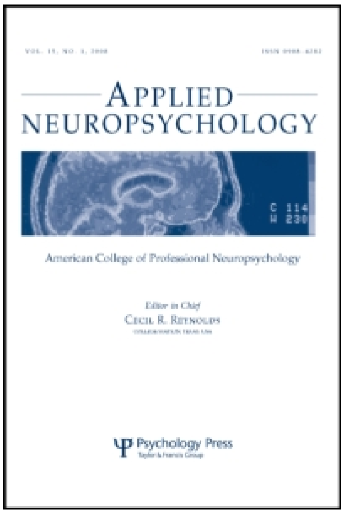

Applied Neuropsychology
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t775648089

Pesticide Poisoning in a Preschool Child: A Case Study Examining Neurocognitive and Neurobehavioral Effects

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Online publication date: 13 May 2010

To cite this Article Riccio, Cynthia A. , Avila, Leonor and Ash, Michael J.(2010) 'Pesticide Poisoning in a Preschool Child: A Case Study Examining Neurocognitive and Neurobehavioral Effects', Applied Neuropsychology, 17: 2, 153 — 159
To link to this Article: DOI: 10.1080/09084281003715618
URL: http://dx.doi.org/10.1080/09084281003715618

APPLIED NEUROPSYCHOLOGY, *17*: 153–159, 2010

ISSN: 0908-4282 print/1532-4826 online
DOI: 10.1080/09084281003715618

Psychology Press
Taylor & Francis Group

Pesticide Poisoning in a Preschool Child: A Case Study Examining Neurocognitive and Neurobehavioral Effects

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Exposure to environmental toxins, such as pesticides, has been shown to have adverse effects in humans, particularly neurological effects. Cases of acute pesticide poisoning occur less frequently and are less well documented; specific deficits (e.g., in processing speed, working memory) have not consistently been discussed. This is a case study of a preschooler who underwent a neuropsychological assessment due to a pesticide poisoning. His parents reported attention, speech, social, and gross and fine motor concerns after the poisoning. A number of methods and measures were used, including observational data, neuropsychological, and behavioral and social-emotional measures. Consistent with past research, results from the assessment demonstrated the subtle and not-so-subtle effects of acute pesticide poisoning. Implications of the findings are discussed.

Key words: *early childhood, neurocognitive assessment, pesticide, poisoning, teratogens*

Issues related to the negative effects of environmental substances have received increased attention with the passage of an executive order (Clinton, 1997), as well as Healthy People 2010. Toxic exposure comes in a number of forms that ultimately are poisonous to one or more aspects of the neural system (Williams & Ross, 2007). Exposure may be in the form of direct interaction as in the case of a child who chews on a toy that has been finished with lead paint; alternatively, effects on an unborn child are indirect and occur through maternal contact or ingestion of the toxin. Neurodevelopmental toxicity of various pesticides or metals (e.g., lead) constitutes an important public health concern (Buck, 1996). In many ways, children may be more susceptible to the effects of toxins such as pesticides or lead due to their developmental status.

Of the various environmental toxins, pesticides are toxic chemicals that are intentionally introduced into the environment to reduce some nuisance species (Colosio, Tiramani, & Maroni, 2003). The primary uses of pesticides are for control of insect populations in homes and in agricultural settings; there is consistent research to suggest an association between even low levels of pesticide exposure and neurobehavioral deficits (Rothlein et al., 2006). Unfortunately, the same toxicity that makes pesticides effective in eliminating target species may pose significant risks to humans. The organophosphates (OPs) and carbamates, for example, inhibit acetyl cholinesterase, in turn increasing the level of acetylcholine (ACh) at the synapse and overactivating the cholinergic pathways (Jokanovic, 2009). The cholinergic system is directly related to habituation, attention, and activity level. Effects may be acute, but there may also be delayed onset effects resulting from permanent changes or inhibition of specific enzymes (Aldridge, Meyer, Seidler, & Slotkin, 2005).

