

# Evaluation of a modified German version of the Q16 questionnaire for neurotoxic symptoms in workers exposed to solvents

A Ihrig, G Triebig, M C Dietz

## Abstract

**Objectives**—To assess sensitivity and specificity of a questionnaire designed to detect neurotoxic symptoms in workers exposed to solvents and in patients with a psycho-organic syndrome.

**Methods**—The Swedish Q16 is a self administered questionnaire for neurotoxic symptoms. The modified German version consists of 18 questions. The results were analysed from 1166 questionnaires which were completed by adults belonging to the following groups; 483 workers with occupational exposure to solvents and 193 non-exposed controls, 25 patients with a psycho-organic syndrome, 25 sex and age matched patients with a lung disease, and a sample of 440 people from the general population.

**Results**—The German Q18 was easy to handle and quick to perform. Workers exposed to solvents reported significantly more complaints than controls (2.9 *v* 2.5). All patients with a psycho-organic syndrome had five or more complaints. This was true for only 32% of patients with lung disease. These comparisons showed that chronic exposure to solvents was associated with subjective complaints related particularly to cognitive functions. In the sample of the general population, age, education level, smoking habits, and time of performance showed no significant influence on the Q18 result. Women had significantly more complaints than men (3.2 *v* 2.3). People who reported drinking alcohol occasionally or moderately had significantly fewer complaints than teetotalers.

**Conclusions**—The German Q18 has an acceptable sensitivity and reliability, a reasonable specificity, and a good practicability. It is a useful instrument for screening workers exposed to solvents. A cut off point of 5 for men is recommended, and a cut off point of 6 for women is proposed.

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Keywords: neurotoxicity; solvents; questionnaire Q18

Organic solvents can cause a chronic toxic encephalopathy in overexposed workers. In Germany this disease has been acknowledged as an official occupational disease since 1997.<sup>1</sup>

Because subjective complaints may indicate an encephalopathy, early recognition is impor-

tant.<sup>2</sup> Particularly at workplaces with exposure to neurotoxic chemicals, a sensitive, specific, and practicable screening instrument is required.

The Q16 is a screening questionnaire for neurotoxic symptoms developed by Hogstedt *et al.*<sup>3</sup> It has been used in several studies with differing results.<sup>4–8</sup>

The aim of the study was to evaluate a cut off point for the German Q18 as a screening instrument. Furthermore we wanted to examine the effects of exposure to solvents on the prevalence of complaints. Further objectives were to analyse the influences of sex, age, education, alcohol consumption, smoking habits, medication, and time of performance on the Q18 result. Also, a reliability analysis and a comparison between the questions from the Swedish Q16 and the additional questions contained in the Q18 was performed.

## Methods

The original Q16 consists of 16 questions on complaints which have to be answered with yes or no. For use as a screening instrument a cut off point of 7 or more yes answers would suggest that further evaluation for people older than 28 years of age is necessary.<sup>9</sup> Sensitivity depends upon the identification of patients with psycho-organic syndrome and workers exposed to solvents. Specificity depends upon the unobtrusive results in the controls.

The German version of the Q16 was translated and slightly modified in the early 1980s to improve its sensitivity.<sup>10</sup> This version consisted of 18 questions. Table 1 shows the retranslated English version of the Q18. Most questions are translations of the English version. The three questions which were removed were “Do you have problems with buttoning and unbuttoning?”, “Do you often have painful tingling in some part of your body?” and “Do you often have to go back and check things you have done such as turned off the stove, locked the door?”. Five questions (14–18) were added or modified to improve the sensitivity of the questionnaire.

We used data from 1166 questionnaires, which were completed by adults between 1991 and 1998. They were divided into three groups (table 2).

The first group consisted of 50 outpatients of the Heidelberg clinic of occupational medicine. All patients filled out the Q18 questionnaire during the examination periods. The result of the Q18 did not influence the diagnosis.

