase in wine prices, and the population found refuge in absinthe, which could be produced using inexpensive industrial alcohol and was thus affordable for everybody. The increasing mass consumption and misuse of absinthe eventually made drinking it an ill-reputed act. On July 5, 1908, absinthe was banned in Switzerland after a man murdered his family while he was under its influence. Bans in other European countries followed. As a consequence, absinthe was used only occasionally—as a preventive measure against malaria in French soldiers during the Algerian war, for example. This therapeutic approach was also known in traditional Chinese medicine (Quing-hao plant is Artemisia annua) (Arnold, 1989; Hein et al., 2001; Höld et al., 2001; Huckenbeck, 2001; Vogt and Montagne, 1982).

Currently, absinthe is experiencing a renaissance because the processing of thujone-containing plants and extracts was again permitted in 1991 on the adoption of the flavor decree by European legislation. Since then, the purchase of absinthe has become legal, and absinthe has once again turned into a cult drink around which many rumors have arisen (Huckenbeck, 2001). Absinthe is said to have a psychoanaleptic effect and, sometimes, an effect comparable to that of cannabis, which is clearly different from that exerted by alcohol alone (del Castillo et al., 1975). Not much is known, however, about the objective effects of

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absinthe on general mood state and attentiveness. It was the aim of this study, therefore, to determine whether absinthe has effects on attention performance and mood state that are clearly different from those of alcohol.

Method

The study protocol was approved by the Ethical Committee of the Medical Faculty of the University of Heidelberg.

Subjects

A total of 25 healthy subjects (15 men) ages 19 to 58 years (average: 33.7 years) participated in the study. Three subjects were excluded because their alcohol absorption was insufficient.

Beverages

Each subject was offered three drinks containing identical amounts of alcohol but different amounts of thujone (100 mg/l, 10 mg/l, no α-thujone; Fluka, München, Germany). Thujone is available as a chemical reference material (purity 99%) for laboratory use only. In Germany its use is allowed only as an additive to food or beverages. For these reasons a thujone-alone subject group was not tested.

Because we did not want the subjects to know which drink they consumed, all drinks were matched to each other in color and taste by adding red food color and an infusion of fennelseed. The alcohol content was adjusted to 16 g/l in all beverages. The amount of liquid to be consumed depended on the weight of the subject. We tried to attain a maximum blood alcohol concentration (BAC) of 0.05% for each subject. The calculated total amount of thujone consumed by each subject in each experiment was 0.28 mg/kg weight (100 mg/l) and 0.028 mg/kg weight (10 mg/l) for men and 0.24 mg/kg weight (100 mg/l) and 0.024 mg/kg weight (10 mg/l) for women.

Tests

The subjects were tested using an attention performance test (APG; Mueller, 1980). This test was developed for aptitude diagnostics in the area of performance and is applied in the diagnostics of alcohol and drug-induced effects on visual orientation performance (Mueller, 1980; Strohbeck-Kuehner, 1998; Urban, 1992; Zuschlag and Jacobshagen, 1982). The attention performance test was chosen because it allows differentiation between the peripheral and central field of selective attention, a distinction that also has important implications in regard to driving. This differentiation allows the assessment of alterations in the field of attention (Werth, 1990).

The testing device is a signal-presenting tool consisting of three boards. The central board is equipped with nine lamps and is located in the subjects' central field of vision. The two adjacent boards, which are located in the subjects' peripheral fields of vision, are equipped with six lamps each. Using this experimental arrangement, an angle of vision of 130° is achieved. In intervals of 1.2 seconds the lamps flash irregularly and thus produce different patterns. Subjects were asked to press a button as soon as four neighboring lamps formed a square. In the present study, the 4-minute testing time included 50 of these signals (32 in the central field, 8 in the left peripheral field and 10 in the right). The number of correct reactions (differentiated according to central and peripheral field of attention), the unnoticed signals and the reactions that occurred without stimulation ("false alarm" reactions) were recorded. The reaction times were also recorded.

Mood was assessed using two questionnaires that test different mood dimensions. The Basel Mood Test questionnaire (BBF-Basler Befindlichkeitsskala; Hobi, 1985) records the factors "vitality," "intrapsychic equilibrium," "social extraversion" and "attentiveness." The general activation-high activation state scale (GA-HA-state; Wieland-Eckelmann, 1992) records state anxiety and current subjective activation.