Although the use of a selected number of pesticides (e.g., dichloro-diphenyl-trichloroethane; DDT) has been prohibited, other pesticides have taken their place, including pyrethoids and organophosphorus insecticides. The OPs account for about half of all pesticides used; they act against a broad range of insects. The OPs, for example, break down into a number of substances including the dialkyl phosphate metabolites. Of

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the OPs, parathion use was banned as of 2003 in the United States. Another OP, chlorpyrifos, is believed to act on the serotonergic system and the 5-HT receptors, transporters, and signal transduction (Aldridge et al., 2005; Aldridge, Seidler, Meyer, Thillai, & Slotkin, 2003), as well as on the dopaminergic system (Aldridge et al., 2005). Although chlorpyrifos accounted for one-fifth of the insecticides used in 1997, it is expected that with the increased restrictions of the Food Quality and Protection Act of 1996 its use will decrease (Centers for Disease Control and Prevention, 2003). Diazinon and malathion, however, continue to be used extensively. Guidelines for evaluation of pesticide neurotoxicity are limited in that they do not include assessment of effects at various periods of vulnerability or of effects that only may become evident with time (Claudio, Kiva, Russell, & Wallinga, 2000).

Few cases of acute pesticide poisoning have been reported in the literature. In fact, the majority of studies examining neurotoxic effects of pesticides have focused on the workers who have direct, identified contact with the pesticides. In general, results indicate that exposure by workers to pesticides such as diazinon result in lowered performance overall (Maizlish, Schenker, Weisskopf, Seiber, & Samuels, 1987). Depending on the study, however, specific deficits (e.g., in processing speed, vigilance, working memory, inhibition, visual motor processing, constructional abilities, and psychiatric) have or have not emerged (Bazylewicz-Walckzak, Majkzakova, & Szymczak, 1999; Després et al., 2005; Fiedler, Kipen, Kelly-McNeil, & Fenske, 1997; London, Myers, Neil, Taylor, & Thompson, 1997; Roland-Tapia et al., 2006). While most of the research has focused on adult exposure, it has been suggested from animal studies that many pesticides are "neurodevelopmental toxicants even at moderate levels" (Eskenazi et al., 2008, p. 228). One study in particular examined the mechanisms by which chlorpyrifos affected the ACh as well as the serotonergic system in rats to further examine the mechanisms that might contribute to neurodevelopmental disorders (Slotkin & Seidler, 2009). Slotkin and Seidler concluded that even nontoxic effects could impair neurodifferentiation and ultimately the neurotransmitter phenotypes. Exposure of children can originate from multiple sources and can occur prenatally as well as postnatally (Curl et al., 2002; Eskenazi et al., 2008; Lambert et al., 2005; Quandt et al., 2006). Residential contamination has been found at farms, from children's exposure when they visited their parents in the fields, from drift associated with spraying (Otto, Calderon, Mendola, & Hilborn, 2000), or from soil that is tracked into or blown into the home (Infante-Rivard & Weichenthal, 2007; Lambert et al., 2005; Moses et al., 1993; Mott, 1995; Zahm & Ward, 1998). In addition to agricultural settings, pesticide exposure to children is also very high in urban settings (Adgate et al., 2001), probably as a result of the heavy use of pesticides in many city dwellings. More acute exposure occurs when small children gain access to pesticides used in the home and these are ingested. Given that the chemical mechanisms of pesticides all have neurological effects, and that development of the central nervous system can be impacted postnatally as well as prenatally, the outcomes of those children who experience acute level exposure to pesticides is of great interest.

THE CASE OF PETER

The case study presented here is of a 3-year, 11-month-old male, identified as "Peter" in this case study to protect confidentiality; Peter is an African American child of average height and weight with dark skin and dark hair. He was referred for assessment due to a pesticide poisoning that occurred when he was 3 years, 1 month of age. The pesticide was not identified but was one commonly used in households; the level of exposure was not determined. Subsequent to this event and his hospitalization, his parents expressed concern about his short attention span. Background information was provided by his parents using a questionnaire and interview format. Peter was born and raised in a small town in the Southwestern United States. He always has lived with his mother. His mother and father are not married; however, he has daily contact with his father. Both parents completed the 12th grade. His father is employed and has been employed for the same company for 5 years. His mother began work at her current position within the past 3 months; prior to that time, she stayed at home with Peter. The nature and location of their positions is not relevant to the case and intentionally has been withheld. Peter's father reported that he takes care of Peter when his mother is gone, usually for 8 hours a day. Parents reported that Peter's relationship with both of them is good. His father reported that Peter participates in many family activities, such as eating meals, playing sports, watching television, visiting relatives, and going to church. Peter sees his grandparents once or twice a month. There was some indication of possible family history of learning problems; both parents reported that they are currently in good health.

