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NEUROBEHAVIORAL EVALUATION OF HOUSEHOLD EXPOSURE TO DURSBAN¹

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Rationale: Exposure to Dursban has been reported to be associated with chronic neurobehavioral effects (head-aches, fatigue, problems with memory and concentration, irritability etc.) EPA's document states that the application of termiticide post construction may result in exposures to applicators and to residents that exceed acceptable toxicity limits. Dursban TC, an organophosphate pesticide, contains 42.8% chlorpyrifos, and 57.2% unspecified "inert ingredients".

Subject: Male, 41 years, high school graduate, married, 3 children

Exposure: Approximately 70 gallons of Dursban residential termite applied in a structure with foundation cracks, with prior applications of Dursban, and liquid present on the basement floor. 14 pet fish immediately died. All family members had acute symptoms, including nausea, diarrhea, chest tightness, anxiety. The subject was involved with clean-up intermittently over a period of months. Dust samples one month after the application showed 810,000 mcg/kg of chlorpyrifos. Air sampling another month later showed elevated VOC's consistent with Dursban exposure.² ACHE testing was inconclusive. Later and persistent symptoms included fatigue, memory loss, personality changes, and impaired executive function.

Assessment approach: Comprehensive neurobehavioral toxicity evaluations were performed 4 years post-incident. The assessment included an extensive interview, administration of tests which have established normative bases and which are known to be sensitive to neurotoxicity, tests for malingering and distortion, and record review (medical, educational).

Findings: Prior IQ was at the 50thtile, or in the average range. The Neurotoxicity Screening Survey showed

¹March 12, 2003. Singer, R. (2003). Neurobehavioral evaluation of household exposure to Dursban. Toxicological Sciences, Vol. 72, Number S-1, March, page 311. Presented at the 42nd Annual Meeting of the Society of Toxicology, March 12, 2003 at the Salt Palace Convention Center, Salt Lake City, Utah.

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Air sampling showed elevated levels in the house included 1,3,5-trimethylbenzene; 1,2,4-trimethylbenzene; and o-xylene. The State of New York Department of Health, Bureau of Toxic Substance Assessment, stated "The basement levels were higher than the dining room, indicating a basement source... Laboratory comparison of the hydrocarbon pattern from your basement air samples to that of other homes known to have Dursban TC contamination show a very close match. It appears that the source of the elevated levels of VOCs in your home may be from the petroleum carrier of Dursban TC.

a symptom constellation (frequency and severity) consistent with those of patients diagnosed with neurotoxicity. Current Full-scale IQ had declined to the 6th%tile, with Working Memory at the 2nd%tile. Additional deficits were seen in verbal fluency (COWAT) (10th%tile); manual dexterity (Grooved Pegboard) (2nd%tile); auditory information processing and tracking (PASAT) (1st%tile); Stroop Color and Word Test (mental flexibility) 7th%tile; Visual Search and Attention Test (visual detection skills) 2nd%tile. Distortion was within normal limits. Malingering was ruled out by 5 separate tests. Personality testing using the NEO Personality Inventory found significant personality disorder, but there was no evidence of such disorder pre-incident. Record review found no competing explanations of his illness.

See Appendix 1 for a listing of the neurobehavioral test results.

Conclusion: Dursban exposure can cause neurotoxicity, revealed by neurobehavioral evaluation, lasting many years after exposure.

Appendix 1: Neurobehavioral test results

Gender: Male
 Age: 41
 Educational level: Some college
 Height: 6' 1"
 Weight: 230 lbs
 Ethnicity: White
 Marital Status: Married
 Number of Children: 3

(Note: WNL means within normal limits for the individual. “*” indicates a deficit.)

Premorbid IQ Estimate: Stanford-Binet, 1967, IQ was 100.

Cognitive Testing Standard: Scores significantly below the standard are considered abnormal for the subject and deficit.

