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Feasibility and Validity of Three Computer-Assisted Neurobehavioral Tests in 7-Year-Old Children[1]

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DAHL, R., R. F. WHITE, P. WEIHE, N. SØRENSEN, R. LETZ, H. K. HUDNELL, D. A. OTTO AND P. GRANDJEAN. *Feasibility and validity of three computer-assisted neurobehavioral tests in 7-year-old children.* NEUROTOXICOL TERATOL **18**(4) 413–419, 1996.—Three tests from the computerized Neurobehavioral Examination System (NES) were administered to a group of 917 Faroese children at approximately 7 years of age. The NES Continuous Performance Test (CPT) was modified to use animal silhouettes as stimuli instead of letters. Almost all children completed Finger Tapping (FT), the modified CPT, and Hand–Eye Coordination (HE). However, 18% of the children missed at least 25% of the stimuli on the CPT (full test period), and 37% of the children did not improve their HE performance by at least 10%, as compared to the first trial. Boys obtained better results than girls, and older children performed better than younger ones. However, both factors were confounded by acquaintance with computer games. Children who used glasses, who had strabismus, or who had decreased contrast sensitivity obtained less satisfactory scores, especially on CPT and HE. The NES performance was significantly associated with functional neurological performance, including catching a ball, diadochokinesia, and finger agnosia. Slight, though statistically significant, decrements were seen with increased levels of prenatal exposure to neurotoxicants, as indicated by the mercury concentrations in cord blood obtained at the time of birth. In conclusion, the tests were feasible in this age group after slight modifications, and the test results showed meaningful associations with major predictors, thus supporting the validity of the data.

Epidemiology   Mercury   Neurobehavioral Evaluation System   Neurotoxicity   Pediatrics   Vision

THE nervous system is particularly sensitive to neurotoxicant exposures during the early developmental period (11). Accordingly, populations with prenatal or early postnatal exposures to potential neurotoxicants would be considered at increased risk of damage to the nervous system. Neurobehavioral testing has been widely used to assess the functional integrity of the nervous system. However, epidemiological studies of early neurotoxicity are complicated by the fact that detailed examination of neurobehavioral functions require certain levels of maturation of the nervous system. For this purpose, neurobehavioral tests need to be refined and validated to detect subtle dysfunctions in preschool children.

Computerized tests may be advantageous in test batteries for examination of children, particularly for the evaluation of reaction time, motor speed, and motor coordination. Such tests are included in the Neurobehavioral Evaluation System

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[1]This document has been reviewed by the U.S. Environmental Protection Agency, and has been approved for publication. Mention of trade names and commercial products does not constitute endorsement or recommendation for use.

(NES), originally developed for epidemiological studies of adults (9). Several NES tests have been successfully administered to 6-year-old children in Germany (14) and 7- to 10-year old children in North Carolina (1) and in the Czech Republic (12). For preschool children, slight modifications might be warranted. Thus, the Continuous Performance Test (CPT) assumes that the subject is familiar with the Latin alphabet, and use of another type of stimulus would therefore be advantageous.

We have developed and applied a modified version of NES to a population of almost 1000 preschool children from the Faroe Islands in the North Atlantic. The main purpose of the cohort study was to determine whether prenatal exposure to methylmercury had caused any neurobehavioral toxicity. In this article, we describe the test modifications and the feasibility of the tests. We also discuss their validity in the light of the associations with other parameters of neurobehavioral performance, relevant risk factors, visual function, and the prenatal exposure to neurotoxicants.

METHOD

Population

The birth cohort was established between 1 March 1986 and the end of 1987 from consecutive deliveries at the three Faroese hospitals. The mothers of 1022 single-born children (75% of all births) agreed to participate in the prospective study. In connection with the parturition, questionnaire data were obtained, as were maternal hair and umbilical cord blood for mercury analysis. The median blood mercury concentration was 24.2 μg/l, with 25 % of the samples above 40 μg/l; the maternal hair mercury concentrations showed a median of 4.5 μg/g, with 13 % above 10 μg/g (5).

