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Test battery for investigating functional disorders — The TUFF battery

by Kerstin Ekberg, MA,[1] Monical Hane, PhD[2]

Swedish psychologists have collaborated to design a test battery applicable for both clinical practice and group studies on effects of occupational exposure to toxic solvents. The 13 tests were assembled from different clinical test batteries, eg, that of the Wechsler Adult Intelligence Scale. The tests have been thoroughly described by Hogstedt et al (4), and will not be taken up in this presentation.

The battery was factor analyzed on a sample of 99 school pupils 16 years of age. The analysis yielded four factors measuring verbal ability, reasoning and spatial ability, perceptual ability, and psychomotor ability. The memory tests did not fit into the factor matrix because of reduced variation but were nevertheless included.

As a form of external validation the correlation between performance on the tests and the mean school grade was computed for the sample of 99 pupils. Except for the spatial Block Design test all the verbal, reasoning, spatial, and perceptual tests correlated with mean school grade, whereas the Benton Visual Retention Test and the psychomotor tests did not correlate (5).

The reliability coefficients of the tests vary between 0.85 and 0.96, except for three tests which are less acceptable, a spatial test (Unfolding, $r_{tt} = 0.74$), the Visual Gestalt Ability test ($r_{tt} = 0.74$), and a retention test ($r_{tt} = 0.49$). Hence the tests in general have acceptable reliability.

Reference group

The TUFF battery has been standardized on a group of 138 nonexposed male industrial workers between 20 and 66 years of age (mean 46 years) (2). The group was divided into five age groups, and the test results of each subgroup were transformed to a normally distributed stanine scale with nine steps (mean = 5, SD = 2). The scale provides a transformation matrix for the raw test scores to standardized scores with age regression allowed for; this feature is particularly useful in clinical practice.

Clinical validation

The test battery was evaluated on a group of 75 patients referred to occupational health clinics for suspected psychoorganic syndrome caused by solvent exposure. The group was heterogeneous with respect to exposure, and nearly half of its members were painters. The mean exposure time was 20 years (range 1—47 years), and the mean age 46 years. The performance of the clinical group was compared to that of the nonexposed reference group. The clinical group performed significantly less well on the perceptual tests, on two of the psychomotor tests, on the Benton Visual Retention Test, and on the Visual Gestalt Ability test, whereas the performances on verbal, reasoning, and spatial tests were roughly similar in the two groups (2).

Recently a similar evaluation has been reported for 212 consecutive clinical patients at the occupational health clinic in Göteborg and a reference group (unpublished results by Ekberg & Wising). The mean age of the Göteborg series was 44 years, 89 % being men. About half were painters. The mean number of years in a solvent-exposed occupation was 16. A pattern similar to that in the previous clinical study was obtained, ie, the clinical group performed significantly less well on perceptual tests, psychomotor tests, and the Benton Visual Retention Test (figure 1). The inferior performance was the most apparent in the oldest age group, who also performed less well than the reference group on the Block Design and reasoning tests. The performance pattern may therefore indicate a faster ageing process in the clinical group.

The present reference group appears to be less valuable for clinical use on two tests. Performance on the psychomotor Bolt and Cylinder tests was inferior in the clinical group, even in the youngest age groups, as compared to the performance of the reference group (figure 2). The Visual Gestalt Ability and Unfolding tests also appear to be of less value because they did not differentiate between the groups (figure 2).

