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British studies on the neuropsychological effects of solvent exposure

by Nicola Cherry, PhD, Helen Venables, BSc, Harry A Waldron, MD¹

Over the past years several studies have been conducted in Britain to investigate the neuropsychological effects of occupational exposure to organic solvents. Studies on the acute effects of organic solvents have shown that these substances consistently produced a deterioration in the mood and performance of exposed workers over a workshift when these workers were compared with nonexposed factory workers (1, 4, 5). In order to detect long-term neuropsychological impairment in solvent-exposed workers, a short test battery was developed (3). This battery, originally validated for use in the field on a population of methylene chloride workers (2), takes only 50 min to complete; it encompasses a range of skills, including manual dexterity, spatial skills, memory, and reaction time. A summary of the use of this battery in detecting the behavioral effects of toluene and paint solvents on exposed factory workers is given.

Study population

Toluene

Fifty-nine men exposed to toluene for a mean of 9.4 years were tested. They were engaged in the manufacture of rubber mats, and current exposure levels were around 100 ppm. Exposure levels had been twice as high, reaching 500 ppm at times, only one year before the study took place.

Fifty-nine men at the same factory, doing manual jobs, were matched for age, race, and length of employment at the factory. They acted as the referents for the study.

Paint solvents

Forty-two men exposed to a number of paint solvents, but mainly white spirit, in a naval dockyard

for a mean of 11.7 years formed the exposed group in this investigation.

Forty-two joiners at the dockyard were matched with the painters for age, educational level, drinking, and smoking history. They formed the reference group.

Details of the study populations are summarized in tables 1 and 2.

Results

Toluene

Matched-pairs t-tests were carried out for each performance variable. The test battery has been further described in another presentation of these proceedings. The means for both groups are shown in table 3, along with the outcome of the t-tests. The toluene workers did significantly less well ($p < 0.05$) on the test of premorbid ability (the National Adult Reading Test) than the referents. Their performance was also worse for 12 of the 17 other variables, but only significantly worse for that of circle errors ($p < 0.05$).

Table 1. Details of the exposed and reference populations at the toluene factory.

	Exposed subjects	Referents
Number of workers	59	59
Mean age (years)	41.8	41.7
Mean score on the National Adult Reading Test	16.6	19.6

Table 2. Details of the exposed and reference populations at the dockyard.

	Exposed subjects	Referents
Number of workers	42	42
Mean age (years)	41.4	41.3
Mean score on the National Adult Reading Test	19.4	26.1

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Table 3. Results of behavioral tests at the toluene factory. (NS = not significant)

Variable	Exposed workers (N = 59)	Nonexposed workers (N = 59)	p
<i>Reading test</i>			
National Adult Reading Test	16.6 ^a	19.4	0.05
<i>Reaction time</i>			
Mean reaction time	325.4	338.1 ^a	NS
Excluded responses	0.5	0.6 ^a	NS
<i>Manual dexterity</i>			
Pegboard			
Preferred hand	79.6 ^a	75.5	NS
Nonpreferred hand	85.4 ^a	80.2	NS
Lines	35.1	33.7 ^a	NS
Circles	25.5	24.6 ^a	NS
Circle errors	2.5 ^a	1.4	0.05
<i>Speed of working and spatial ability</i>			
Trail Making, part A	35.6	36.9 ^a	NS
Trail Making, part B	94.4 ^a	87.0	NS
Digit Symbol	42.1 ^a	43.7	NS
Visual Search (mean)	23.8 ^a	22.5	NS
Block Design	30.5 ^a	32.3	NS
<i>Memory</i>			
Total recall	12.7 ^a	13.2	NS
Intrusions	5.6 ^a	4.1	NS
Long-term store	10.7 ^a	11.3	NS
Retrieval			
Long-term	9.4 ^a	9.6	NS
Short-term	4.5 ^a	3.5	NS

^a Group with poorer performance.