Between the months of April and June in the years 1993 and 1994, the children of the cohort residing in the Faroes and Denmark were invited for clinical examinations at approximately 7 years of age. Most of the children were examined at the National Hospital in Tórshavn, the capital of the Faroe Islands, but clinics were also set up at the two smaller hospitals in the Faroes, and at two locations in Denmark (for families who had moved). A total of 917 of the cohort children (90%) participated in these examinations. Because of a slightly lower participation rate of children from Tórshavn, the prenatal mercury exposure levels of the 917 children who appeared for the examinations was significantly higher than that of those who did not participate (median blood mercury concentrations, 24.7 μg/l vs. 20.9 μg/l). Otherwise, the loss to follow-up did not cause any major selection bias.

Clinical Examinations

Every examination day, four children were invited to begin at 0800 h, and four at 1300 h. Each child was examined at five different stations, each taking up to 1 h. The NES tests were administered at one of the first four stations; the time of testing was recorded. As most examinations required limited efforts of the child, and because breaks and refreshments were provided, this schedule was tolerated well by virtually all of the children.

The examinations included a physical examination and an interview. Strabismus and use of glasses were noted. Visual acuity was determined by Snellen's board at a distance of 6 m. Also, a functional neurological examination (10) was conducted with special emphasis on motor coordination and perceptual-motor performance. The coordination tests consisted of diadochokinesia (fast pronation/supination), reciprocal coordination (alternately closing and opening the fists), and finger opposition (the pulpa of the thumb touching the pulpa of the other fingers of the same hand). The perceptual-motor tests consisted of a "ball game" (catching a ball with a diameter of 15 cm thrown from a distance of 3 m), finger agnosia (indicating, without seeing, which finger was touched by the examiner), and double finger agnosia (same, with two fingers on the same hand being touched simultaneously by the examiner). Performance was rated as "automatic" or "questionable/poor."

Neurobehavioral Examination System 2 (NES2)

Three tests were selected to assess motor speed, sustained attention, and motor coordination. No changes were deemed necessary for the Finger Tapping (FT) and Hand–Eye Coordination (HE) tests (9), but instructions were given orally in Faroese. The same portable computer (Toshiba 3200) with the recommended joystick was used for the examination of all children. Each child was asked about familiarity with computer games, and the answer was rated as "none," "some," or "much."

In the FT task, the child tapped a key on the joystick unit with the index finger seven times for 15 s, first with the preferred hand for practice, followed by two trials with the nonpreferred hand, and finally two trials tapping alternately with each hand. A pilot study indicated that the usual 30-s period was too arduous for the children, and the time was therefore decreased by 50%. Score was the maximum tapping count obtained in a 15-s period. This task is a measure of manual motor ability, but focuses specifically on speed rather than coordination. Performance on FT would be associated with motor system function lateralized to the opposite side of the brain from the hand being tested.

In the NES2 CPT, large letters are flashed briefly on the screen, and the subject is required to press a joystick key when they see the letter "S," which appears intermittently in the sequence of letters. As the children had not started school and few, therefore, were familiar with the alphabet, the stimuli for the CPT had to be changed. Animal silhouettes were chosen because they would be easily recognized. All silhouettes were drawn so that the shaded area would cover approximately the same area of the screen, disregarding the relative size of the real animals they represent. The head was drawn in the same direction for all animals. The original silhouettes are shown in Fig. 1. The "cat" was selected as the critical stimulus. The images of the drawings were digitized and stored in a standard graphic computer file format for later display by the revised CPT computer program.