Experimental design

Every subject had to undergo all three treatments (no thujone, 10 mg and 100 mg thujone/l). Each treatment was performed on a different day. The sequence of the individual treatments was randomized. To take daily variations into account, the experiments were always carried out at the same time of day. Several days before the first experiment, the subjects had to undergo a training phase with the attention-performance-testing device to get acquainted with the tool and thus reduce effects usually obtained with repeated measurement. In each session the subjects answered the mood state while testing negative for blood alcohol (T0). The attention performance of the subject was then assessed with the attention performance test. Subsequently, the subjects received a small standard meal (a roll with ham or cheese) and then the beverage, which had to be drunk within 10 minutes. All tests were performed once again 30 (T1) and 90 (T2) minutes after drinking. The mood state questionnaires were administered first and attention performance was tested immediately afterwards. Alcohol concentration was then measured using a breath analyzer (Siemens Alcomat; Siemens AG, Ditzingen, Germany), and a blood sample was taken to determine the BAC. The concentration of alcohol was determined by both flame-ionization gas chromatography/headspace analysis (Perkin Elmer, Konstanz, Germany) and an enzymatic method involving alcohol dehydrogenase (ethyl alcohol; Microgenics, Passau,

TABLE 1. Means of blood alcohol concentration (BAC in %) and breath alcohol concentration (BrAC in %) at T1 (30 minutes after alcohol intake) and T2 (90 minutes after alcohol intake)

	T1		T2	
	BAC	BrAC	BAC	BrAC
Without thujone	0.040	0.039	0.029	0.025
Low thujone	0.039	0.039	0.028	0.023
High thujone	0.039	0.038	0.029	0.025

Germany). Each method was run in duplicate, and values given are the means ($n = 4$). The measurement points T1 and T2 were chosen to catch the BAC at its maximum and during the elimination phase, respectively. On completion of the study, the subjects were asked which beverage they believed they had consumed on each of the 3 days.

Statistical analysis

The three treatment conditions (no thujone, 10 mg and 100 mg thujone/l) represent the independent variables and the five attention parameters (attention in the central and peripheral field of vision, the reaction time in the central and peripheral field of vision and the number of "false alarm" reactions) as well as the mood dimensions—the dependent variables.

Results were analyzed by ANOVA *t* test for conjoint measurement. Statistical calculations were carried out using SPSS (Version 11.5; SPSS GmbH Software, München, Germany). A p value <.05 was considered to be statistically significant.

Results

The objective of this study was to examine whether the impacts of absinthe on attention performance and mood were different from those of beverages that contain only alcohol.

We first tested whether the subjects were able to classify the consumed drinks correctly. Only three of the 22 subjects were able to do so; hence, we can assume that subjects' expectations did not affect performance or mood, and expectation effects did not have to be taken into consideration.

TABLE 2. *P* values of changes in attention performance from T0 to T1 and from T0 to T2 under the influence of alcohol alone (without thujone): Testing negative for blood alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2)

	p	
	T0-T1	T0-T2
Correct reactions-central	.710	.613
Correct reactions-peripheral	.333	.565
Time central	.106	.203
Time peripheral	.985	.336
False alarm reaction	.468	.612

TABLE 3. *P* values of changes in attention performance from T0 to T1 and from T0 to T2 at low thujone concentrations: Testing negative for blood alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2)

	p	
	T0-T1	T0-T2
Correct reactions-central	.134	.220
Correct reactions-peripheral	.363	.118
Time central	.245	.425
Time peripheral	.296	.173
False alarm reaction	.815	.073

Because the individual BACs (Table 1) differed, we tested the dependence of BAC differences, and alterations in attention performance were measured by the applied test; we followed the same procedure if changes in the mood state depended on the BAC. To do this, the BAC values were correlated with the changes in attention performance and mood state between T0 and T1, as well as between T0 and T2. To exclude accidental results obtained because the number of tested correlations was large, the data were alpha adjusted according to Bonferroni.

Pearson's correlations between the change in attention performance from T0 to T1 and the BAC were, in most cases, close to zero. Significant correlations were not observed. With regard to mood alterations (T0-T1), there were no indications that they could be primarily explained by differences in BAC (Spearman correlations). The correlation of the differences of the results obtained from the assessment of attention performance at T0 and T2 with the BAC also did not show significant differences in the mood state or attention performance values.

As the influence of blood alcohol concentration seems to have no impact on the alteration of attention performance, the changes in attention performance from T0 to T1 and from T0 to T2 could be analyzed for the three treatments independent of BAC. The design was analyzed separately for the three treatments referring to changes from T0 to T1 and from T0 to T2. The results (see Tables 2-4, Figures 1-5) revealed no significant alterations in attention performance after the consumption of alcohol and low thujone concentration.

