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Psychological function changes among house painters

by MONICA HANE, Ph.D., OLAV AXELSON, M.D., JAN BLUME, CHRISTER HOGSTEDT, M.D., LENNART SUNDELL, M.D., and BERIT YDREBORG¹

HANE, M., AXELSON, O., BLUME, J., HOGSTEDT, C., SUNDELL, L. and YDREBORG, B. Psychological function changes among house painters. *Scand. j. work environ. & health* 3 (1977) 91-99. Nonspecific complaints such as fatigue, partial amnesia, loss of appetite, etc., have been reported by house painters and could be effects of occupational exposure to solvents. A random sample of union-affiliated house painters was compared for a number of parameters and psychological test results with a group of industrial workers having a corresponding age distribution. The groups proved to be on par in relevant background variables. A simple health check did not reveal any correlates to the subjective complaints, except for a somewhat lower hemoglobin concentration among the house painters. However, the painter group had significantly lower mean scores on psychological tests measuring intellectual capacity and psychomotor coordination than the reference group of industrial workers. The painter group also had significantly lower performances than expected on the memory test and the reaction time test. A discriminant analysis of indicators of change, as derived from psychological tests, was carried out, and a point biserial correlation of 0.35 was obtained between the discriminant function and the dichotomous exposure variable defined by group affinity. Furthermore a study based on clinical patients, i.e., another body of data, indicated reasonable diagnostic validity for this discriminant function. Although no correlations were found within the painter group between exposure ("painter years") and the indicators of function change, the results indicate an effect of the work environment on health.

Key words: brain damage, hemoglobin concentration, psychological function tests, solvents, work environment.

Previously, disturbances in memory, thinking, and affect have been reported among workers exposed to trichloroethylene, carbon disulfide and toluene (20). Hänninen (12) found that a group of workers exposed to carbon disulfide, but without clinical signs of poisoning, had significantly lower scores on tests measuring speed, vigilance, manual dexterity,

and general intelligence than an unexposed reference group. Another exposed group showing clinical signs of poisoning performed still worse than the other exposed group. In a study of workers exposed to different types of solvents, Lindström (17) found that the exposed group had some impairment on all psychological tests, the greatest changes occurring on tests measuring visual perception and manual dexterity. Hänninen concluded in her study (12) that psychological tests are more sensitive in detecting early disturbances of the central nervous system due to solvents than traditional medical examinations.

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Since house painters complaining of extreme fatigue, impaired memory, loss of appetite, and diffuse chest pain have appeared as patients, we have initiated further studies on the possible health effects of their work environment.

MATERIAL AND METHODS

In 1973, a sample of house painters with more than 5 years of experience was randomly drawn from the trade union register in the county of Örebro. Their ages ranged from 25 to 60 years (mean 42.5, SD 11.4). These painters were compared in a number of psychological tests to a group of industrial workers with a matched age distribution (± 2 years) who were unexposed to solvents. The reference group came mainly from a wire producing industry, a printing office (solvent exposed workers excluded) and a stone crusher, all in the county of Örebro.

In addition to psychological testing the subjects underwent a penetrating interview concerning prior professional exposure to solvents. In the interview the number of years as a painter was estimated for each individual. In Sweden the trade of "painter" includes that of wallpaper hanger, and, by correcting for these periods of nonexposure, we were

able to create a rough exposure index of "painter years," which presumably should be a more adequate measure of exposure than the crude number of occupational years as a painter. The "painter years" ranged from 4 to 42 years (mean 14.2, SD 6.7).

It can be estimated that the painters had been exposed to several hundred parts per million of hydrocarbon solvents, as such concentrations seem to be common (13). The exposure to paint pigments is probably of minor importance, and, in Sweden at least, exposure to lead is rather unusual because of the special regulations for the utilization of lead pigments in paints.

A health interview, based on a questionnaire concerning subjective symptoms like tiredness and impaired memory, was also included in the study along with a traditional medical examination, i.e., checking blood pressure, hemoglobin concentration, sedimentation rate, serum transaminases, and respiratory function (table 1).

Psychological test battery

The test battery utilized in this study is generally used at psychiatric and neurological clinics in Sweden in diagnosing organic brain damage. It covers those

Table 1. Means of the medical variables for the painter and reference groups.

