

Neurophysiological findings among workers exposed to organic solvents

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SEPPÄLÄINEN AM. Neurophysiological findings among workers exposed to organic solvents. *Scand j work environ health* 7 (1981): suppl 4, 29—33. Workers exposed to organic solvents often complain of symptoms indicating central or peripheral nervous system effects. Neurophysiological methods offer a sensitive and noninvasive way to study early impairment in the nervous system. The present communication is a review of neurophysiological studies done at the Institute of Occupational Health, Helsinki. The studies concern workers occupationally exposed to various solvents. Both encephalopathic and neuropathic findings were frequent, especially among patients with solvent poisoning. Certain exposure-response relationships emerged when the prevalence of abnormal electroencephalograms was studied in various groups of workers exposed to different levels of solvents.

Key terms: electroencephalography, electroneuromyography, neurophysiological methods, solvent exposure.

The usual symptoms complained of by workers occupationally exposed to organic solvents are, eg, headache, vertigo, a feeling of drunkenness, poor memory, and insomnia or other sleep disturbances. These symptoms could be related to dysfunction or lesions in the central nervous system.

Lately, attention has been paid to peripheral neuropathy caused by solvents (1, 2, 4, 5). In severe cases such neuropathy can lead to paresis of, especially, the lower limbs, and in milder cases it is manifested as numbness and, possibly, as pain in the extremities.

Although a careful neurological examination may reveal signs of neural damage, more sensitive and objective measures are needed to prove early impairment in cases with mainly subjective symptoms. Objec-

tive measures are also needed in epidemiologic studies on groups of exposed workers and referents.

Neural functions can be studied with neurophysiological techniques, which have lately been extended into new areas with the aid of modern computer methods. The well-known tool used to study brain lesions, electroencephalography (EEG), has been linked with computer-assisted methods of analyzing spontaneous electrical activity of the brain and evoked potential techniques. The latter refers to the study of brain activity elicited by external stimuli like light, sound, or other sensory stimuli. Evoked potentials are so low in amplitude that they are completely masked by spontaneous electrical activity; their latencies and forms can be studied with computerized averaging, which improves the signal-to-noise ratio.

The peripheral nervous system and muscles are studied with electromyography and electroneurography. Electromyography (EMG) helps to diagnose neurogenic and myogenic diseases. Electroneurography, which refers to the measur-

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ing of motor and sensory nerve conduction velocities and to the study of electrical activity of nerves, reveals neuropathy and helps to localize neurogenic lesions. When nerve action potentials are studied, eg, in the measurement of sensory conduction velocities, computer-assisted techniques are needed.

The present communication is a review of neurophysiological studies done at the Institute of Occupational Health, Helsinki.

In high concentrations most organic solvents have narcotic effects, and consequently changes occur in the EEG activity of exposed persons. Low concentrations, eg, those within presently applied threshold limit values (TLVs) usually do not affect the spontaneous EEG. During exposure to varying levels (50 to 400 ppm with a time-weighted average exposure of 100 or 200 ppm) of m-xylene, an increased occurrence of slow transients in the occipital areas has been noted in four studied subjects; these changes probably represent a slight lowering of the vigilance level (11). Among German workers with long-term occupational exposure to trichloroethylene some changes have been noted in EEGs registered telemetrically during the workday (9); these changes were probably related to lowered vigilance. However, some changes can be noted in evoked potentials during and shortly after exposure lasting only a few hours (17, 19).

Long-term occupational exposure to solvents has caused an increased frequency of abnormal EEGs among workers (6, 12). Patients with a psychoorganic syndrome or other neurological signs caused by solvents often have an abnormal EEG (3, 7).