The child was instructed to press the joystick key as quickly as he/she could every time that the cat appeared on the computer screen, but not for other animals. A total of 48 critical stimuli were presented during a 4-min test, where the first minute was disregarded as a practice period. The stimulus duration was 1200 ms, and each stimulus was replaced on the screen instantaneously with the succeeding one. Failure to respond to a critical stimulus within 1200 ms was considered a nonresponse, and a response to a stimulus other than the cat was recorded as a false alarm response. A reaction time measure was also derived, when a positive response was recorded within 1200 ms after appearance of the "cat" on the screen (i.e., in time before the next stimulus). Slow responses would therefore be recorded as false negatives. In the default version of the CPT, a mean reaction time is determined for true

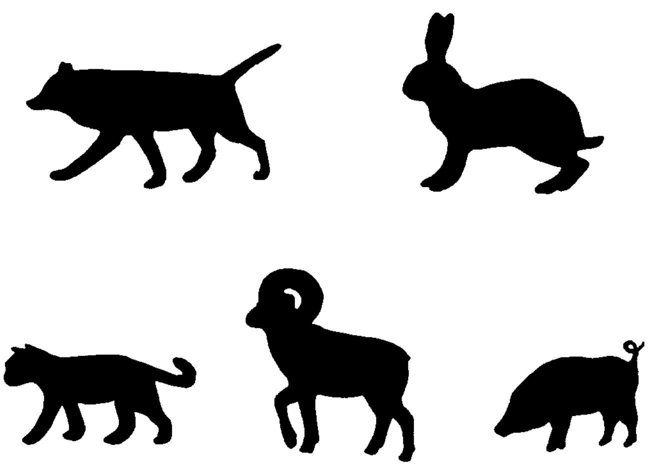

FIG. 1. Animal silhouettes used as stimuli for the continuous performance test (CPT).

positive responses (recorded after the practice period). As this measure does not take into account the occurrence of false negatives, two different alternatives were used. First, we restricted the analysis by excluding subjects with more than 25% false negatives. Second, instead of using means, we calculated overall median reaction times, taking into account the false-negative responses. Three subjects had at least 50% false negatives, and their median reaction time was therefore more than 1200 ms. Calculations were also performed for all 48 trials (i.e., including the practice period). This test measures attention, which is associated with functioning of the frontal lobes of the brain.

In the HE test, the child had to use the up-and-down movement of the joystick to control a cursor moving horizontally across the computer screen to follow a sine-wave pattern as closely as possible. Five trials were administered, and the score for each trial was the root mean squared (RMS) deviation of the cursor from the vertical position of the target for 300 points across the screen. The summary measure was the mean of the RMS error score on the two best of the five trials. However, some children performed so poorly on the HE test that it was considered that they could not understand the instructions. Therefore, two analyses were performed on these data: one of all the children who performed the test and a second, censured analysis of those children whose summary scores were at least 10% better than the practice trial. This latter pattern is consistent with the normal within-task learning of how to perform this task for naive subjects. The HE test measures manual motor coordination. Performance on such tests is impaired in patients with cerebral motor system disease.

All tests were administered in the following sequence: FT, CPT, and HE. In a few cases, if a child failed to perform a particular test, the test was aborted, and the subsequent one was attempted.

Functional Acuity Contrast Test (FACT)

The FACT was carried out in a room with uniform illumination within the recommended intensity range and with the chart at a required distance of 18 in. (45 cm). The eye not tested was occluded with a patch, and the child would use glasses if normally worn. The FACT consists of five rows, each containing nine circular areas with a pattern of dark and light bars. Moving from left to right, the contrast of the bars decrease by 0.15 log units, and, moving downward, the size of bars increases from 1.5 cycles per degree (cpd) to 18 cpd. Starting in the upper left corner, the child is asked to say or show in what direction (left, up, or right) the bars are tilted. The test is continued by moving from left to right, until an incorrect response is obtained. After the first incorrect response, the child was then asked to look at the preceding patch or patches to the left until a correct response was again obtained. Then testing resumed to the right until an incorrect response was obtained. The score was the contrast level at which the last correct response was given. The test was then continued by moving down to the next row. Each score was translated into contrast sensitivity values according to the instructions (4). Children with "poor" contrast sensitivity were those who performed below the 25th percentile for this cohort