TABLE 4. *P* values of changes in attention performance from T0 to T1 and from T0 to T2 at high thujone concentrations: Testing negative for blood alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2)

	p	
	T0-T1	T0-T2
Correct reactions-central	.111	.465
Correct reactions-peripheral	.003	.073
Time central	.028	.391
Time peripheral	.045	.068
False alarm reaction	.005	.363

The number of correct reactions in the peripheral field of attention, however, decreased significantly ($p < .01$) when the subjects were under the influence of the high thujone concentration (Figure 2). Reaction time increased significantly in both the peripheral and central fields of attention ($p < .05$) (Figures 4 and 5). The number of "false alarm" reactions also increased ($p < .01$) (Figure 1). No differences could be observed regarding the number of correct reactions in the central field of attention (Figure 3).

An analysis of the changes of performance from T0 to T2 by the procedure described above (see Tables 2-4) revealed results that show a pattern similar to, but less pronounced than, that observed for alterations in attention performance at T0, in contrast to T1, under the high thujone condition. Although we found no significant differences, a tendency ($p < .10$) could be observed for the reaction in the peripheral field of attention to deteriorate at T2 in comparison with T0 under the high thujone condition (Table 4). We also found a tendency towards longer reaction time at T2 in the central and peripheral field of attention ($p < .10$), whereas the number of correct reactions in the central field of attention and "false alarm" reactions did not differ. When the subjects were exposed only to alcohol or only to low thujone concentrations, no differences in attention performance were observed (Tables 2 and 3).

TABLE 5. *P* values of changes in mood state from T0 to T1 and from T0 to T2 under the influence of alcohol alone (without thujone): Testing negative for blood alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2)

	p	
	T0-T1	T0-T2
State anxiety	.007	.003
Subjective activation	.130	.059
Vitality	.304	.013
Intrapsychic equilibrium	.678	.529
Social extraversion	.088	.391
Attentiveness	.002	.002

We next analyzed differences in attention performance between the three treatments. ANOVA that tested significant differences in the alteration of attention performance between the three treatments revealed no significant differences in attention performance either from T0 to T1 or from T0 to T2 (all F values <2.426).

When the tested mood dimensions obtained at T0 were compared with those of T1 (Tables 5-7), a significant decrease of "attentiveness" was observed under all three