Developmental History

Parents reported that Peter was not a planned pregnancy but that his mother was under a doctor's care. She had not had any previous pregnancies or miscarriages; there were no complications during her pregnancy or during birth reported. Peter's father was 25 years old and his mother was 18 years old when Peter was born. Peter was born full term, in the hospital with normal delivery and without anesthesia; he weighed 7 lb at birth. His condition at birth was ''healthy,'' and his mother's condition at birth was ''good;'' Peter and his mother remained in the hospital only 2 days.

Peter's development was reported as relatively normal. He turned over by 2 months, sat alone by 3 months, crawled by 6 months, stood alone by 8 months, walked alone by 9 months, walked up and down stairs by 1.5 years; he showed interest in or attraction to sound at around 1 month, understood his first words by 10 months, spoke his first words by 12 months, and spoke in sentences by 18 to 20 months. Peter does not have any hearing problems. Peter's only language is English; it is the only language spoken at home. Peter was not breast-fed and was bottle fed and weaned by 1 year. He was toilet trained by age 2. He did not wet the bed or soil the bed after training.

Peter has (and has always had) unclear speech because he talks too fast. Although he has always been like this, his mother reported that after the accident his speech is different in that it is harder to understand. Peter has had minor walking difficulties and is described as being clumsy from an early age. After the poisoning incident, his mother reported that he has become clumsier, he tends to fall, and he has poor coordination. He also never learned to skip. Peter writes and eats with his right hand; he does other activities like throwing and kicking with his left hand. His father reported that before the pesticide poisoning, he used to throw and kick with his right hand and foot but that he now does these with his left hand and foot. His father further reported that Peter used to hold the pencil correctly but that now he does not; his grip is immature.

Medical Status

Peter has never been on any long-term medication. He does not have any respiratory, cardiovascular, gastrointestinal, genitourinary, hearing, or vision problems. He has never been told he had a neurological problem; he has never had a neurological exam. Peter's medical history indicates he was hospitalized for pesticide poisoning for a week at the age of 3 years, 1 month. When he was hospitalized, his speech was slurry, he would say things that did not make sense, and he was vomiting, limp, and unconscious. He was treated for poisoning and hospitalized until stable. He was not given any medication, and parents were told that there would not be any lasting effects—he would be the ''same'' as he was before the incident. At the time of his release from the hospital, he barely spoke and was still a bit limp; he started getting better as the weeks went by. His parents reported that now, after the poisoning incident, Peter is ''not the same.'' Specifically, it is difficult for him to pay attention, and he is easily distracted. He also sometimes does not remember certain things. His teacher reported that he is not interested in his school work anymore. He also has many temper tantrums when things do not go his way; these are more frequent and more intense than before the accident. Also, Peter currently bruises from his ''clumsiness,'' and he sometimes falls.

Educational History

Peter attended a Head Start Home-base program beginning at age 3 years. As part of this program, his teacher would go to his house a few times a week for a few hours. His teacher reported that before the accident, he used to be very engaged and interested in the activities that she would bring to do with him. In contrast, after the accident, he seemed to have lost that interest. She also reported that it is very difficult for him to pay attention; he has difficulty remembering colors, shapes, numbers, and letters. His mother reported that Peter used to know most of them but that after the accident he only sometimes recognizes them. Peter will continue in preschool until entry into kindergarten. He has never been tested for special education. His father did not express any concern about the quality of Peter's preschool or his teacher.