TABLE 1
PERFORMANCE ON NES TESTS BY SEX

	Boys		Girls		
	N	Average	*N*	Average	*p*
Finger Tapping (FT)					
Preferred hand	453	(43)	454	(42)	0.005
Nonpreferred hand	454	(41)	453	(40)	< 0.001
Both hands	448	58.0	453	53.1	< 0.001
Continuous Performance (CPT)					
Nonresponses	454	(3)	456	(3)	0.90
Mean reaction time (ms)	454	745	456	757	0.021
Same, censured	381	728	372	737	0.079
Median reaction time (ms)	454	(737)	456	(754)	0.042
Hand–Eye Coordination (HE)					
Deviation, all	451	2.60	452	2.60	0.88
Same, censured	275	2.49	301	2.53	0.048

For results with a Gaussian distribution (K-S test), arithmetic means are given, and comparison is by Student's *t*-test; for other results, medians are in parentheses and are compared by Mann–Whitney *U*-test.

TABLE 2

PERFORMANCE ON NES TESTS IN RELATION TO ACQUAINTANCE WITH COMPUTERS AND JOYSTICKS

	None		Some		Much	
	N	Average	*N*	Average	*N*	Average
Finger Tapping						
Preferred hand*	291	(41)	371	(42)	249	(45)
Nonpreferred hand*	290	(39)	372	(41)	249	(43)
Both hands*	288	52.5	368	55.3	249	59.4
Continuous Performance						
Nonresponses*	289	(4)	371	(3)	249	(2)
Mean reaction time (ms)*	289	776	371	748	249	724
Same, censured*	213	749	315	733	224	715
Median reaction time (ms)*	289	(786)	371	(739)	249	(715)
Hand–Eye Coordination						
Deviation, all*	285	2.65	373	2.60	249	2.54
Same, censured†	181	2.54	234	2.52	163	2.46

For results with a Gaussian distribution (K-S test), arithmetic means are given, and comparison of the three groups is by parametric analysis of variance; for other results, medians are in parentheses, and the groups are compared by Kruskal–Wallis test.

*$p < 0.001$.

†$p < 0.01$.

on two or more rows with the right eye (scores for the two eyes were highly correlated).

Statistics

All data were entered into a single computer file, and statistical calculations were made by SPSS-PC version 5.0.1. For parameters with a Gaussian distribution, as determined by a Kolmogorov–Smirnov (K-S) test, parametric methods, such as Student's *t*-test, were used. For other parameters, nonparametric tests, such as Mann–Whitney *U*-test and Kruskal–Wallis test, were applied. Regression analysis was carried out with and without adjustment for covariates, which were entered before the independent variable of interest.

RESULTS

Almost all children who appeared for the examinations also completed all three NES tests. FT was easy for most children, although the large push-button on the joystick was not ideal for the children, as the wrist must rest on the counter during the test. We obtained complete data from 898 children. A total of 917 were examined with the CPT, 914 completed the full test, and 755 (83%) had less than 25% nonresponses. A few children had serious difficulty following the sine curve in the HE test, and only 575 (63%) were capable of improving their result by 10%. The coefficient of variation was highest (22%) for the FT both-hands condition and about 10% for CPT reaction time and HE.

The boys appeared to perform better than girls, especially on the FT test counts (Table 1), but they also had much more experience with computers and joysticks. After adjustment for this factor (Table 2), the sex-related differences almost disappeared. Within the age interval tested (80% of the children were between 6.5 and 7.2 years), age was significantly associated with all measures. When the children were separated into groups according to age quartiles, minimal associations with age remained within these narrow groups; the quartiles were therefore used as dummy variables in the subsequent regression analyses. There was no sex difference in the age at examination, but computer acquaintance clearly increased with the age of the child. When adjusted for the latter factor, associations of test results with age diminished considerably.