Styrene exposure can be monitored through the measurement of the urinary mandelic acid concentration after the workday. Ninety-seven workers employed in the reinforced plastics industry were submitted to EEG studies, and their styrene exposure was graded according to urinary mandelic acid concentrations based on the mean of five measurements taken during five consecutive weeks, on a different weekday every time (13). An exposure-response relationship emerged in this study, as the frequency of abnormal EEGs increased as the exposure level increased, the noneffect level corre-

sponding to a urinary mandelic acid concentration of 700 mg/l (4.9 mmol/l). No clear relationship was noted between polyneuropathic signs and styrene exposure; the few workers with slightly slowed nerve conduction velocities all had a low exposure level in the study period.

Carbon disulfide is well known for its neurotoxicity (14). In one study viscose rayon workers with a median of 15 a of exposure to 10–30 ppm of carbon disulfide had abnormal EEGs in 39 % of the cases, while 12 % of the age-matched papermill workers had abnormal EEGs (18). Motor nerve conduction velocities, especially in the legs, but also in the arms, were statistically significantly slower among 118 viscose workers than among 100 papermill workers with a similar age distribution (18).

Abnormal EEGs were usual among 233 workers who had been occupationally exposed to various solvents or their mixtures and who had been referred to an EEG examination because of suspected solvent poisoning or because, in a periodic health examination, they had expressed symptoms suggesting dysfunctions in the central nervous system (CNS) (12). The exposure to solvents was graded into three categories according to information given by the employee and employer and, at times, by hygienic measurements made at the work sites. Exposure category I denoted low-level or occasional exposure, category II intermediate exposure, and category III referred to exposure levels close to the present TLV. A certain exposure-response relationship was noted, as workers of exposure category III had abnormal EEGs significantly more often than workers in exposure categories I and II (fig 1). In the highest exposure category abnormal EEGs were recorded for over 70 % of the subjects; in the other two categories around 40 % of the subjects had abnormal EEGs.

Abnormally slow nerve conduction velocities were found in many solvent exposed workers (12). Fig 2 displays the cumulative percentage distribution of the conduction velocity scores of 107 workers exposed to solvents. This score indicates the number of abnormally slow conduction velocities (out of four motor conduction

velocities) of each person; a person with normal conduction velocities was given a score of 0 and one with, eg, three abnormally slow velocities received a score of 3. The workers of exposure category III had the highest frequency of abnormal values, and those in category I the lowest.

Among actual patients with solvent poisoning, abnormal EEGs are also frequent. During 1971–1973 neurophysiological and psychological examinations were given to 107 patients who, on the basis of various medical examinations, were diagnosed as suffering from solvent poisoning; exposure to various solvents was always established and adequate differential diagnostics considered (16). Of these patients 48 were men with a mean exposure of 9.6 a, and 59 were women with a mean exposure of 7.6 a. An abnormal EEG was recorded for 70 subjects (65.5 %). Electro-neuromyographic examinations were given to 77 of the patients, 48 of whom had signs of neuropathy. There was some tendency for those with higher exposure levels to have more abnormal nerve conduction velocities, but patients with intermediate and high exposure (ie, close to the TLV) to solvents had abnormal EEGs in the same proportions. Patients with solvent poisoning represent a higher degree of selection than workers coming to periodic health examinations and complaining of some CNS symptoms when questioned about such symptoms. Among patients a certain number of persons is always more susceptible to the effects of solvents than the average worker; thus the exposure-response relationship is obscured.

Some interesting relationships were discovered between EEG and psychological findings (16). For example the frequency of the background activity in the EEG correlates to performance on the Digit Span subtest of the Wechsler Adult Intelligence Scale — persons with a good performance on this test show a higher background frequency.