With files from 1992–8, 21 men and four women were identified with the diagnosis of

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Table 1 Percentages of complaints, odds ratio (OR) (95% CI) in workers and patients in response to the retranslated version of the German Q 18 (questions 14–18 were added to compare with the Swedish Q 16)

Questions	Exposed to solvents	Controls	OR (95% CI)	Psychoorganic syndrome (%)	Lung disease (%)	OR (95% CI)
1 Do you have a short memory?	29	21	1.9 (1.2 to 2.8)	84	28	12.0 (3.0 to 48.1)
2 Have your relatives told you that you have a short memory?	16	12	1.7 (1.0 to 2.9)	80	16	21.0 (5.0 to 89.5)
3 Do you often have to make notes about what you must remember?	40	37	1.5 (1.1 to 2.2)	84	24	14.9 (3.6 to 61.4)
4 Do you generally find it hard to get the meaning from reading newspapers and books?	10	8	1.3 (0.7 to 2.3)	52	4	29.9 (3.4 to 260)
5 Do you often have problems with concentrating?	19	15	1.4 (0.9 to 2.2)	88	16	57.7 (9.5 to 349)
6 Do you often feel irritated without any particular reason?	12	6	2.2 (1.2 to 4.3)	60	12	11.0 (2.6 to 46.8)
7 Do you often feel depressed without any particular reason?	6	3	3.2 (1.2 to 8.4)	68	12	15.6 (3.6 to 67.8)
8 Are you abnormally tired?	12	7	2.2 (1.1 to 4.1)	72	24	8.1 (2.3 to 28.9)
9 Do you have palpitations of the heart even when you don't exert yourself?	10	11	1.0 (0.6 to 1.7)	44	20	3.0 (0.9 to 10.9)
10 Do you sometimes feel an oppression in your chest?	29	28	1.3 (0.9 to 1.9)	48	48	1.0 (0.3 to 3.1)
11 Do you often perspire without any particular reason?	13	21	0.7 (0.4 to 1.0)	60	36	2.5 (0.8 to 7.9)
12 Do you have an headache at least once a week?	20	11	2.1 (1.3 to 3.4)	68	24	7.6 (2.2 to 27.4)
13 Are you less interested in sex than what you think is normal?	7	11	0.8 (0.4 to 1.4)	52	20	4.2 (1.1 to 15.3)
14 Do you often feel sick?	5	3	1.9 (0.7 to 5.2)	48	8	10.2 (2.0 to 52.7)
15 Do you have numb feelings in your hands or feet?	14	14	1.2 (0.7 to 2.0)	76	24	7.9 (2.1 to 29.6)
16 Is there a weak feeling in your arms or legs?	12	12	1.3 (0.8 to 2.3)	76	24	8.9 (2.4 to 33.2)
17 Do your hands tremble?	12	12	1.1 (0.7 to 1.9)	44	20	3.8 (1.0 to 13.8)
18 Does alcohol not agree with you?	24	23	1.2 (0.8 to 1.8)	72	32	5.0 (1.3 to 19.0)

Table 2 Number of subjects in the different groups (n=1166)

Group	Exposed	Controls
Patients	25 With psycho-organic syndrome	25 With lung disease
Workers	483 Exposed to solvents	193 Bricklayers
General population		202 Women and 238 men

psycho-organic syndrome. The 25 patients with lung disease were selected as matched controls for sex and age.

The second group consisted of 544 male workers from 219 companies, most of whom were painters (90%). Ten per cent were printers, shoemakers, and floorlayers. Exclusion criteria were acute illness, alcohol misuse, relevant contact with other neurotoxic agents, and missing data. Data from 483 workers were eventually used for analysis. All participants were exposed to solvents at their workplace, and are referred to as the solvent group.

The mean (range) exposure time at work was greater than 15 (1–46) years. In a subsample of 119 subjects we measured the concentrations of solvents in air with personal air samplers. The median concentration of white spirit was 1.3 (0.1–127) ppm, toluene 0.2 (0–22) ppm, xylenes 0.2 (0–21) ppm, butylacetate 0.2 (0–13) ppm, and ethylbenzol 0.1 (0–5) ppm. Detailed descriptions of the samples, the exposure, and other neuropsychological methods performed are published elsewhere.<sup>11 12</sup>

To exclude the effects of acute exposure, the questionnaire was completed after at least 16 hours without occupational exposure to solvents.