As the examination schedule might be tiring to some of the children, especially for those who did the NES tests during the fourth hour of the examinations, we examined the influence of examination time on NES results. Slightly, though significantly ($p < 0.05$), poorer performance was seen during the fourth hour of examinations in three CPT parameters (i.e., number of nonresponses, and average and median reaction times), and in the HE test score, especially before censuring. Association with time of examination was not apparent in FT counts.

As the children belonged to a birth cohort, little clinical disease was expected. A total of seven children had major neurological diagnoses (mainly epilepsy). From past medical histories obtained from the mothers, 58 children had had seizures, 37 had suffered skull trauma with apparent loss of consciousness, and 11 had had meningitis. These groups of children did not show any significant decrements on the NES tests.

The tests, especially CPT and HE, assume that the subject has excellent vision. Forty-six children wore eye glasses. They exhibited an increased number of nonresponses ($p < 0.01$), and the three measures of reaction time were all elevated ($p < 0.01$) relative to those who did not wear eye glasses. The average increase in the uncensored data was about 60 ms. Decreased visual acuity (less than or equal to 0.5 on both eyes without glasses) in 44 children at the clinical examination was associated with increased median reaction time ($p < 0.05$). Strabismus in 15 children was associated with increased reaction times ($p < 0.05$), similar in magnitude to those associated with the use of glasses.

Contrast sensitivity was generally excellent (Fig. 2), and results for the right and left eyes were highly correlated. Also, relative performance on one level of spatial frequency correlated highly with performance on other levels. Contrast sensitivity improved with age, especially for the two lower spatial frequencies on the right eye ($r_s = 0.12$, $p < 0.001$). Children

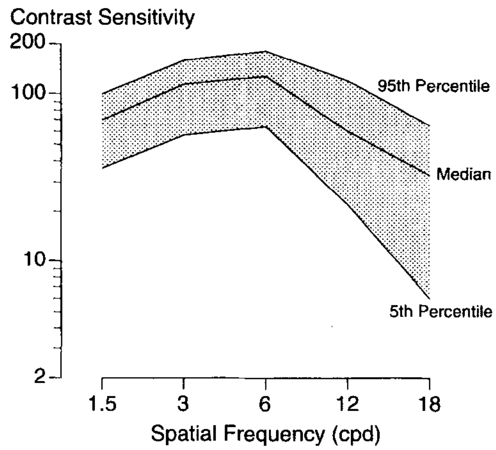

FIG. 2. Functional Acuity Contrast Test (FACT) results for the right eye obtained by 884 Faroese children at age 7 years. The contrast sensitivity values are indicated in accordance with the standardized procedure (4). The median and the 5th and 95th percentiles are shown.

with poor performance on this test (i.e., at least two scores on the right eye in the lowest quartile) showed poorer performance on the NES tests, other than FT. The median number of nonresponses on the CPT was 4 in those with poor contract sensitivity and 3 in those with better contrast sensitivity. Median reaction time showed an increase of about 45 ms in these children, but uncensured HE was increased only by about 2%. These differences decreased only slightly by adjustment for age.

As part of the pediatric examination, several relevant clinical tests were performed to assess motor function. The results obtained on each of the NES tests were compared for the children who showed automatic vs. questionable/poor performance on the functional neurological examination tests (Table 3). It appears that especially the both-hands condition of finger tapping is related to clinical examination data, and that performance on the ball game is most clearly related to finger tapping counts. With CPT, number of nonresponses and median reaction time are the two parameters that best correlated with clinical findings, whereas censured reaction time correlated poorly. Again, the ball game was the clinical test most closely associated with CPT performance. For HE data, performance on double finger agnosia was the best predictor.

None of the above predictors was clearly related to prenatal mercury exposure ($p < 0.05$). On the other hand, increased mercury exposure was associated with decreased performance on all NES parameters, in most cases statistically significant. As the logarithmic transformation of the two mercury exposure parameters approached a Gaussian distribution, they were used as independent variables in multiple regression analyses. The change associated with a doubling in mercury exposure was then obtained by multiplying the regression coefficient by 0.3010 (log 2) (Table 4). All covariates (sex, age, computer acquaintance, and visual function parameters) that were statistically significant on the bivariate analyses were then included as independent variables, age being translated into dummy variables as indicated above; these factors were included before mercury was entered into the regression. Because mercury exposure was poorly, if at all, associated with these covariates, the regression coefficients changed only slightly after adjustment (Table 4).