Medical variable	Painters n = 52	Referents n = 52	Two-tailed p values from Student's t-test
Blood pressure, systolic (mm Hg)	138.0	137.3	0.79
Blood pressure, diastolic (mm Hg)	85.5	88.6	0.10
Hemoglobin concentration (g/l)	151	160	0.01
Sedimentation rate (mm)	11.6	9.3	0.40
Height (cm)	176.8	175.2	0.20
Weight (kg)	78.8	78.1	0.76
S-ASAT (asparat-amino-transferas) (μ kat/l)	0.67	0.73	0.21
S-ALAT (alanin-amino-transferas) (μ kat/l)	0.55	0.54	0.96
Spirometry (% of normal values)			
Vital capacity	97.7	97.1	0.79
FEV ^a (s)	105.1	105.2	0.96
FEV %	107.4	108.4	0.57

^a FEV = Forced expiratory volume.

Table 2. Hemoglobin concentrations of the painter and reference groups in relation to smoking habits.

Group	Non-smokers	1—15 cigarettes/day or pipe	15 cigarettes/day	Total
Painters				
Number	35	15	2	52
Hemoglobin concentration (g/l)				
Mean	151	149	149	151
Range	134—170	133—162	133—162	133—170
Referents				
Number	21	24	7	52
Hemoglobin concentration (g/l)				
Mean	161	157	168	169
Range	149—175	144—162	157—178	144—178

psychological functions for which impairment has been demonstrated in earlier studies of workers exposed to solvents (12, 14, 17). When this battery of tests is administered to individual patients for diagnostic purposes with regard to diffuse organic brain damage, the discrepancy between "hold tests" and "nonhold tests" is used. Thus it is assumed that verbal ability is fairly resistant (a hold test) and can be used as an indicator of the intellectual predamage level, while the other functions measured by the battery (nonhold tests) are known to be impaired more quickly than verbal ability in cases of diffuse organic brain damage (21, 24). This principle has been criticized (16), but some kind of estimation of prior intellectual capacity has to be used when isolated cases are being considered, and there are few alternatives. When groups are being studied by means of psychological tests, it is beneficial if the tests chosen also serve further individual diagnostics. The tests used in our study can be found in table 3, where also the psychological function measured by each test and references to the respective manual are given.

Statistical methods

Since all variables turned out to have fairly symmetrical distributions, the means were compared by the Student's t-test throughout. Also a stepwise multiple discriminant analysis (7) was undertaken so that the weighted sum of the

indicators of intellectual impairment with the highest correlation to dichotomized exposure (i.e., exposed versus nonexposed) could be obtained.

RESULTS

Evaluation of background variables

Valid conclusions from cross-sectional studies presuppose that the exposed and the nonexposed are comparable in respects other than exposure and its possible effects. Ascertaining the comparability was possible since, starting in 1943, all Swedish men are tested for general intelligence when they enter the military service. Although the main purpose of that testing has been to estimate the capacity of the individual to utilize military education, some of the subtests can be used in the estimation of verbal and logical inductive intelligence (two tests) and spatial ability (one test) at about 20 years of age, i.e., prior to any pertinent exposure to solvents. About half of the subjects in both groups in this study had entered the military service after 1943 and their test results were available for the estimation of pre-exposure capacity. The mean score of the painter group was not found to be lower than that of the reference group; in fact the painters' scores were somewhat (but not significantly) better.

In Sweden there is a registration of people suffering from alcoholism with social complications. The number of sub-

jects from the painter and reference groups registered there were found to be four and five, respectively. Nor were there any differences between the groups with respect to brain injuries, episodes of unconsciousness or alcohol consumption as reported in the interview, but the referents were found to smoke more than the painters (table 2).

Health interview and medical examination

The health interview revealed that eczema and experiences of impaired memory were significantly more frequent among the painters than among the referents. There was also an overrepresentation of diffuse chest pain, extreme fatigue, and

Table 3. Means and standard deviations of the psychological tests for the painter and reference groups.