For comparison we examined 209 bricklayers without regular and relevant exposure to organic solvents.<sup>12</sup> Sixteen people had to be excluded for the same reasons as in the solvent group.

The mean (SD, range) age of workers exposed to solvents was 41 (10, 19–66); significantly younger than the controls 45 (11, 24–64). Age was considered in the statistical evaluation as a covariate.

Both groups were composed of manual labourers, therefore education and social status of both groups were comparable. The partici-

pants also completed the MWT-B which is a German inventory to test vocabulary and so evaluate the premorbid intelligence.<sup>13</sup> Both groups had the same mean (SD) IQ of 96 (10 and 11, respectively).

The third group consisted of 700 people from the general population who were recruited by a market research company. No financial incentive was given. Participants were asked whether they would fill out the questionnaire without knowing anything about the hypothesis under test. The 457 (65%) participants completed the Q18 and a standardised anamnesis. Seventeen participants were excluded because of chronic exposure to solvents or missing data. Two hundred and two women and 238 men (both with a mean (SD, range) age of 42 (12, 21–69) years) were analysed.

The quality of the five questions, which had been added to the German Q18, were compared with the original Q16 questions. The odds ratio of each question was calculated on the basis of the comparison between the workers exposed to solvents with their controls and the patients with psycho-organic syndrome with their controls.

The statistical analysis was performed with SPSS statistical software. Depending on the distribution of the data we used mean, SD, median, or range in the descriptive statistical analysis. In analyses with potential confounding variables multiple linear or logistic regression was applied. The confounding variables entered the stepwise models if their influence exceeded  $p=0.1$ . Because of the paired matching, the differences between the patient groups were examined by the Wilcoxon signed rank sum test or McNemar's test. The odds ratios (95% confidence interval (95% CI)) in the item analysis were calculated by logistic regression. Results where  $p<0.05$  are described as significant.

## Results

Table 3 gives an overall view of the Q18 results in the different groups.

In figure 1 the frequencies of the Q18 results of patients are described. All patients with

Table 3 Results of the Q18 in different groups

Q18 results	Psycho-organic syndrome	Lung disease	Exposed to solvents	Controls	Men	Women
n	25	25	483	193	238	202
Mean	11.8	3.9	2.9	2.5	2.3	3.2
Median	14	3	2	1	2	3
Range	5–18	0–11	0–18	0–18	0–13	0–15
≥5 (%)	100	32	26	17	16	26
≥6 (%)	84	24	18	11	10	18
≥7 (%)	76	24	13	9	7	11

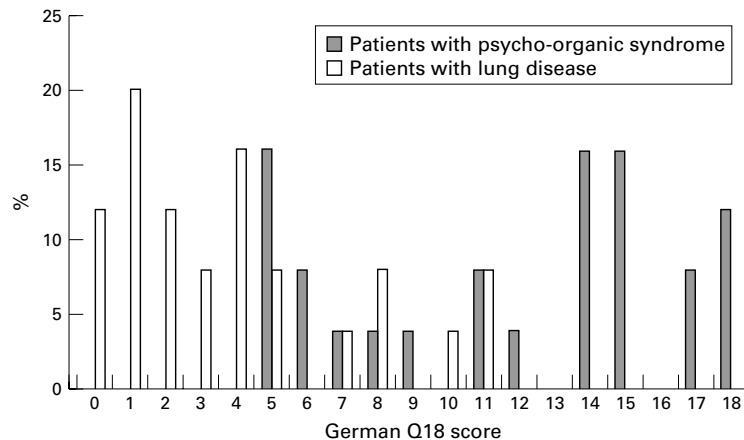


Figure 1 Frequency of the number of positive answers in the Q18 in patients with psycho-organic syndrome and lung disease (n=50).

psycho-organic syndrome had a Q18 result of five or more yes answers. By contrast more than two thirds of the patients with lung disease showed scores less than 5. The patient groups differed from each other significantly ( $p<0.01$ ). Both group comparisons (patients and workers) showed the most discriminative results for sensitivity and specificity when they were divided into  $<5$  and  $\geq 5$  (cut off point 5).