The calculations were also carried out for the CPT scores obtained for the full 4-min test period (i.e., including the practice period). The results were almost the same, although stronger associations were in general seen with the nonresponse counts and weaker associations with the reaction time measures. In Table 4, both nonresponse measures have been included for comparison.

DISCUSSION

Several NES tests have proven useful in adults, but limited experience has been published on the use of these tests in children (1,12,14). We found that, at age 7 years, the 15-s FT and the revised CPT were entirely feasible tests, although FT was somewhat difficult for the children, as the recommended joystick used as a response panel was clearly designed for adults. The CPT with the animal silhouettes offered limited difficulties in children who had not yet started school, although some children showed a high proportion of nonresponses, especially for the full 4-min test period. For reaction time, exclusion of the first minute probably provides a more precise estimate, which appears to show a better association with the risk predictors. The HE test appeared too difficult for many of the children. The error scores were relatively high, and most of the children were capable of improving their performance only minimally during successive trials. An attempt to exclude children with many missed responses on the CPT and with limited improvement on repeated trials on HE resulted in scores that were less clearly associated with the predictors.

TABLE 3

ASSOCIATION BETWEEN SCORES ON NES TESTS AND FUNCTIONAL NEUROLOGICAL TESTS

	Finger Tapping			Continuous Performance Test			Hand–Eye		
	Preferred Hand	Nonpref. Hand	Both Hands	Nonresp.	Mean RT All	Mean RT Censured	Median RT, All	Deviation All	Deviation Censured
Diadochokinesia	*	*	***	***	**	—	**	***	*
Reciprocal Coordination	*	**	***	***	**	—	***	***	—
Finger Opposition	*	—	**	**	**	—	**	***	*
Ball Game	***	***	**	***	***	***	***	**	—
Finger Agnosia	—	—	—	***	**	—	***	***	*
Double Finger Agnosia	—	—	—	**	—	—	—	***	**

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$ (Student's t-test and Mann–Whitney U-test).
RT = reaction time.

TABLE 4

CHANGE IN NES TEST RESULT ASSOCIATED WITH A DOUBLING OF MERCURY EXPOSURE, AS INDICATED BY THE MATERNAL HAIR-MERCURY CONCENTRATION AT PARTURITION, OR THE UMBILICAL CORD BLOOD-MERCURY CONCENTRATION, BEFORE AND AFTER ADJUSTMENT FOR SEX, AGE, COMPUTER ACQUAINTANCE, AND VISUAL FUNCTION

	Hair Mercury		Blood Mercury	
	Before	After	Before	After
Finger Tapping				
Preferred hand	−0.52†	−0.43*	−0.39*	−0.45†
Nonpreferred hand	−0.37*	−0.32*	−0.17	−0.23
Both hands	−0.93†	−0.89*	−0.51	−0.62
Continuous Performance				
Nonresponses	0.18	0.06	0.26	0.18
Nonresponses (incl. practice period)	0.25	0.09	0.33*	0.23
Mean reaction time (ms)	6.2†	4.0	6.4†	5.2†
Same, censured	4.3*	2.5	4.4*	3.6
Median reaction time (ms)	8.6*	4.3	10.0†	7.5*
Hand–Eye Coordination				
Deviation, all	0.022†	0.018*	0.016*	0.015*
Same, censured	0.023*	0.025†	0.016	0.020*

*$p < 0.05$, †$p < 0.01$.

Accordingly, the poor performance of some children must be accepted as meaningful and not due to a failure of the tests.