Social Development

There are children in the neighborhood with whom Peter can play. Peter's father reported that prior to the accident, Peter used to socialize with a lot of people and used to share toys; now he socializes with ''just a couple of kids'' and does not share toys. Specifically, his father reported that Peter now ''only wants to play with certain kids.'' He fights frequently with playmates and has difficulty making friends because he is ''bashful.'' His father also reported that in group activities, Peter is usually a follower. Peter enjoys playing basketball and going horseback riding and fishing; his interest in these activities has not declined recently. At the same time, his father reported that Peter has a short attention span, seems overly energetic in play, overreacts when faced with a problem, seems uncomfortable when meeting new people, requires a lot of parental attention, and cannot calm down; further, he becomes angry when other children play with his toys. Peter's mother is mainly in charge of discipline at home, but both parents agree on discipline. By parent report, what makes it most difficult in raising Peter currently is that he sometimes does not listen and can be frustrating.

Estimated Premorbid Intelligence

There is not a specific algorithm for predicting ability as measured by the cognitive measure used in this assessment process. To provide some estimate of premorbid intelligence, the general Child Premorbid Intelligence Estimate (CPIE; Schoenberg, Lange, Saklofske, Suarez, & Brickell, 2008) demographic algorithm was used. This algorithm incorporates parent educational level, a constant, and ethnicity [CPIE(DEM) = Constant (72.868) + (Parent Years of Education × 2) + Ethnicity Constant (African American = −7.162)]; all other CPIE algorithms are for specific scales or subscales and could not be used. Based on this algorithm, Peter's CPIE was 89.706 or estimated IQ of 90.

Neuropsychological Evaluation Results

A number of methods and measures were used to better understand Peter's strengths and weaknesses. This includes observational data at the Main Office of Head Start on four different occasions for actual assessment. All assessment was conducted in a well-lit, well-ventilated room during the course of the four sessions; each session took around 1 hour. Peter was dressed comfortably and was well groomed. Rapport was easily established. His affect was good, and he would smile at the examiner often. During the first session, Peter had just woken up and would not move much; he appeared tired, although interested in the tasks. During the remaining sessions, Peter would gradually become more and more inattentive and had to be prompted constantly to sit down and to put on his "listening ears." He was constantly moving even when he was sitting down; he fell off the chair a couple of times. At one point during the assessment, Peter started jumping around the room and rolling on the ground; the examiner had to redirect him to the tasks at hand. The examiner had to end sessions when it was becoming extremely hard for Peter to pay attention to the tasks. His verbalization was limited. When he would say one or a few words, his speech was clear; when he said more than a few words at a time, he spoke very quickly and it was difficult to understand him. His eye contact was good sometimes, but most of the time, Peter would look around the room. He would also smile often. He did not ask any questions during the testing, other than asking if he could play with the blocks. It was not hard for him to answer a question after one that he had found difficult.

Peter was the administered the Kaufman Assessment Battery for Children, Second Edition (KABC-II; Kaufman & Kaufman, 2004); this is a measure of processing and cognitive ability for children aged 3 to 18 years. It is composed of subtests that require the child to complete a variety of tasks that measure processing areas and broad abilities. The theoretical model of choice for this administration was the Cattell-Horn-Carroll, yielding a Fluid Crystallized Index (FCI). The Nonverbal Index (NVI) was also administered to determine if he would obtain a better score when presented with only nonverbal tasks; results are presented in Table 1. On this administration of the KABC-II, Peter obtained an FCI of 77. Given the potential for chance error in testing, there is a 90% likelihood that his "true" score falls between 72 and 84, suggesting below-average overall ability with his scores as good or better than 6% of his same-age peers; thus, Peter's cognitive abilities are below average and lower than expected based on his CPIE. Peter obtained an NVI of 59. Given the potential for chance error in testing, there is a 90% likelihood that his "true" score falls between 54 and 70, suggesting overall ability in the lower-extreme range with his scores as good or better than 0.3% of his same-age peers; Peter's cognitive abilities on solely nonverbal tasks are at the lower extreme range and well below his estimated CPIE. Comparison of the FCI and NVI indicates that Peter performed better when he was given verbal tasks in addition to nonverbal tasks; therefore, the FCI is a better measure of cognitive ability for Peter. Although not considered clinically, the Mental Processing Index was computed and is included in Table 1. When expressive vocabulary and riddles are excluded from the global scale, Peter's obtained standard score of 90 (confidence interval of 83 to 99) is more consistent with his CPIE.