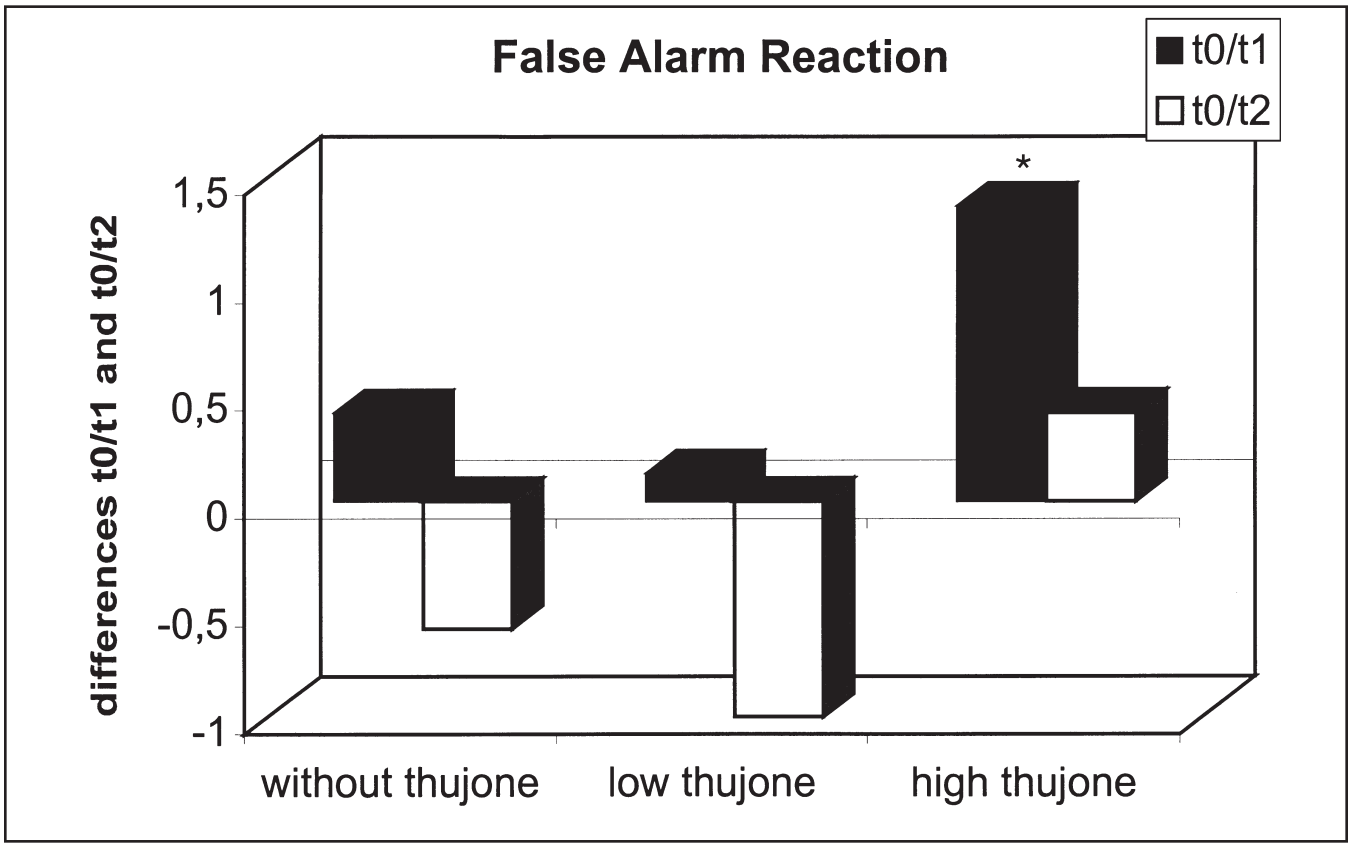

FIGURE 1. Comparison of the differences of false alarm reaction at T0-T1 (T0-T2) for the three treatments: Testing negative for alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2) (*indicates significant differences)

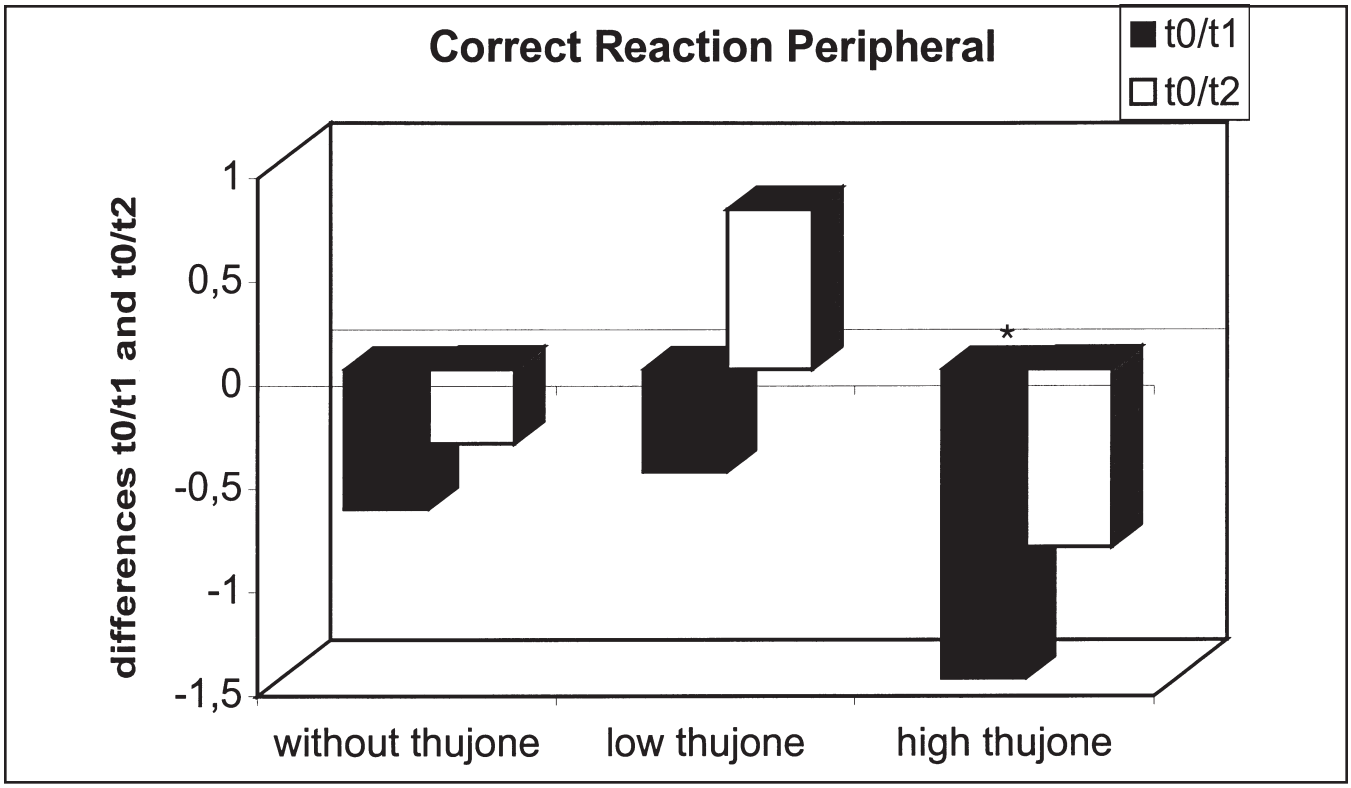

FIGURE 2. Comparison of the differences of peripheral correct reactions at T0-T1 (T0-T2) for the three treatments: Testing negative for alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2) (*indicates significant differences)