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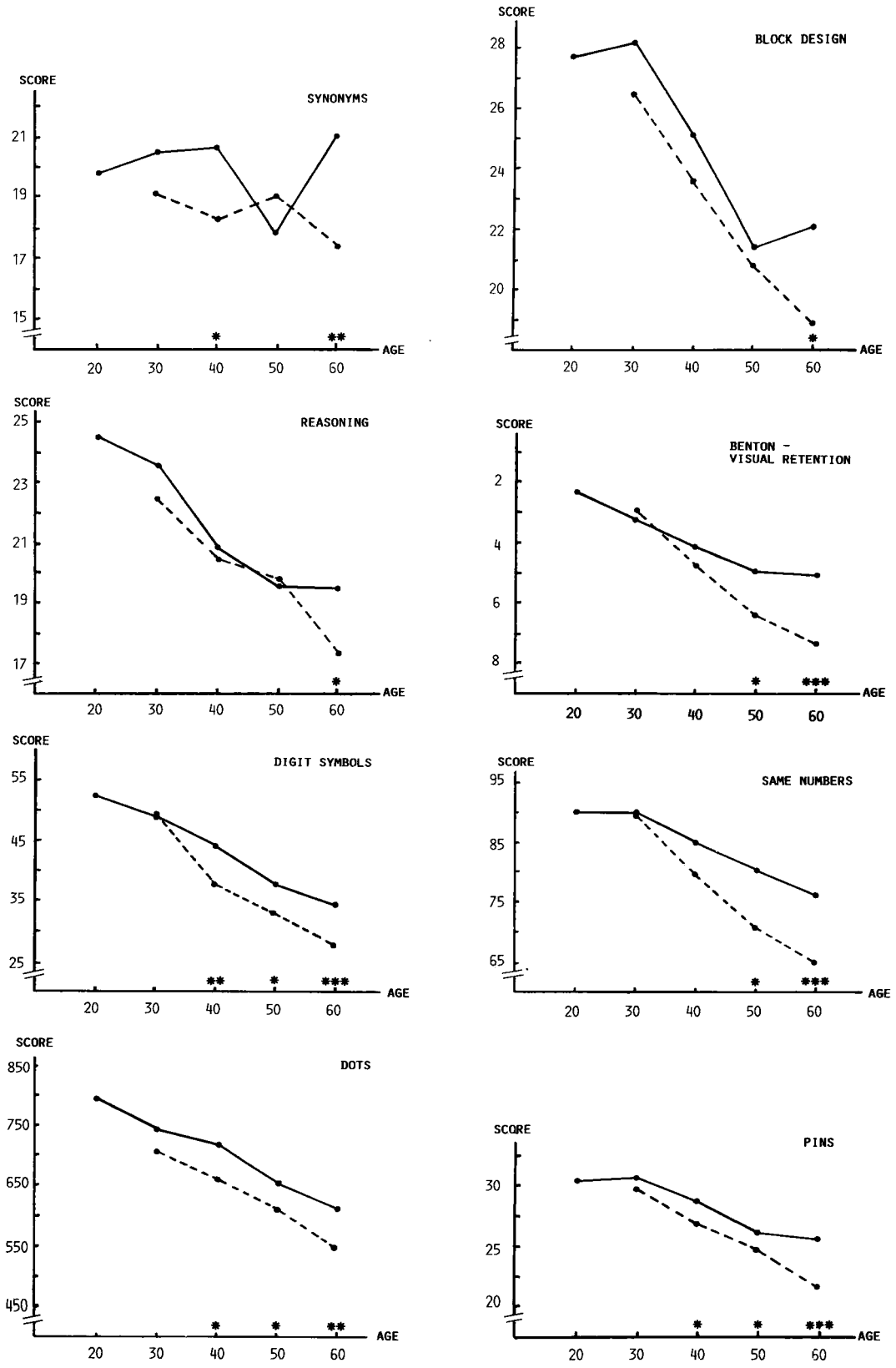

Figure 1. Psychometric test performance of nonexposed industrial workers (unbroken line) [from Frömark et al (2)] and solvent-exposed workers referred to an occupational health clinic (broken line). (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