Paint solvents

The mean test performance and the results of the matched-pairs t-tests are shown in table 4 for the painters and joiners. The painters did significantly less well on the National Adult Reading Test ($p < 0.001$) than the joiners. Their performance for all but one of the other variables was worse, and significantly so for nine of these measures. It is noticeable that, apart from the memory test, the variables on which the painters did worse — such as reaction time, trail making, digit symbol substitution, and block design — are highly correlated with ability. As the difference in the scores of the groups on the National Adult Reading Test was highly significant and many of the other test scores were highly related to the reading test score, it might be that the worse performance of the painters on some of the tests was due to lower premorbid ability rather than to solvent exposure. However, we had the scores on identical tests for the reference group at the toluene factory; these men had a mean reading test score that was almost identical to that of the exposed painters, and this information allowed us to rematch 34 painters with nonexposed men from the toluene factory (see table 5). Matched-pairs t-tests were carried out for all the performance variables, and the results are shown in

Table 4. Results of behavioral tests at the dockyard. (NS = not significant)

Variable	Painters (N = 42)	Joiners (N = 42)	p
<i>Reading test</i>			
National Adult Reading Test	19.4 ^a	26.1	0.001
<i>Reaction time</i>			
Mean reaction time	369.1 ^a	321.3	0.10
Excluded responses	1.3 ^a	0.1	0.05
<i>Manual dexterity</i>			
Pegboard			
Preferred hand	74.9 ^a	71.0	NS
Nonpreferred hand	79.2 ^a	73.0	0.01
Lines	31.6 ^a	33.5	NS
Circles	24.8 ^a	25.5	NS
Circle errors	0.8	1.2 ^a	NS
<i>Speed of working and spatial ability</i>			
Trail Making, part A	35.4 ^a	31.5	NS
Trail Making, part B	91.7 ^a	79.7	0.05
Digit Symbol	44.8 ^a	47.2	NS
Visual Search (mean)	21.0 ^a	18.8	NS
Block Design	34.3 ^a	38.6	0.05
<i>Memory</i>			
Total recall	12.8 ^a	14.6	0.05
Intrusions	5.4 ^a	3.7	0.05
Long-term store	11.2 ^a	13.0	0.05
Retrieval			
Long-term	8.9 ^a	11.5	0.05
Short-term	4.0 ^a	3.2	0.05

^a Group with poorer performance.

Table 5. Details of the 34 painters and their matched non-exposed referents from the toluene factory.

	Painters	Referents from toluene factory
Number of men	34	34
Mean age (years)	42.7	42.4
Mean score on the National Adult Reading Test	20.4	20.6
Length of exposure to paint solvents (years)	11.9	—

table 6, along with the means for both groups. With this more rigorous match, the painters still performed less well for 12 of the 17 test variables, but only one of these results (mean reaction time) was significantly worse ($p < 0.05$).

Conclusions

The results in tables 3–6 demonstrate that many of the apparent differences between solvent-exposed and nonexposed workers may be explained by pre-existing differences between the groups. In the painter study, the exposed and reference groups had been carefully matched for educational level, but inspec-

Table 6. Results of behavioral tests of painters from the dockyard rematched with referents from the toluene factory. (NS = not significant)

Variable	Painters (N = 34)	Referents (N = 34)	p
<i>Reading test</i>			
National Adult Reading Test	20.4	20.6	NS
<i>Reaction time</i>			
Mean reaction time	380.2 ^a	331.0	0.05
Excluded responses	1.4 ^a	0.5	NS
<i>Manual dexterity</i>			
Pegboard			
Preferred hand	75.8	76.3 ^a	NS
Nonpreferred hand	80.0 ^a	79.7	NS
Lines	31.8 ^a	34.7	NS
Circles	25.1	24.7 ^a	NS
Circle errors	0.8	1.3 ^a	NS
<i>Speed of working and spatial ability</i>			
Trail Making, part A	35.8 ^a	33.4	NS
Trail Making, part B	93.3 ^a	80.2	NS
Digit Symbol	45.0	45.0	NS
Visual Search (mean)	20.6	20.8 ^a	NS
Block Design	34.7	33.2 ^a	NS
<i>Memory</i>			
Total recall	12.7 ^a	13.1	NS
Intrusions	5.7 ^a	4.5	NS
Long-term store	11.0 ^a	11.4	NS
Retrieval			
Long-term	8.7 ^a	11.4	NS
Short-term	4.1 ^a	3.5	NS

^a Group with poorer performance.

tion of the scores on the National Adult Reading Test suggests that this matching was not adequate. After a rematch for estimated ability before exposure, the differences between the exposed subjects and referents were substantially reduced. This result appears to indicate that, if full confidence is to be put in the results of cross-sectional studies of solvent workers, the investigators must bear the responsibility of demonstrating the adequacy of the matching. Only then can any differences between the groups be confidently attributed to solvent exposure.

References

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