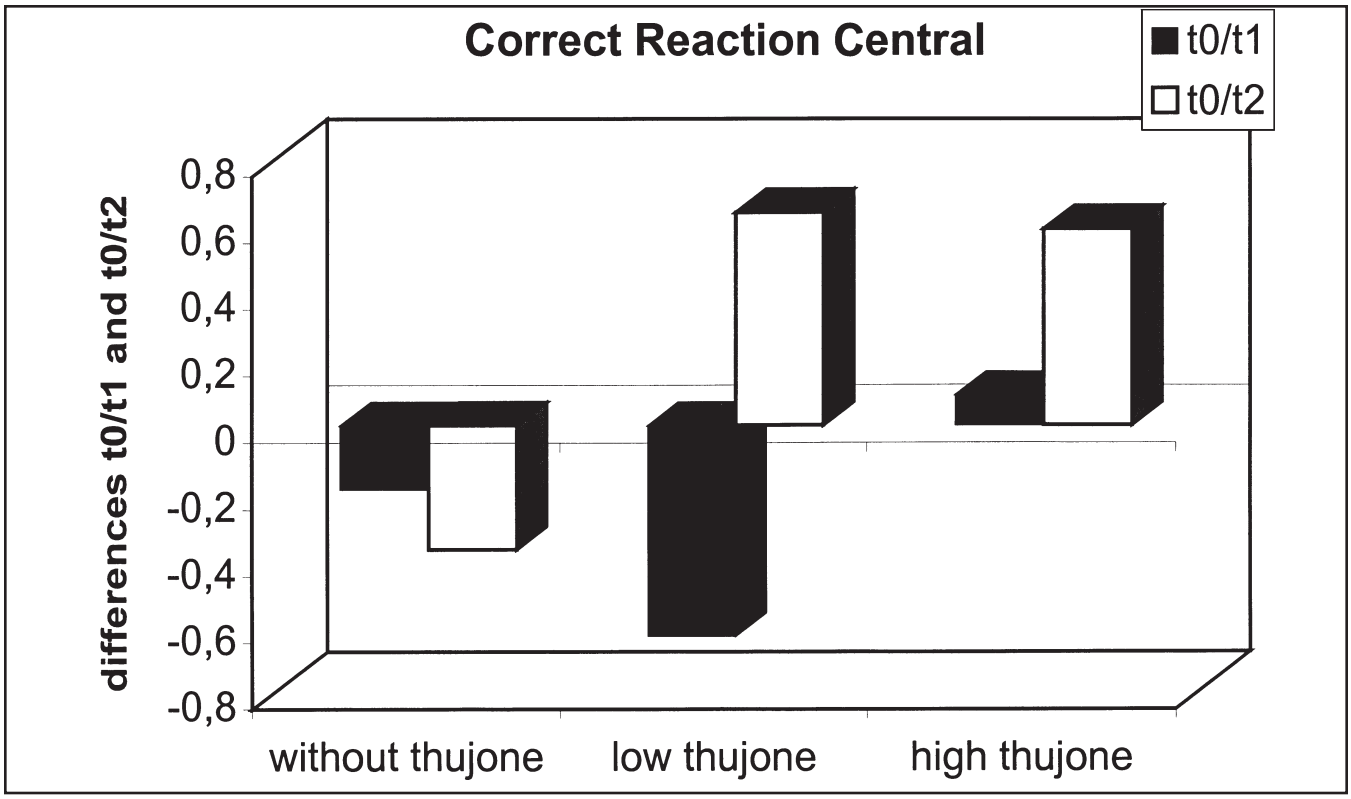

FIGURE 3. Comparison of the differences of central correct reactions at T0-T1 (T0-T2) for the three treatments: Testing negative for alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2)