Test	Intellectual function measured by the test	References	Painters (n = 52)		Referents (n = 52)		Two-tailed p values from Student's t-test
			Mean	SD	Mean	SD	
Synonyms	verbal ability (vocabulary)	Dureman et al. (8)	18.0	6.5	16.3	6.4	0.14
Figure Classification	visual-logical ability	Dureman et al (8), based on Thurstone's primary mental abilities (22)	17.2	4.5	19.0	3.8	0.03
Block Design	spatial ability	Dureman et al. (8), identical with Koh's test in the Wechsler Adult Intelligence Scale (23)	22.2	6.5	21.2	6.1	0.43
Figure Identification	vigilance, perceptual speed	Dureman et al. (8), based on Thurstone's primary mental abilities (22)	28.5	9.9	27.3	7.1	0.49
Rivet Test	psychomotor coordination	Dureman et al. (8)	156.8	27.9	144.5	29.5	0.03
Konzentrations-Verlaufs-Test	vigilance	Abels (1)	95.8	9.5	97.5	9.8	0.38
Claeson-Dahls Learning Test	learning capacity	Claeson et al. (6) and Luria (18)	158.7	73.9	173.9	63.5	0.26
Revised Visual Retention Test	visual retention	Benton (3)	5.7	1.6	5.9	1.8	0.42
Simple Reaction Time			0.32	0.08	0.33	0.07	0.57
Choice Reaction Time			0.48	0.06	0.47	0.06	0.18
Mirror Tracing (total time)	sensorimotor coordination	Dureman et al. (9), modification of Starch's Mirror Drawing Test	83.3	41.7	82.0	32.2	0.87
Mirror Tracing (error time)	sensorimotor coordination	Dureman et al. (9), modification of Starch's Mirror Drawing Test	20.4	14.0	19.3	12.9	0.70

longer periods of sick leave among the painters [for further details the reader should consult the report by Blume (4)]. In the medical examination the only significant difference found between the groups was a higher hemoglobin concentration in the reference group (table 1). The smoking habits (table 2) cannot explain the differences found in hemoglobin concentration (15). No painter suffered from clinical anemia, but the difference in the mean hemoglobin concentration might indicate an effect of exposure.

Psychological tests

The mean of each variable for the painter and reference groups is presented in table 3. Since some of the test scores are inversely related to the performances, the results are possibly more clearly illustrated in fig. 1, in which the scores have been transformed to a standard scale. The painters were found to have significantly ($p < 0.05$) lower mean performances on the visual/logical and psychomotor tests.

The scores on the psychomotor test and the visual/logical test were transferred into a uniform scale (mean 5, SD 2) by means of the age-adjusted norms given in the manual (8). The differences between the test results and the expected values derived from the verbal test were assumed to reflect the degree of impairment in the measured psychological function; they were calculated for each individual. The means of these differences differed significantly between the groups as shown in table 4. Also on the visual retention test the expected score, as given

by the manual with regard to the result on the verbal test and age, was compared with the observed score. As shown in table 4 the mean of the deviations from the expected values among the exposed was significantly greater than that of the reference group, and this result indicates an impaired memory function. Although neither the simple reaction time (a single visual stimulation) nor the choice reaction

Fig. 1. Deviations of the means of the psychological tests of the painter group from those of the reference group, expressed in terms of standard deviations, i.e., as Z scores. A Z score with a negative sign indicates an inferior performance for the painters and a Z score with a positive sign indicates the reverse.

Table 4. Means of indicators of function change for the painter and reference groups.

Variable	Mean of individual deviation from expected value		One-tailed p value from Student's t-test
	Painters n = 52	Referents n = 52	
Figure Classification (visual-logical ability)	-0.0	-1.1	$p < 0.01$
Rivet Test (psychomotor coordination)	-0.9	-2.0	$0.01 < p < 0.05$
Revised Visual Retention Test	1.5	0.9	$0.01 < p < 0.05$
Choice Reaction Time	16	14	$0.01 < p < 0.05$

time (a complex visual stimulaton) differed significantly between the groups, the mean of the individual differences between simple and choice reaction time was significantly greater for the painters than for the referents. Taking this difference is in accordance with the clinical practice of using reaction time measurements in the diagnosis of organic brain dysfunction, a practice which is based on the assumption that diffuse brain damage

affects responses to more complex stimuli before it affects responses to simpler ones (16).

Multiple discriminant analysis

As shown in table 5, the four indicators of function change are intercorrelated, and it might be conceivable that some kind of aggregation of these variables would in-

Table 5. Intercorrelations between indicators of function change, age, occupational years and "painter years" for the painters (n = 52).

Variable	Variable (see column 1)							Discriminant function (see table 6)
	1	2	3	4	5	6	7	
1 Age	—	0.97	0.90	—0.07	—0.02	0.06	—0.02	—0.11
2 Occupational years		—	0.92	—0.02	—0.21	0.10	—0.02	—0.08
3 "Painter years"			—	—0.05	—0.20	0.17	—0.03	—0.05
4 Figure Classification				—	0.37	0.25	0.33	0.83
5 Rivet Test					—	0.24	0.30	0.59
6 Revised Visual Retention Test						—	0.15	0.49
7 Choice Reaction Time							—	0.62

Table 6. Multiple discriminant analysis.