Peter also was administered the Developmental Neuropsychological Assessment, Second Edition (NEPSY-II; Korkman, Kirk, & Kemp, 2007) to assess neuropsychological development. Based on the Luria developmental theory, the NEPSY-II is a standardized instrument that yields composite scores in six content domains (Attention/Executive Functioning, Language, Memory and Learning, Social Perception, Sensorimotor Functions, and Visuospatial Processing). After examination across domains, it is evident that Peter's abilities varied depending on the types of tasks; he evidenced relative weaknesses and strengths across different areas.

Peter's major deficiencies are in the language domain with his obtained scale scores ranging from 4 to 9 (below expected level to at the expected level); his lowest scores occurred within the Language domain. Peter evidences strengths in phonological awareness and processing abilities, as well as in his executive control of language production, initiative, and ideation. His scores indicate borderline ability on word finding, expressive language, and/or vocabulary. He also evidences borderline ability on linguistic or syntactic knowledge and on his ability to follow multistep commands. He evidences below-expected levels of automaticity of lexical access, processing speed, and/or naming ability.

Peter's obtained scale scores in the Sensorimotor domain, ranging from 7 to 16, indicate significant variability in this area. Although his fine-motor programming and visuospatial skills are at the borderline level of ability, his fine-motor coordination and speed are at

TABLE 1
Psychometric Summary for "Peter," Age 3 Years, 11 Months

	Scaled Score	Standard Score (with 90% Confidence Interval)
Kaufman Assessment Battery for Children, Second Edition (KABC-II)		
Atlantis	8	
Conceptual Thinking	7	
Face Recognition	9	
Expressive Vocabulary	8	
Triangles	5	
Word Order	4	
Hand Movements	3	
Riddles	9	
NONVERBAL INDEX		59 (54–70)
FLUID CRYSTALLIZED INDEX		77 (72–84)
MENTAL PROCESSING INDEX*		90 (83–99)
Developmental Neuropsychological Assessment, Second Edition (NEPSY-II)		
Attention/Executive Function Statue	7	
Language		
Body Part Naming	7	
Body Part Identification	6	
Comprehension of Instructions	7	
Phonological Processing	9	
Speeded Naming Completion	5	
Time		
Speeded Naming Combined	4	
Word Generation Semantic Total	8	
Memory and Learning		
Narrative Memory	7	
Sentence Repetition	9	
Sensorimotor		
Imitating Hand Positions	7	
Visuomotor Precision Total	16	
Completion Time		
Visuomotor Precision Combined	8	
Social Perception		
Affect Recognition	9	
Theory of Mind	7	
Visuospatial Processing		
Block Construction	9	
Design Copying	7	

	T-Scores	
	Mother	*Father*
Behavior Assessment System for Children, Second Edition (BASC-II)		
Hyperactivity	85	81
Aggression	64	92
Anxiety	69	61
Depression	68	82

(*Continued*)

TABLE 1
Continued

	T-Scores	
	Mother	*Father*
Somatization	48	51
Atypicality	78	105
Withdrawal	62	68
Attention Problems	73	70
Adaptability	36	47
Social Skills	41	39
Activities of Daily Living	46	54
Functional Communication	37	41
EXTERNALIZING PROBLEMS	77	90
INTERNALIZING PROBLEMS	65	69
BEHAVIORAL SYMPTOM INDEX	79	95
ADAPTIVE SKILLS	37	44

*Mental Processing Index is included here only to illustrate the difference in functioning depending on the combination of subtests considered.

the expected level of ability. Further, the speed with which he carries out manual motor tasks is at the above-expected level of ability and is a strength for Peter. For the visuospatial processing domain, Peter's visuoconstructional skills on three-dimensional tasks (e.g., block building) are at his expected level, while his visuoconstructional skills in two-dimensional tasks (drawing) are at the borderline level.