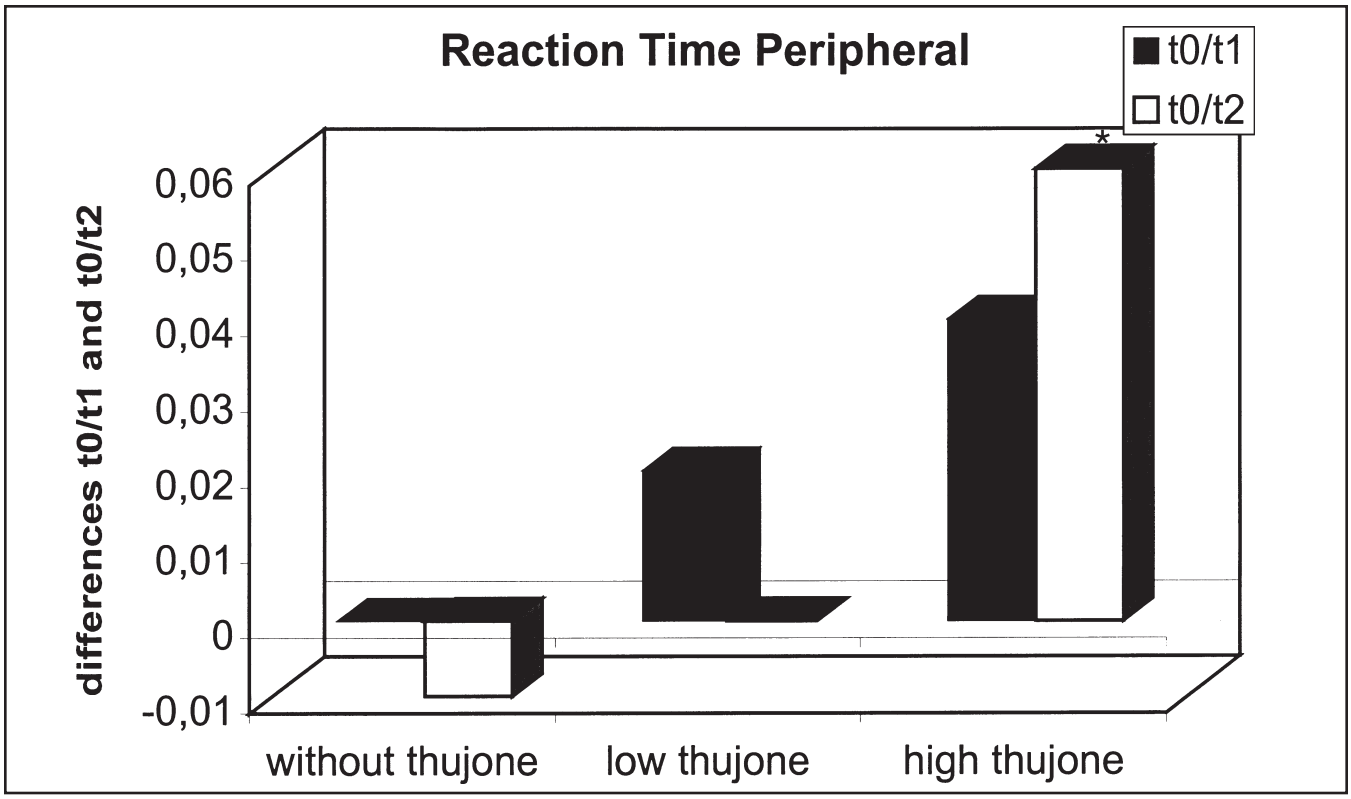

FIGURE 4. Comparison of the differences of peripheral reaction time at T0-T1 (T0-T2) for the three treatments: Testing negative for alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2) (*indicates significant differences)