Figure 2 presents the Q18 results in the workers exposed to solvents and controls.

The workers exposed to solvents had significantly higher Q18 scores than the controls. In the multiple linear regression analysis, exposure ( $\beta=0.11$ ;  $p<0.01$ ) and age ( $\beta=0.29$ ;  $p<0.01$ ) had an influence on the Q18 result. The premorbid intelligence had no significant influence ( $p=0.34$ ).

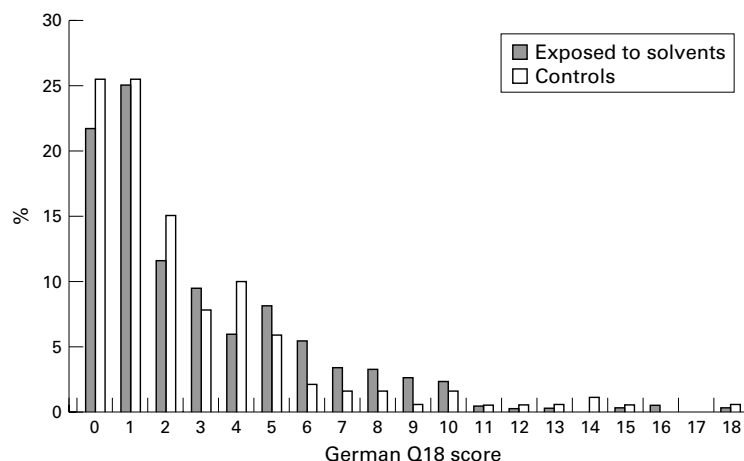


Figure 2 Frequency of the number of positive answers in the Q18 in workers exposed to solvents and controls (n=676).

In table 1 the percentages of yes answers to the questions of the Q18 in workers and patients are presented.

The workers exposed to solvents complained significantly more of short memory, headaches, having to make notes, irritation, depression, and tiredness than did the controls.

The patients with psycho-organic syndrome answered most questions (n=14; 78%) significantly more often with yes than the patients with lung disease. Only four of the questions (palpitations, oppression, perspiration, and trembling) were not discriminative.

In the item analysis the median of the odds ratios of the five questions, which had been added to the German Q18, was 1.2 (non-significant) in workers exposed to solvents and 7.9 (all significant) in patients with psycho-organic syndrome. By comparison the 13 questions from the original Q16 showed odds ratios of 1.5 (54% significant) and 11.0 (69% significant) respectively.

The reliability of the Q18 was calculated with the split half method. The results showed a reasonable correlation ( $r=0.66$  ( $p<0.01$ ; Spearman-Brown coefficient: 0.80)).

Women had significantly more complaints in the Q18 than men ( $p=0.01$ ). Figure 3 presents the distribution of the summary score for men and women.

The result of the Q18 was dichotomised at a cut off point of 5. In the subsequent logistic regression, sex entered the calculation even if its influence was not significant ( $p=0.07$ ).

Participants who took medication had more complaints than others ( $p<0.01$ ). Participants who declared that they never drank alcohol (28%) had also significantly more complaints than those who stated that they drank alcohol at least occasionally ( $p<0.01$ ).

Education level ( $p=0.34$ ), smoking habits ( $p=0.25$ ), and time of performance ( $p=0.13$ ) had no significant influence on the Q18 result.

There was no significant correlation between age and the Q18 results in participants between 21 and 69 years of age ( $p=0.16$ ). On further examination we found a non-linear connection between age and Q18 results. People from 35 to 45 years had fewer complaints than the younger or older ones. However this effect was small and not considered as relevant to the evaluation of different cut off points.

The Q18 had optimum sensitivity and specificity at a cut off point of 5. With that cut off point, all patients with psycho-organic syndrome and 26% of the solvent group were correctly identified (sensitivity 100% and 26%). Of the controls, 17%, and of men in the general population, 16% fulfilled or exceed the specified cut off score (specificity 83% and 84%).

## Discussion

The main result of this study is that chronic exposure to solvents is associated with additional complaints which can be evaluated by the questionnaire Q18. These complaints refer particularly to cognitive deficits—for example, memory and concentration, and mood.