Peter evidences borderline ability in the domain of Attention and Executive Functioning; he obtained a scaled score of 7. This is indicative of relatively low inhibitory control and motor persistence. Further, his obtained scaled scores of 7 and 8 in the Social Perception domain indicate some problems in this area as well. Specifically, his facial affect recognition abilities are at his expected level, but his ability to comprehend perspectives, experiences, and beliefs of others are at the borderline level. Finally, in the area of memory and learning, Peter obtained scaled scores of 7 to 9. Specifically, his short-term memory abilities are at his expected level, while his verbal expression, comprehension, and verbal learning abilities are at the borderline level and consistent with his significant weaknesses in the language area.

Behavior/Social-Emotional Status

A number of rating scales were completed by Peter's parents, including the Behavior Assessment System for Children, Second Edition (BASC-II), Structured Developmental History (Reynolds & Kamphaus, 2004), and the BASC-II, Parent Rating Scales – Preschool

(Reynolds & Kamphaus). These scales present the parent with a number of statements; the parent indicates the frequency with which these statements describe Peter. A clinical interview was also conducted with his parents to clarify information regarding Peter. Although response patterns for his mother suggest that her responses are valid, his father's response pattern suggests that the results should be interpreted with caution.

On both his parents' forms, Peter falls in the clinically significant range for hyperactivity, atypicality, and attention problems. Specifically, both of them noted that he almost always acts out of control, almost always is unable to slow down, almost always fiddles with things while at meals, and almost always interrupts parents when they are talking. They also noted that he sometimes seems unaware of others, sometimes stares blankly, and that he almost always has a short attention span and is easily distracted. Based on both parent reports, Peter falls into the at-risk range for anxiety and withdrawal. Specifically, both of them noted that he often or almost always worries about parents, gets very upset when things are lost, and sometimes worries about what other children think.

On his mother's BASC-II, Peter falls in the at-risk range for aggression, depression, adaptability, and functional communication. On his father's BASC-II, Peter falls in the clinically significant range for aggression and depression. Both of them noted that he often annoys others on purpose, breaks other children's things, and bullies others. They also noted that he almost always pouts, cries easily, and is easily frustrated. According to his mother, Peter sometimes shares toys with other children, tries new things, says all letters of the alphabet when asked, and almost always speaks in short phrases that are hard to understand. On his father's BASC-II, Peter falls in the at-risk range for social skills. He noted that he never compliments others, never encourages others to do their best, and never uses appropriate table manners. Results on the forms, in combination with the information obtained in interviews, suggest that Peter appears to be experiencing a number of behavioral problems that may warrant monitoring depending on the rater, with significant problems only in the areas of inattention, hyperactivity, and atypical behavior.

SUMMARY

The case study of Peter illustrates the subtle and not-so-subtle effects of acute pesticide poisoning. Although prior to the poisoning incident, Peter had some speech and motor difficulties, he generally appeared to be progressing within normal limits. Behaviorally, no specific concerns had emerged, and he was described as being relatively social and able to play well with others. Behavioral changes appear to be the most obvious and provided the impetus for parental requests for assistance and evaluation. Currently, Peter exhibits problems with hyperactivity, atypicality, and attention problems. Given indications of neurodevelopmental effects from animal studies and Peter's behavior ratings, behaviors related to anxiety, withdrawal, social skills, aggression, depression, adaptability, and functional communication may need to be monitored.

More subtle deficits are also evident. Results indicate that cognitively, Peter is functioning in the below-average range with uneven functioning across neuropsychological domains. Thus, his current level of functioning is not consistent with his attainment of earlier developmental milestones. Consistent with the behavior problems, he evidences problems in attention/executive functioning and social perception. He also evidences relative weaknesses in memory and learning, sensorimotor functions, and some aspects of visuospatial processing. His most severe problems emerged in the language domain and likely contribute to his difficulties in other areas (e.g., memory and learning of verbal material). His ability to complete manual motor tasks quickly appears to be a strength for him. The similarity in pattern of strengths and weaknesses (i.e., speech and motor deficits) is maintained, however, suggesting diffuse effects across domains of functioning. This would be consistent with findings from research on long-term exposure to pesticides by agricultural workers and global lowering of functioning. At the same time, however, there are indications of more acute deficits in attentional control, self-regulation, and memory.

