

TCE Murao

Evaluation of the psychophysiological functions in humans exposed to trichloroethylene

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Salvini, M., Binaschi, S., and Riva, M. (1971). *Brit. J. industr. Med.*, 28, 293-295. Evaluation of the psychophysiological functions in humans exposed to trichloroethylene. To provide data on the psychophysiological efficiency of human beings exposed to solvent vapour currently used in the industry the effects of trichloroethylene (TCE) were evaluated by exposing six male university students to an average vapour concentration of 110 p.p.m. for two 4-hour exposures, separated by a 1½-hour interval. Each subject was examined on two different days, on one day undertaking a set of tests in an atmosphere contaminated with TCE vapours and on another day in a 'control' atmosphere which did not contain TCE.

On each of the two days two sets of test were performed at 8.30 a.m. and at 6 p.m. The following tests were performed: perception test with tachistoscopic presentation, Wechsler Memory Scale, complex reaction time test, and manual dexterity test. A crossed scheme analysis was used. In all the tests performed a statistically very significant decrease in performance ability was seen; the greatest decrease occurred during the more complex tests. The suggested TLV for TCE (100 p.p.m.) appears to be very close to the average concentration capable of interfering with psychophysiological efficiency, even in the absence of other undesirable subjective and objective manifestations.

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Experiments performed on experimental animals to ascertain the effects of trichloroethylene (TCE) vapour have shown that this substance interfered with their psychophysiological efficiency (Grandjean and Bättig, 1964).

Recently, experiments have been conducted to find whether the same phenomenon occurs in humans. In one experiment, a human subject was exposed to four concentrations of TCE for 2 hours + 5 minutes. The results indicated that at the TLV of TCE (100 p.p.m., as recommended by the American Conference of Governmental Industrial Hygienists, 1967), no significant effects occurred in human

psychomotive efficiency (Stopps and McLaughlin, 1967). This conclusion may be questioned on two grounds: firstly, all of Stopps's experiments were performed for a limited period, not comparable to the 8-hour working day; secondly, the results are of somewhat limited value because only one human being was exposed.

Therefore, to provide more realistic and reliable information on the psychophysiological efficiency of human beings exposed to solvent vapours currently used in industry, a research programme was initiated to evaluate the effects on six persons exposed to TCE at an atmospheric concentration of 110 p.p.m. for 8 working hours.

Methods

The effects of TCE were evaluated by exposing six male

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university students, between 20 and 22 years of age, to an average vapour concentration of 110 p.p.m. and fluctuations between 90 p.p.m. and 130 p.p.m. TCE was periodically atomized into the test room to maintain the desired concentration. The air was analysed at regular intervals by gas-chromatography. The temperature, humidity, and ventilation rates were kept constant (dry bulb temperature 20 °C; relative humidity 45%).

Details of the experimental method are similar to those given in the companion paper (Salvini, Binaschi, and Riva, 1971).

During each exposure the following tests were applied (for details, see the companion paper):

1. *Perception test* with tachistoscopic presentation (exposure time 1/20 sec) - to evaluate the extension of the perceptive field, the span of perception, and the organizing capacity of stimuli in space;

2. *Wechsler Memory Scale* - to evaluate immediate memory and the perceptive field extension;

3. *Complex reaction time* - to evaluate the time lapse between different visual stimuli and the correct psychomotor response and the regularity between stimuli and response intervals.

Manual dexterity tests involving the right, left, and both hands simultaneously were also conducted.

Results

From an objective clinical standpoint, no disturbances in motor functions, co-ordination, equilibrium or behaviour patterns were observed after two 4-hour exposures to TCE. A slight sense of dizziness coincided with the maximum fluctuations in TCE concentrations. During these periods some transient eye irritation was observed. All the test subjects complained about the odour of TCE.

In all the tests performed there was a statistically significant decrease in performance ability; the greatest decrease occurred during the more complex experiments (Tables 1 to 5).

TABLE 1
PERCEPTIVE TEST - ANALYSIS OF VARIANCE

	SSQ	D.F.	S ²	F
Trichloroethylene (TCE)	28.12	1	28.12	27.84 ²
Mental fatigue (MF)	2.34	1	2.34	2.32
TCE × MF	15.81	1	15.81	15.65 ²
Learning (L)	35.02	1	35.02	34.67 ²
L × MF	15.75	1	15.75	15.59 ²
Subjects (S)	38.60	5	7.72	7.64 ¹
S × MF	15.10	5	3.02	2.99
Error	8.11	8	1.01	

¹p < 0.05 ²p < 0.01 ³p < 0.001

SSQ sum of square about the mean
D.F. degrees of freedom
S² estimate of variance
F Snedecor's variance ratio