IQ	Percent	Scaled Score equiv.	Cutoff Scaled/Percentile
100	50%	10	10/6

Wechsler Adult Intelligence Scale, Third Edition: WAIS-III:

	Age - Adjusted Scaled Scores	Percentile	Classification
Verbal Subscales			
Vocabulary	7	16%	
Similarities	4	2%	*
Arithmetic	4	2%	*
Digit Span	5	5%	*
Information	7	16%	
Comprehension	10	50%	
Letter-Number Sequencing	6	9%	*
Performance Subscales			
Picture Completion	8	25%	
Digit Symbol - Coding	6	9%	*
Block Design	8	25%	
Matrix Reasoning	5	5%	*
Picture Arrangement	8	25%	
Symbol Search	6	9%	*
Object Assembly	9	37%	

Optional Procedures:
 Digit Symbol -
 Incidental Learning

Pairing	10	25%
Free Recall	6	10%
Copy	89	5-10%

	<u>Score</u>	<u>Percentile</u>	<u>Confidence Interval - 90%</u>
IQ Scores:			
Verbal IQ:	77	6%	74 - 82
Performance IQ:	80	9%	76 - 87
Full Scale IQ:	77	6%	74 - 81
Index Scores:			
Verbal Comprehension	78	7%	74 - 84
Perceptual Organization	82	12%	77 - 89
Working Memory	69	2%	65 - 77
Processing Speed	79	8%	74 - 89

Interpretation: Deficit in all composite aspects of IQ.

Wechsler Memory Scale, Third Edition (WMS-III):

<u>Primary Subtests</u>	<u>Age Scaled Score</u>	<u>Percentile</u>
Logical Memory I - Recall	8	25%
Faces I - Recognition	9	37%
Verbal Paired Assoc. I - Recall	5	5%
Family Pictures I - Recall	8	25%
Letter-Number Sequencing	6	9%
Spatial Span	5	5%
Logical Memory II - Recall	9	37%
Faces II - Recognition	9	37%
Verbal Paired Assoc. II - Recall	4	2%
Family Pictures II - Recall	7	16%
Auditory Recognition - Delayed	8	25%

Auditory Process Subtests

Logical Memory I			
1 st Recall Total	7	16%	
Learning Slope	10	50%	
Verbal Paired Assoc. I			
1 st Recall Total	7	16%	
Learning Slope	8	25%	
Logical Memory II			
Percent Retention	11	63%	
Verbal Paired Assoc. II			
Percent Retention	3	1%	
			Confidence
Primary Index Scores	<u>Index Score</u>	<u>Percentile</u>	<u>Interval (90%)</u>
Auditory Immediate	80	9%	75-87 *
Visual Immediate	91	27%	84-101
Immediate Memory	82	12%	77-90 *

Auditory Delayed	80	9%	75-90	*
Visual Delayed	88	21%	82-98	
Auditory Recog. Delayed	90	25%	83-102	
General Memory	82	12%	77-90	*
Working Memory	76	5%	71-87	*

Auditory Process Composites	<u>Scaled Scores</u>	<u>Sum of Percentile</u>
Single Trial Learning	14	9%
Learning Slope	18	34%
Retention	14	11%
Retrieval	2	78%

Interpretation: Deficit in numerous areas of memory, see composites above with *.

Benton Visual Retention Test (Administration B, Form C). This test assesses the ability to remember, based upon visual input. Comparison IQ = 92

	<u>Expected for IQ</u>	<u>Observed</u>	<u>Difference</u>
Number correct	7 - 1 = 6	5	1
Number errors	4 + 2 = 6	9	3

Interpretation:

Number correct score: WNL

Number of errors score: Raises the question of acquired impairment of cognitive functioning.

Controlled Oral Word Association Test evaluates verbal fluency, the ability to find and use words (Benton Controlled Oral Word Association Test: Reliability and updated norms. RM Ruff et al. *Archives of Clinical Neuropsychology*, **11**(4), 329-338, 1996).

<u>Raw Score</u>	<u>Correction</u>	<u>Total</u>	<u>Percentile</u>	<u>Classification</u>
25	+3	=28	10%	Borderline

Interpretation: Deficit

Perseverations: 0, 56%, Intact

Embedded Figures Test evaluates the ability to detect visual figure-ground relationships (the use of the eyes to make sense out of what the eye sees).

Number detected out of 40 objects: 34

Percentile for age and education: 58%

Interpretation: Within normal limits

Frontal Systems Behavior Scale (FRSBE) is a rating scale designed to measure behaviors associated with damage to the frontal lobes and frontal systems of the brain.

Self Rating

T-score

T-score

	<u>Before Illness</u>	<u>%</u>	<u>After Illness</u>	<u>%</u>
Apathy	37	10%	81	>99
Disinhibition	56	73%	80	>99
Executive Dysfunction	54	65%	96	>99
Total	49	46%	93	>99

Interpretation: Symptoms of damage to the frontal lobe systems of the brain.