The extent to which these results can be generalized is limited by a number of factors—among these, the various unknowns of the case study. The pesticide, amount consumed, how long before treatment, and other variables were not known. As with any case study, there are limitations to the single case. A more thorough understanding of the developmental sequelae of both acute and chronic exposure will come only from long-term, longitudinally and developmentally sensitive studies. One final note regarding this case study needs consideration. Because there had been no significant concerns, Peter had not previously been evaluated, and his parents were advised that there would be no long-term effects. The changes in Peter's behaviors and abilities were, however, evident to his parents and led to the assessment and identification of a pattern of strengths and weaknesses that may very well be the result of this single acute exposure to an unknown pesticide, particularly given the changes observed and data related to his estimated, premorbid level of overall cognitive functioning.

In summary, this case supports the need to consider the effects of exposure to—at the very least—rule out potential effects. This case study also raises questions about the subtle and overt potential effects of other kinds of insecticide and toxic exposure issues with children.

REFERENCES

Adgate, J. L., Barr, D. B., Clayton, C. A., Eberly, L. E., Freeman, N. C. G., Lioy, P. J., et al. (2001). Measurement of children's exposure to pesticides: Analysis of urinary metabolite levels in a probability-based sample. *Environmental Health Perspectives*, *109*, 583–590.

Aldridge, J. E., Meyer, A., Seidler, F. J., & Slotkin, T. (2005). Alteration in central nervous system serotonergic and dopaminergic synaptive activity in adulthood after prenatal or neonatal chlorpyrifos exposure. *Environmental Health Perspective*, *113*, 1027–1031.

Aldridge, J. E., Seidler, F. J., Meyer, A., Thillai, I., & Slotkin, T. (2003). Serotonergic systems targeted by developmental exposure to chlorpyrifos: Effects during different critical periods. *Environmental Health Perspective*, *111*, 1736–1743.

Bazylewicz-Walckzak, B., Majkzakova, W., & Szymczak, M. (1999). Behavioral effects of occupational exposure to organophosphorous pesticides in female greenhouse planting workers. *Neurotoxicology and Teratology*, *20*, 819–826.

Buck, G. M. (1996). Epidemiologic perspective of the developmental neurotoxicity of PCBs in humans. *Neurotoxicology and Teratology*, *18*, 239–241.

Centers for Disease Control, & Prevention. (2003). *Second national report on human exposure to environmental chemicals* (NCEH Pub. No. 03-0022). Retrieved November 1, 2009, from http://www.cdc.gov/exposurereport

Claudio, L., Kiva, W. C., Russell, A. L., & Wallinga, D. (2000). Testing methods for developmental neurotoxicity of environmental chemicals. *Toxicology and Applied Pharmacology*, *164*, 1–14.

Clinton, W. (1997, April 21). Executive Order 13045: Protection of children from environmental health risks and safety risks. *Federal Register*, 19883–19888.

Colosio, C., Tiramani, M., & Maroni, M. (2003). Neurobehavioral effects of pesticides: State of the art. *Neurotoxicology and Teratology*, *24*, 577–591.

Curl, C. L., Fenske, R., Kissel, J. C., Shirai, J. H., Griffith, T. W., Coronado, G., et al. (2002). Evaluation of take-home organophosphorous pesticide exposure among agricultural workers and their children. *Environmental Health Perspective*, *110*, 787–792.

Després, C., Beuter, A., Richer, F., Poitras, K., Veilleux, A., Ayotte, P., et al. (2005). Neuromotor functions in Inuit preschool children exposed to Pb, PCBs, and Hg. *Neurotoxicology and Teratology*, *27*, 245–257.

Eskenazi, B., Rosas, L. G., Marks, A. R., Bradman, A., Harley, K., Holland, N. T., et al. (2008). Pesticide toxicity and the developing brain. *Basic and Clinical Pharmacology and Toxicology*, *102*, 228–236.

Fiedler, N., Kipen, H., Kelly-McNeil, K., & Fenske, R. (1997). Long-term use of organophosphates and neuropsychological performance. *American Journal of Industrial Medicine*, *32*, 487–496.