Step number	Variable added, deviation from expected values	Point biserial correlation between the discriminant function and the dichotomus exposure variable (exposed vs. non-exposed)	Equation
1	Figure Classification (X ₁)	0.29	$y' = 0.081 * X_1 + 0.546$
2	Choice Reaction Time (X ₂)	0.32	$y' = 0.073 * X_1 + 0.012 * X_2 + 0.367$
3	Rivet test (X ₃)	0.34	$y' = 0.055 * X_1 + 0.012 * X_2 + 0.026 * X_3 + 0.381$
4	Revised Visual Retention Test (X ₄)	0.35	$y' = 0.048 * X_1 + 0.012 * X_2 + 0.025 * X_3 + 0.022 * X_4 + 0.350$

Fig. 2. Distribution of the discriminant functions of the painters, the controls (reference group) and a small sample of patients with clinical signs of brain dysfunction.

crease the correlation between the degree of intellectual impairment and exposure. Therefore, a stepwise multiple discriminant analysis was undertaken which resulted in the equations shown in table 6. A point biserial correlation of 0.35 was obtained between the weighted sum of these variables and the dichotomous exposure variable defined by group affinity for this sample. Thus, this discriminant function can be regarded as a measure of intellectual impairment and it is therefore helpful when effects on individual patients are considered. However, within the painter group, no correlation was found between the measures of exposure, i.e., occupational years and "painter years," and the effect (table 5).

Diagnostic validity of applied tests

An evaluation of the diagnostic validity of the discriminant function requires testing a new sample for which either the degree of brain damage is known or, if the assumption of a linear correlation between the degree of exposure and functional disturbances is accepted, the ex-

posure history is well known. Finding such a sample is difficult, but obviously some kind of validity analysis is necessary if the difference found between exposed and nonexposed subjects is to have any implications for diagnostic procedures in clinical practice.

For the purpose of validating the discriminant function another body of data was available, namely, 11 clinical patients that had been referred to a psychologist because they showed symptoms attributable to brain dysfunction (19). They were 39 to 62 years of age, most of them above 55. All of them had been exposed to solvents (25–45 years) and most of them were painters. For some individuals a few of the tests included in the discriminant function had been omitted, but in these cases the mean score of the active painters replaced the missing test result. The distribution for the patient group in the discriminant function is presented in fig. 2, which also shows that the clinical patients tended to get higher values in the discriminant function than the active painters, a finding which supports the usefulness of this discriminant function for diagnostic purposes.

DISCUSSION

The house painters who consulted the Clinic of Occupational Medicine showed symptoms of memory impairment, fatigue, and personality changes of an asthenic or depressive type which were in fairly good agreement with the "chronic psycho-organic syndrome" according to Mayer-Gross et al. (19). Case reports indicating similar effects of solvents can be found in the literature (5), but there are very few epidemiologic studies on nonacute effects. Hänninen (12) and Lindström (17) however showed that there might be such an effect, and the present investigation is consistent with these earlier reports.

As the testing took place more than 15 h after exposure, the effects found are either chronic or subchronic. It is conceivable however that the impairment has a chronic character in view of previous reports and another study we have completed (2). Thus, a case-referent study based on a regional disability pension register indicated a risk ratio of 1.8 (95 % confidence interval 1.0—3.2) for the possibility of workers exposed to solvents falling ill with neuropsychiatric diseases in comparison to the same possibility for other skilled workers not so exposed. In that study the diagnoses dementia senilis et presenilis and "nervositas" occurred frequently among the exposed. Husman et al. (14) found lower mean performances for a group of car painters than for a reference group in a study with a design similar to ours. Götell et al. (11) and later Gamberale et al. (10) reported prolonged reaction times among workers exposed to styrene even 16 h after exposure. Thus a number of studies have shown subchronic and chronic effects of solvents on the central nervous system although the solvent concentrations which caused these effects are more or less unknown. Therefore field studies of prevailing exposures to solvents and other agents in painting operations are desirable. There is also a need to study more closely the relations between the degree of exposure and intellectual impairment, both with regard to measures of exposure (e.g., time-concentration products, frequent peak concentrations, etc.) and possible modifiers of effect, such as age, individual susceptibility, and

interactions with other pertinent exposures, e.g., alcohol and medicines.

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