The results of our study suggest different cut off points for men and women in the Q18.

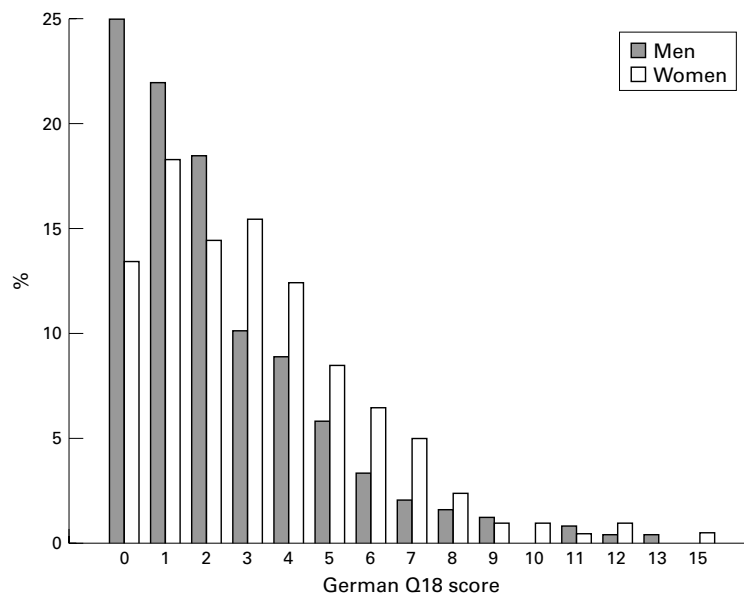


Figure 3 Frequency of the number of positive answers in the Q18 in men and women (n=440).

Varying cut off points for age and level of education does not seem to be necessary, as there are no significant correlations with the Q18 results. Alcohol and medication showed significant correlations with the Q18 result—but these variables could not be used to establish particular cut off points.

We note that the 100% sensitivity in patients with psycho-organic syndrome is due to the small sample size and is thus not representative. However, the sensitivity and specificity of the Q18 with a cut off point of 5 for men seem to be acceptable for use as a screening instrument.

The percentage of women with a Q18 score of 5 or more (26%) is comparatively high. Women in the general population achieved higher scores than men in the Q18. This phenomenon has also been found in another German health questionnaire.<sup>14</sup> We therefore

propose that women should be subject to a separate cut off point. Of the women in the general population examined, 18% had 6 or more yes answers. This percentage is similar to the male percentage at the cut off point of 5 and might be a starting point for further evaluation of a higher cut off score for women.

Although the Swedish Q16 and the German Q18 are different questionnaires, they share 13 questions. We therefore conducted a literature search which identified 21 relevant studies that used the Swedish Q16 in workers exposed to solvents. Their main results are presented in table 4.

Overall estimation shows that the Swedish Q16 was sensitive in identifying effects induced by solvents in 15 out of 21 studies (71%). Thus the main results of most of these studies correspond with our findings on the German Q18.

Despite significant effects on a group basis, Lundberg *et al* found a low sensitivity of the Swedish Q16 in the screening of patients with a psycho-organic syndrome.<sup>8</sup> Reasons for this discrepancy to our results with the German Q18 might—besides the modification of the questionnaire—be different diagnostic procedures or the chosen cut off point.

In three studies the exposed group had higher Q16 scores than the controls but the difference was not significant.<sup>7 20 21</sup> In another investigation there was no consistent increase in the Q16 score in four different exposure groups.<sup>6</sup> In only two studies (10%) did the controls have a slightly higher Q16 score than the exposed workers.<sup>22 24</sup>

Therefore it can be concluded that both questionnaires, the Swedish Q16 and the German Q18, show similar results as a screening instrument for neurotoxic symptoms in workers exposed to solvents.