As the NES tests require that the subject use a joystick and watch a computer screen, acquaintance with computer games would be expected to act as an important predictor. In this study, boys and older children performed better than girls and younger children, but these associations were heavily confounded by computer acquaintance. Fortunately, this factor, as assessed in this study, was not associated with other parameters analyzed.

The children belonged to a birth cohort and were expected generally to be in good health. Few children had neurological disease, and small numbers had experienced meningitis, skull trauma, or seizures. These groups did not differ significantly from the rest of the children on the NES tests. Due to the small size of these groups and the fact that these children were capable and willing to participate and complete the tests, the absence of significant deficits is not surprising. Exclusion of data from these children from the overall evaluation was therefore not necessary.

Given the fact that the child is required to watch the computer screen, visual acuity may play a role, even for the FT performance (where each tap recorded produces a spot on the screen). It is noteworthy that decreased visual acuity, strabismus, use of eye glasses, and, in particular, contrast sensitivity were markedly associated with decreased performance, especially on the CPT. That HE (neither censured nor noncensured) did not show any association with visual function, except for contrast sensitivity, could be because the test was already too difficult for most of the children, so that visual acuity had little additional impact on an already poor performance. The fact that contrast sensitivity was assessed at a distance similar to that of the computer screen may, in part, explain why this test was a better predictor than, for example, visual acuity, which was tested at a distance of 6 m. Clearly, in computer-assisted tests where a stimulus is presented on the screen, even slight deficits in visual function are of crucial importance. The improvement in contrast sensitivity with age may have contributed to the better performance of older children. However, available evidence in this area is scant. One study of 15 children aged 67 to 78 months showed average sensitivity in the lower spatial frequencies similar to the fifth percentile in the Faroese children (13). Thus, if, for some reason, the Faroese children have better contrast sensitivity than other children, then visual function must be taken into account when comparing performance on NES tests in different populations. In agreement with this finding, a recent study carried out in adults (6) showed that much of the variance in NES test results can be accounted for by contrast sensitivity scores.

The functional neurological examinations were carried out to determine subtle clinical dysfunctions. However, as expected within the age interval examined (10), only a minority of the children was able to perform all tests optimally. It is interesting to note that FT was mainly related to the ability to catch a ball, whereas FT with both hands was also related to diadochokinesia and reciprocal coordination. The CPT data were significantly associated with all relevant clinical motor-function tests, although the censured mean reaction time was significantly associated with the ball game only. This observation would suggest that censuring the data produced a bias in the results and should be discouraged. The parameters most clearly associated with functional neurological tests were the number of nonresponses and the median reaction time. Although the children had difficulty with the HE test, and many were excluded from the censured calculations, the association with diadochokinesia and double finger agnosia suggests that the test may still be valid in the children who completed the task. Overall, these considerations therefore suggest that especially FT and CPT nonresponses and median reaction time would be useful indicators of neurobehavioral dysfunction related to motor speed and attention.

Prenatal exposure to methylmercury is known to affect a range of neurobehavioral functions, including motor function and vigilance (3,7), although it is unclear whether such adverse effects occur in Faroese children with high prenatal exposures to methylmercury (5). Clear associations were obtained between NES results and two indicators of neonatal neurotoxicant exposure, especially the mercury concentration in cord blood. Although significant and apparently only slightly affected by possible confounding bias, the deficits associated with a doubling of mercury exposure are limited (Table 4). Both mercury parameters reflect prenatal exposure to methylmercury, mainly originating from maternal consumption of pilot whale meat (8). However, particularly pilot whale blubber also contains other neurotoxicants, including PCBs (2). As PCB exposure cannot so far be ruled out as a potential underlying cause of the observed association between prenatal mercury exposure and neurobehavioral dysfunction, these data should not be interpreted as a proof that prenatal methylmercury exposure causes deficits on NES tests. Whatever the identity of any causative neurotoxicants, the data do show that FT (especially preferred hand and both-hands conditions) and CPT (mainly mean or median reaction times after exclusion of the first minute) are useful parameters in a study of 7-year-old children with prenatal exposure to neurotoxicants.

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