Infante-Rivard, C., & Weichenthal, S. (2007). Pesticides and childhood cancer: An update of Zahm and Ward's 1998 review. *Journal of Toxicology and Environmental Health*, *10*, 81–99.

Jokanovic, M. (2009). Medical treatment of acute poisoning with organophosphorus and carbamate pesticides. *Toxicology Letters*, *190*(2), 107–115.

Kaufman, A., & Kaufman, N. (2004). *Kaufman Assessment Battery for Children* (2nd ed.). Circle Pines, MN: Pearson.

Korkman, M., Kirk, U., & Kemp, S. (2007). *NEPSY* (2nd ed.). San Antonio, TX: Pearson.

Lambert, W. E., Lasarev, M., Muniz, J., Scherer, J., Rothlein, J., Santana, J., et al. (2005). Variation in organophosphate pesticide metabolites in urine of children living in agricultural communities. *Environmental Health Perspective*, *113*, 504–508.

London, L., Myers, J. E., Neil, V., Taylor, T., & Thompson, M. L. (1997). An investigation into neurologic and neurobehavioral effects of long-term agrochemical use among deciduous fruit farm workers in the Western Cape, South Africa. *Environmental Research*, *73*, 132–145.

Maizlish, N., Schenker, M., Weisskopf, C., Seiber, J., & Samuels, A. (1987). A behavioral evaluation of pest control workers with short-term, low-level exposure to the organophosphate diazinon. *American Journal of Industrial Medicine*, *12*, 153–172.

Moses, M., Johnson, E. S., Anger, W. K., Burse, V. W., Horstman, S. W., Jackson, R. J., et al. (1993). Environmental equity and pesticide exposure. *Toxicology and Industrial Health*, *9*, 913–959.

Mott, L. (1995). The disproportionate impact of environmental health threats on children of color. *Environmental Health Perspectives*, *103*(Suppl. 6), 33–35.

Otto, D., Calderon, R., Mendola, P., & Hilborn, E. (Eds.). (2000). *Assessment of health effects of pesticide exposure in young children* (EPA/600/R-99/086). Research Triangle Park, NC: Environmental Protection Agency.

Quandt, S. A., Hernández-Valero, M. A., Grzywacz, J. G., Hovey, J. D., Gonzales, M., & Arcury, T. A. (2006). Workplace, household, and personal predictors of pesticide exposure for farm workers. *Environmental Health Perspective*, *114*, 943–952.

Reynolds, C. R., & Kamphaus, R. W. (2004). *Behavior Assessment System for Children* (2nd ed.). San Antonio, TX: Pearson.

Roland-Tapia, L., Nieto-Escamez, F. A., del Aguila, E. M., Laynez, F., Parron, T., & Sanchez-Santed, F. (2006). Neuropsychological sequelae from acute poisoning and long-term exposure to carbamate and organophosphate pesticides. *Neurotoxicology and Teratology*, *28*, 694–703.

Rothlein, J., Rohnlman, D., Lasarev, M., Phillips, J., Santana, J., & McCauley, L. (2006). Organophosphate pesticide exposure and neurobehavioral performance in agricultural and nonagricultural Hispanic workers. *Environmental Health Perspective*, *114*, 691–696.

Schoenberg, M. R., Lange, R. T., Saklofske, D., Suarez, M., & Brickell, T. A. (2008). Validation of the child premorbid intelligence estimate method to predict premorbid FSIQ among children with brain injury. *Psychological Assessment*, *20*, 377–384.

Slotkin, T. A., & Seidler, F. J. (2009). Benxo[a]pyrene impairs neurodifferentiation in PC12 cells. *Brain Research Bulletin*, *80*, 17–21.

Williams, J. H. G., & Ross, L. (2007). Consequences of prenatal toxin exposure for mental health of children and adolescents: A systematic review. *European Child and Adolescent Psychiatry*, *16*, 243–253.

Zahm, S. H., & Ward, M. H. (1998). Pesticides and childhood cancer. *Environmental Health Perspectives*, *106*, 893–905.