The comparison between the questions of the Swedish Q16 which have only been translated (Q 1 to Q 13) and the newly added questions of the German Q18 (Q 14 to Q 18)

Table 4 Results of the Q16 in different studies of workers exposed to solvents and controls

Authors	Year	Exposed		Controls		Significant results†
		n	Q16 score (mean (SD))	n	Q16 score (mean (SD))	
Hogstedt <i>et al</i> <sup>3</sup>	1980	229	4.3*	179	1.8*	Yes
Anselm Olson <sup>4</sup>	1982	47	3.3 (2.5)*	47	2.4 (2.2)*	Yes
Cherry <i>et al</i> <sup>5</sup>	1985	198	3.7 (3.5)	93	2.6 (3.2)	Yes
Ekberg <i>et al</i> <sup>15</sup>	1986	50	3.1*	50	0.6*	Yes
Flodin <i>et al</i> <sup>16</sup>	1989	17	8.0*	—	—	Yes
Bolla <i>et al</i> <sup>6</sup>	1990	187	1 (median)	—	—	No
Ng <i>et al</i> <sup>17</sup>	1990	78	2.9 (3.1)	145	1.9 (2.4)	Yes
Ng <i>et al</i> <sup>18</sup>	1992	15	5.7 (4.0)	15	1.9 (2.9)	Yes
Spurgeon <i>et al</i> <sup>7</sup>	1992	90	3.4 (3.1)	90	3.1 (2.9)	No
	1992	144	3.5 (2.6)	144	2.6 (2.7)	Yes
Edling <i>et al</i> <sup>19</sup>	1993	20	3.1 (2.9)	20	1.5 (1.8)	Yes
Williamson and Winder <sup>20</sup>	1993	43	2.6 (2.5)	44	2.3 (2.6)	No
Spurgeon <i>et al</i> <sup>21</sup>	1994	110	3.2 (2.6)	110	2.9 (2.8)	No
Bolla <i>et al</i> <sup>22</sup>	1995	144	1.9 (2.2)	52	2.1 (2.6)	No
Pauling and Ogden <sup>23</sup>	1996	40	—	10	—	Yes
Bergamaschi <i>et al</i> <sup>24</sup>	1997	46	2.1 (2.1)	30	2.3 (2.3)	No
Edling <i>et al</i> <sup>25</sup>	1997	17	9.5 (3.1)	—	—	Yes
Friis <i>et al</i> <sup>26</sup>	1997	35	—	143	2.3 (2.8)	Yes
Lundberg <i>et al</i> <sup>8</sup>	1997	135	2.4 / 3.6 / 5.3*	71	2.4*	Yes
Chen <i>et al</i> <sup>27</sup>	1999	260	5.3*	539	3.8*	Yes
Chen <i>et al</i> <sup>28</sup>	1999	109	8.4*	255	4.3*	Yes

\*The authors did not specify the mean value of the Q16 results, therefore the values had to be either calculated or estimated.

†Significantly higher Q16 results in exposed workers than in controls or other significant results according to this hypothesis.

show that the modification did not significantly improve the questionnaire.

Two of the five added questions relate to peripheral neuropathy and one question on tremor as a sign of a more severe encephalopathy. Therefore these questions do not relate to the preclinical stage of the disease. We assume that the modification of the Swedish Q16, as it was done in Germany in the early 1980s, seems neither to improve nor to reduce the sensitivity or specificity of the questionnaire.

On the one hand the German Q18 is a sensitive and reliable instrument for the screening of workers exposed to solvents. Our findings support the assessment of Spurgeon who concluded that the Swedish Q16 is "the most useful approach in this area".<sup>29</sup>

On the other hand the German Q18 is not specific enough to ensure diagnosis because of many confounding variables influencing the prevalence of complaints.<sup>26</sup> The complaint score can therefore only be used as additional information to aid the diagnostic process.

### Conclusions

- Chronic exposure to solvents is associated with subjective complaints related particularly to cognitive functions.
- The German Q18 is a sensitive and reliable screening questionnaire for solvent related complaints.
- For men a cut off point of five or more complaints is recommended for use with the German Q18. For women we propose the use of six complaints or more as a starting point for further evaluation.
- The German Q18 is a sensitive instrument for screening but not sufficient for individual diagnosis.
- Our results are consistent with most results of studies reported in publications which used the Swedish Q16.

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