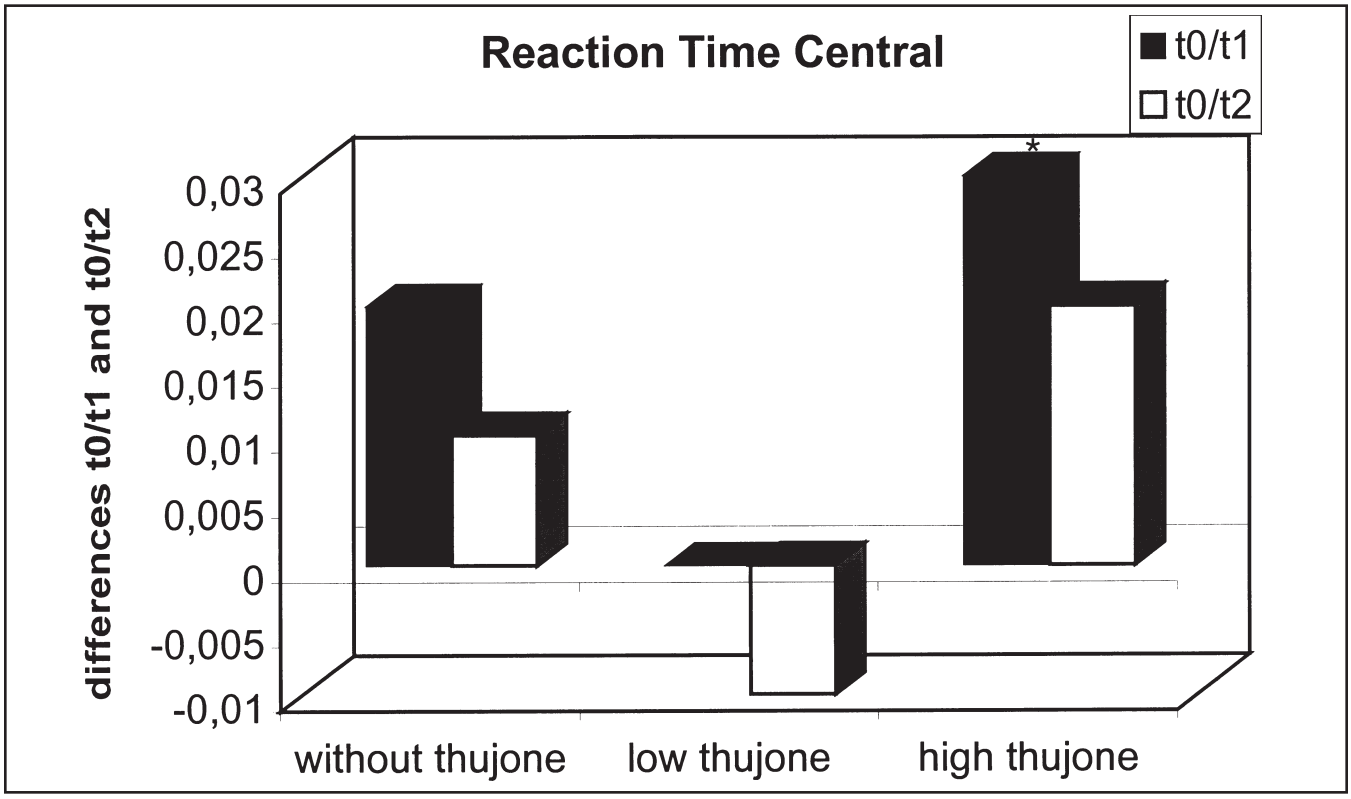

FIGURE 5. Comparison of the differences of central reaction time at T0-T1 (T0-T2) for the three treatments: Testing negative for alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2) (*indicates significant differences)

TABLE 6. *P* values of changes in mood state from T0 to T1 and from T0 to T2 at low thujone concentrations: Testing negative for blood alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2)

	p	
	T0-T1	T0-T2
State anxiety	.301	.228
Activation	.379	.012
Vitality	.107	.024
Intrapsychic equilibrium	.775	.773
Social extraversion	.023	.431
Attentiveness	.015	.016

experimental conditions. Simultaneously, an increase in "social extraversion" was observed. If only alcohol was consumed, the "state anxiety" decreased significantly. No differences were observed with regard to "subjective activation," "vitality" and "intrapsychic equilibrium."

In contrast to the T1 values obtained for attention performance, which were very similar to the values measured at T0, the mood state changes at T2 seemed to persist or to be partly more prominent (see Tables 5-7). At T2, the condition "alcohol alone" (Table 5) reveals a consistently low value of "state anxiety" and "attentiveness." Lower values of "subjective activation" and "vitality" were also measured. On the other hand, the condition "social extraversion" demonstrated elevated values at T1 but decreased to the initial level at T2. The decreases in "subjective activation" and "vitality" and the decrease in "social extraversion" to the initial level could also be measured for the respective thujone concentrations (Tables 6 and 7). A lower degree of "attentiveness" was measured at both points in time. A significant reduction in "state anxiety" at T2 compared with T1 was observed at the high thujone concentration (Table 7).

As in the procedure for depicting the alterations in attention performance, the alterations in the mood state were compared with each other for all three treatment conditions. Friedman rank variance analyses provided no significant differences in the alternation of the tested mood dimensions (all chi-square values <3.04).