The fact that exposure-response relationships between estimated solvent exposure and EEG findings have not been clearly shown among some groups of solvent-exposed workers may depend partly on the difficulties of estimating past exposure and partly on selection, which is un-

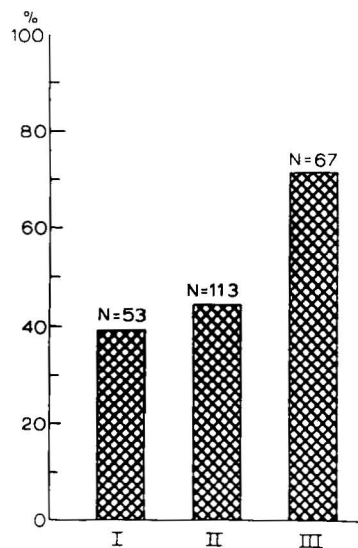


Fig 1. Percentage of abnormal EEGs among 233 solvent-exposed workers with symptoms divided into three exposure categories. The difference is statistically significant between I and III ($\chi^2 = 11.14$, $p < 0.001$) and II and III ($\chi^2 = 11.65$, $p < 0.001$). (I = mild exposure, II = intermediate exposure, III = high exposure, and N = the number of subjects in each category)

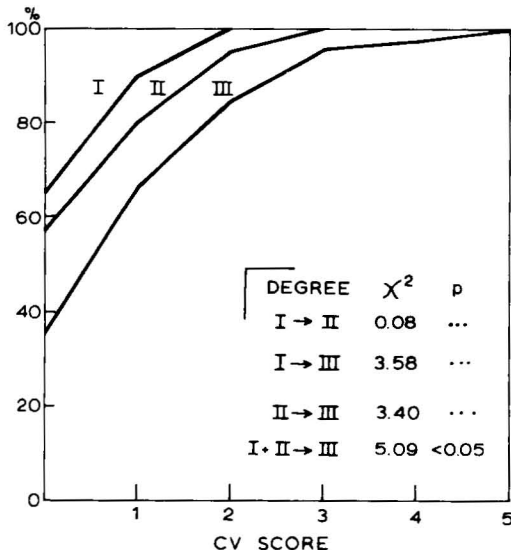


Fig 2. Cumulative percentage distribution of conduction velocity scores (CV scores), denoting the number of abnormally slow nerve conduction velocities, among 107 solvent-exposed workers with symptoms divided into three categories. (I = mild exposure, II = intermediate exposure, III = high exposure)

Table 1. Percentage of abnormal electroencephalograms among solvent-exposed workers in various studies conducted at the Institute of Occupational Health in Helsinki.

Study	Number of workers	Percentage
Lindström & Seppäläinen (10)	72 painters in the building industry	17
Seppäläinen et al (15)	102 car painters	31
Seppäläinen (12)	233 solvent-exposed workers with symptoms	40—72
Seppäläinen et al (16)	107 patients with solvent poisoning	65

avoidable in cross-sectional studies. However, when the frequency of abnormal EEGs is studied in various groups of solvent-exposed workers, a certain relationship is noted between exposure level and EEG findings (table 1). Painters in the building industry are generally exposed only to low concentrations of mixtures of solvents (10), and the prevalence of abnormal EEGs among them is of the same order as that stated in the literature concerning a normal population (8). Car painters may, however, have higher exposure peaks than painters in the building industry, and they have been shown to have a slightly higher frequency of abnormal EEGs, although the frequency did not differ from that of the respective reference group (15). Patients with solvent poisoning have a much higher prevalence of abnormal EEGs than either of the other two groups.

In all groups of workers with solvent exposure EEG abnormalities have mainly comprised excessive amounts of slow activity in the waking record, usually in the theta range (4—7 cps). In about 60 % of the cases, the slow activity has been found diffusely in all brain areas, while it is localized in one area or one hemisphere in about 40 %. Some subjects, usually 5 to 10 % of patients, show paroxysmal EEG abnormalities in the form of spikes or spike-and-wave discharges, which probably indicate a lowered threshold towards seizures.

Studies at the Institute of Occupational Health in Helsinki have thus shown that both neuropathic signs in electroneuromyography and abnormal EEGs indicating cerebral dysfunction are found among solvent-exposed workers, as well as among patients with solvent poisoning. Neurophysiological methods are helpful in aiding the diagnosis in such cases.

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