Grooved Pegboard Test evaluates manual dexterity (the ability to use hands in a sensitive and productive way). Dominant Hand: Right

	<u>Dominant</u>	<u>Non-dominant</u>
Time for completion:	95"	101"
Percentile:	2%	2%
Interpretation:	<u>Deficit</u>	<u>Deficit</u>

Neurotoxicity Screening Survey:

<u>Factor</u>	<u>Results</u>	
	<u>Score</u>	<u>Classification</u>
Memory and Concentration.....	117	Elevated
Autonomic Nervous System.....	69	Elevated
Vision.....	16	Elevated
Hearing.....	9	Elevated
Balance.....	3	Elevated
Smell-Taste.....	9	Elevated
Peripheral Numbness.....	18	Elevated
Sensory-Motor.....	56	Elevated
Chemical Sensitivity.....	7	Elevated
Emotionality.....	83	Elevated
Distortion I.....	19	Borderline
Distortion II.....	14	Borderline
Overall Neurotoxicity Indicator	387	Elevated

Interpretation: Results consistent with those of patients diagnosed with neurotoxicity.

Paced Auditory Serial Addition Test evaluates auditory information processing and tracking.

	<u>Number correct of 60</u>	<u>Percentile</u>
Set A	24	1%
Set B	16	<1%
Set C	14	<1%
Set D	9	<1%

Interpretation: Deficit

Stroop Color and Word Test evaluates mental flexibility (45 sec administration).

	<u>Number</u>	<u>T-Score</u>	<u>Percentile</u>	<u>Interpretation</u>
Word reading:	76	34	5%	<u>Deficit</u>
Color naming:	24	<20	<1%	<u>Deficit</u>
Color/Word:	30	35	7%	<u>Deficit</u>
Interpretation:	<u>Deficit</u>			

Trailmaking Test evaluates visuomotor tracking (the ability to search and locate with the eyes) and attention (the ability to concentrate on a task so learning and other mental functions can take place). (Norms based on gender, age and education.)

Note: there were 4 errors on Part B.

	<u>Part A</u>	<u>Part B</u>
Time for completion:	39"	256"
Scaled score:	7	3
Percentile:	14%	<1%
Interpretation:	Within normal limits	<u>Deficit</u>

Visual Search and Attention Test

	<u>Left</u>	<u>Right</u>	<u>Total</u>
Score	40	44	84
Percentile	1%	5%	2%
Interpretation:	<u>Deficit</u>	<u>Deficit</u>	<u>Deficit</u>

Wide Range Achievement Test

	<u>SS</u>	<u>Percentile</u>	<u>Grade Equiv.</u>
Reading	75	5%	6th (was at the 48% in 10 th grade; 78 th percentile in the 9 th grade)
Spelling	64	1%	4th
Arithmetic	79	8%	6th (was at the 54 th percentile in the 9 th grade)

Interpretation: Deficit in reading and arithmetic.

EMOTIONAL FUNCTION

Beck Anxiety Inventory measures emotional anxiety*. Score: 40

Interpretation: Severe anxiety

Beck Depression Inventory measures emotional depression**. Score: 30

Interpretation: Extremely severe depression

Profile of Mood States

	<u>Raw Score</u>	<u>T Score</u>	<u>%</u>
Tension	34	68	96%
Depression **	46	66	95%
Anger/Hostility	36	72	99%

Vigor	7	44	27%
Fatigue	22	66	95%
Confusion/Bewilderment	23	66	95%

Interpretation: Elevated mood of tension, depression, anger, fatigue and confusion.

Whitaker Inventory of Schizophrenic Thinking

Index: Errors score WNL.

Interpretation: Non-psychotic

WELL-BEING MEASURES

Alcohol Use Disorders Identification Test (AUDIT) was developed by the World Health Organization to identify alcohol use disorders. Cutoff = 8

Score: 4

Interpretation: Severe alcohol use problems are unlikely.

General Well Being Schedule evaluates general well-being compared with the population of the US.

Score: 36 - 14 = 22

0-60 Severe Distress

61-72 Moderate Distress

73-110 Positive Well-being

Human Activity Profile measures levels of physical activity.

	<u>Score</u>	<u>Percentile</u>
Maximum Activity Score	73	6%
Adjusted Activity Score	65	4%
Activity Age	70+	
Activity Classification	Moderately active	
Dyspnea Scale	13	4%
Interpretation:	<u>Deficit</u>	

Quick Environmental Exposure and Sensitivity Inventory, Version 1 (QEESI) identifies health problems respondent may experience in response to various environmental exposures.