TABLE 2
IMMEDIATE MEMORY TEST - ANALYSIS OF VARIANCE

	SSQ	D.F.	S ²	F
Trichloroethylene (TCE)	462.68	1	462.68	27.4
Mental fatigue (MF)	85.58	1	85.58	5.5
TCE × MF	216.74	1	216.74	12.8
Learning (L)	293.88	1	293.88	17.4
L × MF	160.53	1	160.53	9.5
Subjects (S)	347.75	5	69.55	4
S × MF	116	5	23.20	1
Error	135.01	8	16.88	

¹p < 0.05 ²p < 0.01 ³p < 0.001

TABLE 3
COMPLEX REACTION TIMES (SPEED OF RESPONSES)
ANALYSIS OF VARIANCE

	SSQ	D.F.	S ²	F
Trichloroethylene (TCE)	119.72	1	119.72	26.1
Mental fatigue (MF)	77.04	1	77.04	16.8
TCE × MF	127.37	1	127.37	27.8
Learning (L)	87.71	1	87.71	19.1
L × MF	46.44	1	46.44	10.1
Subjects (S)	162.80	5	32.45	7.1
S × MF	105	5	21	4.5
Error	36.68	8	4.58	

¹p < 0.05 ²p < 0.01 ³p < 0.001

TABLE 4
COMPLEX REACTION TIMES (REGULARITY OF
RESPONSES) - ANALYSIS OF VARIANCE

	SSQ	D.F.	S ²	F
Trichloroethylene (TCE)	132.54	1	132.54	12.4
Mental fatigue (MF)	19.65	1	19.65	1.8
TCE × MF	22.86	1	22.86	2.1
Learning (L)	18.48	1	18.48	1.7
L × MF	8.76	1	8.76	0.8
Subject (S)	108.95	5	21.79	2.0
S × MF	101.45	5	20.29	1.9
Error	85.41	8	10.68	

¹p < 0.01

Discussion

Our results indicate that the suggested TLV for trichloroethylene (100 p.p.m.) appears to be very close to the average concentration capable of causing significant decrements in the functions essential to the safety of workers performing industrial operations.

TABLE
MANUAL ABILITY AND DEX
VARIANCE

	SSQ
(a) <i>Right hand</i>	
Trichloroethylene	480.11
Learning	173.61
Subjects	295.95
Error	75.42
(b) <i>Left hand</i>	
Trichloroethylene	83.39
Learning	37.79
Subjects	401.85
Error	14.51
(c) <i>Right and left hands</i>	
Trichloroethylene	71.88
Learning	68.88
Subjects	308.65
Error	10.51

¹p < 0.05 ²p < 0.01

At first it was thought that it could not be regarded as representative of the complaints and reactions to the odour of TCE. These reactions are psychological in nature because they never before exposed and then to the odour of TCE. Nevertheless, if and to what degree this fact is true, for this reason, the experiments using as the subjects six workers with TCE and other so the experiments with workers' conclusions already drawn from them and summarized in Tables 1 to

TABLE 5
MANUAL ABILITY AND DEXTERITY - ANALYSIS OF
VARIANCE

	SSQ	D.F.	S ²	F
Right hand				
Trichloroethylene	480.11	1	480.11	25.47 ^a
Learning	173.61	1	173.61	9.21 ^a
Subjects	295.95	5	59.19	3.14
Error	75.42	4	18.85	
Left hand				
Trichloroethylene	83.39	1	83.39	23.80 ^a
Learning	37.79	1	37.79	10.41 ^a
Subjects	401.85	5	80.37	22.14 ^a
Error	14.51	4	3.63	
Right and left hands				
Trichloroethylene	71.88	1	71.88	27.33 ^a
Learning	68.88	1	68.88	26.19 ^a
Subjects	308.65	5	61.73	23.47 ^a
Error	10.51	4	2.63	

^a < 0.05 ^b < 0.01

At first it was thought that these experiments could not be regarded as representative because of the complaints and reactions of the students about the odour of TCE. These reactions were considered psychological in nature because the students were never before exposed and therefore not accustomed to the odour of TCE. Nevertheless, it was not known to what degree this factor affected the test results. For this reason, the experiment was repeated using as the subjects six workmen who regularly work with TCE and other solvents. The results of the experiments with workers confirmed the conclusions already drawn from the results with students and summarized in Tables 1 to 5.

Conclusion

Two 4-hour exposures, separated by a 1½-hour interval, to trichloroethylene at an average concentration of 110 p.p.m., with fluctuations ranging from 90 p.p.m. to 130 p.p.m., caused a statistically significant reduction in efficiency of both students and workers in performing various psychophysiological tests. The reduction in efficiency is particularly significant in those tests involving perceptive discrimination.

Therefore, it is possible that a TLV of 100 p.p.m. for trichloroethylene may result in interference with the psychophysiological efficiency of a man with executive or technical responsibilities even in the absence of other undesirable subjective and objective manifestations.

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