Effects of Combined Exposure to Trichloroethylene and Alcohol on Mental Capacity

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Summary. Adult male volunteers inhaled a constant concentration of 200 ppm trichloroethylene for 2 1/2 hours, ingested ethanol (0.35 gr/kg body weight) or were exposed to the combination of trichloroethylene and ethanol. After exposure Ss performed a few mental tasks. Performance as indicator of external load and the physiological parameters heart rate, sinus arrhythmia and in the final experiment also breathing rate as indicators of functional load were used as dependent variables. Exposure to a combination of trichloroethylene and alcohol leads to an increase of functional load while performing a mental task, even when exposure to only trichloroethylene or alcohol has no effect. Difficulties in experimental design and interpretation of research of „combined stress“ are discussed.

Key words: Alcohol – Trichloroethylene – Mental Capacity – Performance

In a previous publication (Ettema et al., 1975 a, b) we reported on the effects on mental capacity in exposure to alcohol, carbon monoxide or trichloroethylene. Alcohol produced marked effects at blood alcohol levels > 0.3 g/l, the effects from carbon monoxide and trichloroethylene in dosages as encountered in social and occupational live proved to be much less severe, at most borderline. However, this, in itself already restricted conclusion, only applies to situations with exposure to one toxic substance. When two or more substances — each in a socially accepted dosage — are present in a given situation, the total effect of combined exposure might surpass the tolerance level. So studying the effects of exposure to one toxic substance, one may not conclude that a given dosage can be regarded as safe, when no information on the effects of other stresses, such as other toxic substances, mental load or noise, is present.

In the present study we tried to evaluate the effect on mental capacity of exposure to a combination of two toxic substances, i. e., alcohol and trichloroethylene (more detailed information in Windemuller, 1977). This combination of a solvent — solvents are frequently used not only in industry — and alcohol — the use of which is not uncommon after and sometimes during working hours — serves as a first example of the difficulties in exploring the effects of „combined stress“.
Several authors mentioned side-effects of the combination of trichloroethylene and alcohol. Bardodej et al. (1956) and Smith (1970) found oversensitiveness to alcohol in workers exposed to trichloroethylene. Stewart et al. (1974) and Smith (1966) reported on the so-called "degreasers flush" after using alcohol in subjects exposed for three weeks each day for a few hours to 20–200 ppm trichloroethylene. In our studies with only short-term exposure to trichloroethylene we did not expect and indeed did not find such reactions. The metabolism of trichloroethylene is influenced by alcohol, the concentration of trichloroethylene in blood and exhaled air after exposure being increased (Müller et al., 1975).

Effect on visual-motor-performance is reported by Ferguson et al. (1970); in three of five tests performance was impaired.

Mental Load

In work physiology one speaks of mental load, indicating the "cost" on mental activity, i.e., the biological consequences for the organism. An important aspect of mental activity, for instance in industrial tasks, is the handling of information. Contrary to other psychological aspects, such as emotion, it is possible to manipulate the mental load quantitatively by changing the amount of information handling per unit of time.

The principal limiting factors in information handling are the choice-making mechanisms, which seem to function as a single channel (Welford 1959). In the concept of mental load, not the complexity of a task but the amount of information handled per time unit (the intensity) determines the mental load. So a very complicated arithmetic task to be solved in several hours may mean a smaller mental load than easy tasks such as adding two ciphers, but to be performed in great number in a short period. In this sense, mental load appears to induce a systematical change of many physiological parameters, e.g., heart rate, sinus arrhythmia (the irregularity of the heart rate pattern), breathing rate, blood pressure (Ettema et al., 1971).

If any intervening factor, e.g., exposure to a toxic substance, impairs mental capacity, the subject may not be able to keep up his maximal performance, as determined in experiments in which that factor is not present; he will handle less information per time unit adequately. When the mental load is submaximal, however, as in most industrial situations, one may hypothesize that even if the total available capacity is decreased by intervening factors, the subject will be able to keep up his performance by greater functional exertion, i.e., at greater "cost". In this case this should be observed in a change of physiological parameters. With mental load a suppression of sinus arrhythmia occurs; if combined with an intervening factor, a further suppression might be expected.

In the present experiments the effect on mental load of a combination of alcohol and trichloroethylene may show — when present — in several ways: 1. Impairment of performance due to not following instructions. 2. When performance is not influenced an effect may appear as a change of the parameters of functional load even when trichloroethylene or alcohol dosage as such do not have any effect. 3. When trichloroethylene and/or alcohol influences some physiological parameter of mental load the effect of the combination may be greater.

Material and Methods

Subjects

A pilot experiment was carried out with 24 healthy male students, age 19–26 yrs. They were divided into four groups of 6 Ss each, each group only participating in one session: control condition, condition with exposure to trichloroethylene, condition with exposure to alcohol or condition with exposure to trichloroethylene and alcohol. For statistical analysis the group results were compared.

The final experiment was carried out with 15 students (not the same as in the pilot experiment), but now each subject participated four times, in each condition one time. For statistical analysis