	<u>Score</u>	<u>Interpretation</u>
Chemical Intolerance	76	High
Other Intolerance	15	Medium
Symptom Severity	75	High
Masking Index	2	Low
Life Impact	41	High

Interpretation: Very suggestive of multiple chemical sensitivity.

DISTORTION AND MALINGERING TESTS

Endorsement of Rare Symptoms. The Neurotoxicity Screening Survey presents 14 symptoms that are rare. If a number of these symptoms are endorsed, the question of distortion is highlighted.

Number endorsed: 12
 Distortion I: 6 (but 4 of these symptoms patient says he already had before exposure)
 Distortion II: 6 (but 3 of these symptoms patient says he already had before exposure)

Interpretation: Some distortion present; non-malingering.

Even-Odd Forced Choice Test requires the subject to add two single digit numbers, and determine whether the product is even or odd. If the subject's performance is random, the results will still be approximately the same as the results of someone performing absolutely correctly.

Number correct: 20/20 (However, there were two addition errors correctly classified.)
 Interpretation: Non-malingering

Memorization of "16" Items (Iverson & Franzen, 1991) requires the subject to memorize a list of 16 items. Because the 16 items are grouped into four conceptual categories, the task is easier than it looks. A cutoff of 6 is used to suggest malingering.

Number correct: 16/16
 Interpretation: Non-malingering

Miller Forensic Assessment of Symptoms Test (M-FAST) provides information regarding the probability that an individual is malingering psychiatric illness based on a structured interview. Total score cutoff = 6.

	<u>Raw Score</u>	<u>% Negative Prediction</u>	<u>% Positive Prediction</u>
Reported vs. Observed	1		
Extreme Symptomatology	1		
Rare Combinations	1		
Unusual Hallucinations	1		
Unusual Symptom Course	0		
Negative Image	0		
Suggestibility	1		
Total	5	96%	62%

Interpretation: Non-malingering

Portland Digit Recognition Test, a memory recognition test, requires the subject to memorize a 5 digit number and recognize the same number when given two choices of 5 digit numbers. By chance alone, the subject should respond correctly 50% of the time.

Percent correct responses (5 sec delay): 3/3
 Percent correct responses (15 sec delay): 3/3
 Percent correct responses (30 sec delay): 1/1

Interpretation: Non-malingering

Twenty-one Item Memory Test assesses the probability of malingering based on a forced choice comparison (Iverson and Franzen, 1989). If the subject does not remember correctly nine of the 21 items on the forced choice test, the subject may be malingering.

Number of words correctly recalled:

Free recall:	4
Forced choice:	14

Interpretation: Non-malingering

* *Anxiety and Neuropsychological Test Performance* (1999). Schrage, DA, Morris, DL and Gouvier, W. D. . Archives of Clinical Neuropsychology, 14,1, January 1999. Their findings suggest that anxiety has only a minimal effect on neuropsychological test performance.

** *Evidence that Depression Does Not Influence Neuropsychological Test Performance* (Cancelliere, A. and Livshits, R.) Archives of Clinical Neuropsychology, 14, 8, Nov. 99, p. 760. Upon retesting after depression had lifted, there was no significant change in performance on neuropsychological test performance.

** *The degree of memory impairment and the depression scores did not correlate, indicating that both depression and cognitive impairment could be long-lasting sequelae to the acute intoxication* (Stollery, BT and Flindt, MLH. Memory sequelae of solvent intoxication. Scand J Work Environ Health, 14, 45, 1988.)

** *Does treating depression improve cognitive functioning in depressed patients with multiple sclerosis?* Cox, DS, Mohr DC, Epstein L. Archives of Clinical Neuropsychology, Volume 15, No. 8, November 2000, P. 713. Their findings are more consistent with past research suggesting that cognitive deficits in multiple sclerosis are not impacted by co-morbid depression (DeLuca et al. 1995, Amato 1995, Moeller et al., 1994)

** *Attention and memory function in solvent neurotoxicity* (1992). L.A. Morrow & N. Robin. Presented at the 20th Annual Meeting of the International Neuropsychological Society, February 5th, 1992, San Diego, CA. There was no correlation between mood indices (e.g., depression) and performance on the cognitive measures, suggesting that the reduction in memory efficiency is not caused by current affective status.