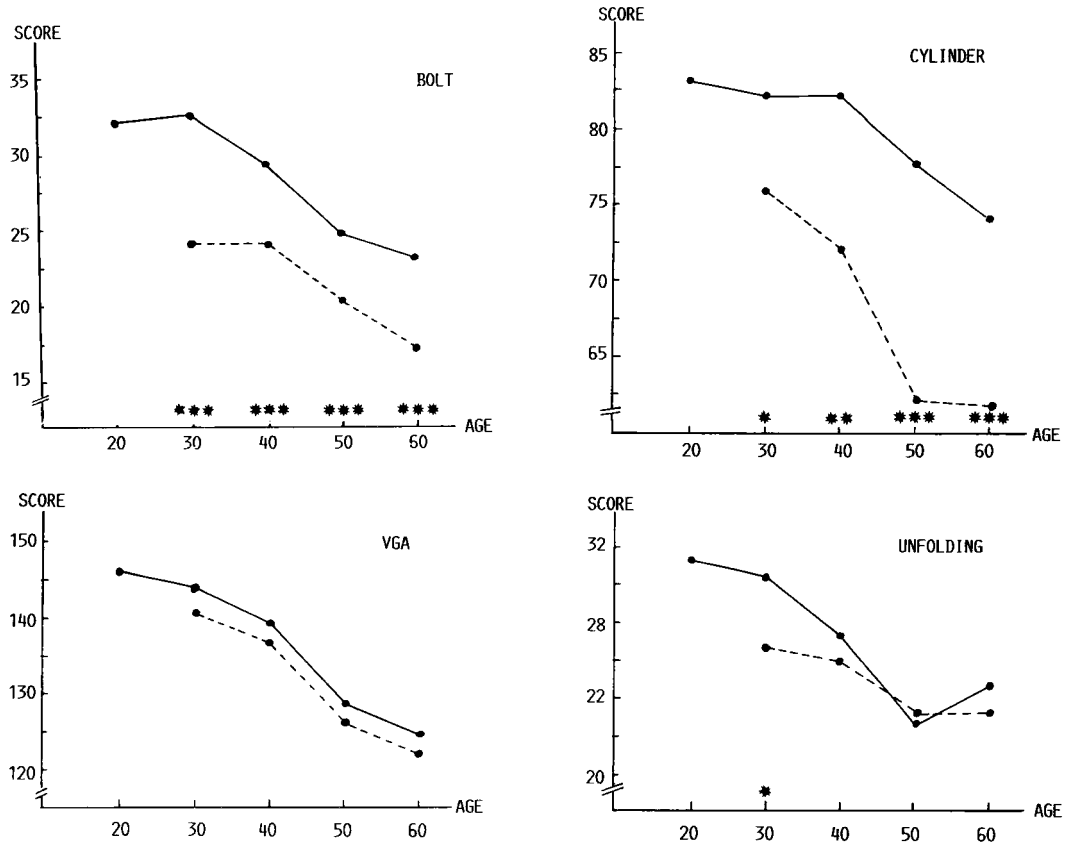

Figure 2. Performance of nonexposed industrial workers (unbroken line) [from Frömark et al (2)] and solvent-exposed workers referred to an occupational health clinic (broken line) on the psychomotor Bolt and Cylinder tests, the Visual Gestalt Ability (VGA) test, and the Unfolding test. (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Table 1. Pearson's product-moment correlation between test performance and sum of symptoms. (NS = not significant)

Test	Product-moment correlation	Level of significance
Cognitive factor		
Block Design	0.06	NS
Unfolding	—0.01	NS
Reasoning	0.01	NS
Visual Gestalt Ability	0.04	NS
Perceptual speed factor		
Digit Symbols	—0.21	0.07
Same Number	—0.34	0.00
Dots	—0.29	0.01
Memory factor		
Benton Visual Retention Test	—0.06	NS
Psychomotor speed factor		
Bolt	—0.01	NS
Pins	—0.30	0.01

Ninety-nine of the patients in this clinical group were screened for neuropsychiatric symptoms by means of a standardized questionnaire (3) before the clinical investigation. The sum of "Yes" answers was assumed to be a rough index of health status. The more complex tests, ie, verbal, logical, and reasoning tests, did not correlate with the symptoms. Performance on the perceptual tests and on one psychomotor test, that is, tests that in the clinical evaluation proved to be affected by prolonged solvent exposure, correlated negatively with the number of symptoms (table 1).

Cross-sectional study

Comparisons were made between 80 exposed car painters and nonexposed workers matched with respect to age, educational background, and occupational competence (1). The performance of the two groups was similar on the verbal and reasoning tests, a finding which indicates acceptable matching with respect to the premorbid state. In perceptual tests, the Visual Retention test, psychomotor tests, and the Block Design test, the exposed group performed less well than the referents. Both age and exposure affected performance on the tests, but there was no interaction between these two independent variables.

In other words, deterioration in performance owing to age was not reinforced by exposure.

Conclusions

The results of the two clinical studies and the cross-sectional study have similar implications, namely, that long-term exposure to solvents affects performance chiefly on perceptual and psychomotor tests. However none of the studies should probably be interpreted as proving that the symptoms are caused by long-term solvent exposure. In the two clinical studies both exposed groups were highly selected and are hence not representative of the exposed population in general. In the cross-sectional study the exposed group may have been suffering from effects of very recent exposure, and it is therefore difficult to draw conclusions about long-term effects of solvent exposure. Nevertheless, the test battery seems to measure aspects of performance that are sensitive to solvent exposure.

In clinical practice the test battery is not the sole tool used for diagnosing psychoorganic syndromes; it yields valuable complementary data in combination with the clinical history. In epidemiologic studies the test battery is useful for providing quantitative information because it is easy to use and can be administered in groups.

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