TABLE 7. *P* values of changes in mood state from T0 to T1 and from T0 to T2 at high thujone concentrations: Testing negative for blood alcohol (T0), 30 minutes after alcohol intake (T1), 90 minutes after alcohol intake (T2)

	p	
	T0-T1	T0-T2
State anxiety	.182	.023
Activation	.364	.018
Vitality	.726	.052
Intrapsychic equilibrium	.163	.072
Social extraversion	.047	.558
Attentiveness	.032	.069

Discussion

Because absinthe was banned for nearly a century, only few case studies or anecdotal observations are available for the beverage and must be interpreted with caution (Albert-Puelo, 1981; Arnold, 1988, 1989; Bonkovsky et al., 1992; Huckenbeck, 2001; Loftus and Arnold, 1991; Monroe, 1991; Strang et al., 1999; Vogt and Montagne, 1982; Weisbord, 1997). Most of the observations ascribed to the effect of absinthe were not scientifically sound. Because the number of such studies is small, it is not possible in retrospect to clearly differentiate the effect of absinthe from that of alcohol (Hein et al., 2001; Olsen, 2000).

In the present study, the effects of a merely alcoholic beverage on attention performance and mood state were compared with beverages containing both alcohol and thujone. The difference of low and high thujone concentration was also tested. A thujone-alone group was not tested because thujone is only permitted to be used as an additive to food and beverages. Thujone is present in some alcoholic beverages, the most prominent being absinthe. The maximum level in the final product ready for consumption is 100 mg/l.

No significant changes were observed in attention performance when beverages with alcohol and low thujone concentration were consumed. Only high thujone concentrations led to significant effects. These were most prominent in test phase T0-T1. In test phase T0-T2, the observed changes were similar to those in the first test phase in all performance parameters but were less pronounced. In test phase T0-T1, the missing alteration in attention performance at low thujone concentrations can be explained by alcohol antagonizing the effect of thujone (Höld et al., 2000).

Consumption of alcohol or alcohol containing the low thujone concentration led to no significant decrease in attention performance. The number of correct reactions decreased significantly, however, at high thujone concentrations. Other studies have shown that people under the influence of alcohol were unable to direct their attention to central and peripheral stimuli simultaneously but tended to concentrate on stimuli in the central field of attention while neglecting signals in the peripheral field of perception (Strohbeck-Kuehner, 1998). These results coincide with those noted by Gustafson (1986), Lamb and Robertson (1987), Marks and Macavoy (1989), Patel (1988) and Strohbeck-Kuehner and Thieme (1998). However, these studies were carried out using higher alcohol concentrations than were used in the present study. The experimental arrangement of this study's attention performance test, however, permits even slight disturbances in attention performance at low alcohol concentrations to be observed. Performance was not reduced at the relatively low BAC values when alcohol alone was consumed. Since we found no significant effects between the treatments when com-

paring the performance differences from T0 to T1, we can assume that the effects of the high thujone condition are quantitative but not qualitative. Our observation that the performance was reduced under high thujone dosage is similar to the observations proposed in other studies. It can be concluded, therefore, that thujone influences attention performance. One possible explanation of this finding is that the effects of alcohol on attentional processing may be an inverted U-shaped function and that thujone simply shifts the dose-effect function to the left.

Although the effect of high thujone concentration had only a short-term effect on attention performance, the changes in the mood state persisted for a longer period or came to fruition only at a much later stage. The changes in the tested mood dimension were similar under all three experimental treatments, with the exception only of state anxiety. At T1 the subjects already judged themselves to be less anxious than at T0. This effect could not be observed at low thujone concentrations; only high thujone concentrations led to a decrease in state anxiety at T2. It is possible to explain the different experience of fear by an interaction of thujone and alcohol at the gamma-aminobutyirc acid (GABA) receptor (Höld et al., 2001; Olsen, 2000) because α-thujone has been shown to act as a GABA type-A receptor antagonistic (Höld et al., 2000). GABA antagonists lead to an increase in fear sensations and also have a stimulating and rousing effect. The effects of α-thujone are opposed to those caused by GABA-enhancing drugs such as ethanol, diazepam or phenobarbital, which are anxiolytic, sedative and amnesic.

The effect at the GABA receptor might also explain an elevated number of "false alarm" reactions when the subjects acted under higher thujone concentrations. In general, these kinds of reaction are signs of exaggerated motivation that can be expected mainly at a higher level of anxiety or fear. Thujone enhances the motivation to provide a good performance. Increased motivation and a simultaneous experience of anxiety or fear are not linked to better attention and thus better performance. The combination of motivation and fear leads to undirected action and thus to a higher number of "false alarm" reactions. The increase in state anxiety and intrapsychic equilibrium can also be attributed to the psychoactivating effect of thujone as observed by Ott (1993) and Pendell (1995) in cases of smoking dried wormwood. Huckenbeck (2001) and Arnold (1988) also reported elevated stimulation of the vegetative nervous system caused by thujone.

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