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LEAD, SOLVENTS & NEUROBEHAVIOR IN CONSTRUCTION WORKERS

FINAL PERFORMANCE REPORT
July, 1998

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Sponsor: National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention (CDC)

Research Grant No: 5 R01 OH03144-03

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LIST OF ABBREVIATIONS

^{109}Cd - Cadmium 109
ATSDR - Agency for Toxic Substances and Disease Registry
BFB - bromofluoro benzene
BP - blood pressure
BUN - blood urea nitrogen
Ca - calcium
CBC - complete blood count
cm - centimeter
CNS - central nervous system
CVLT - California Verbal Learning Test
CVMT - Continual Visual Memory Test
dB - decibel
FDA - Food and Drug Administration
GC/FID - gas chromatography with a flame ionization detector
GC - gas chromatography
GGTP - gamma glutamyl transpeptidase
GSI - General Severity Index
Hct - hematocrit
Hgb - hemoglobin
Hz - hertz
IBPAT - International Brotherhood of Painters and Allied Trades
IQ - Intelligence Quotient
IRB - Institutional Review Board
Iron Workers - International Association of Bridge, Structural, and Ornamental Iron Workers
K-XRF - k wave X-ray fluorescence
m^3/hr - cubic meter per hour
mCi - millicurie
MDL - minimum detection limit
MEL - Micro Experimental Laboratory
μg/ml - microgram per milliliter
mg/hr - milligrams per hour
μg/dl - micrograms per deciliter
μg/g - micrograms/gram
mg/m^3 - milligrams per cubic meter
mmHg - millimeters of mercury
mrem - milliroentgen-equivalent-man
mrem/yr - milliroentgen-equivalent-man per year
MS - mass spectrometry
msec - milliseconds
NES^2 - Neurobehavioral Evaluation System 2
NIOSH - National Institute for Occupational safety and Health

LIST OF ABBREVIATIONS (cont'd.)

NJDOH - New Jersey Department of Health
OSHA - Occupational Safety and Health Administration
OVM - organic vapor monitor
PASAT- Paced Auditory Serial Addition Test
ppm - parts per million
PROC NPAR1WAY - Procedure Non-parametric One-way
PROC GLM - Procedure General Linear Model
RBC - red blood cell
SAS - Statistical Analysis System
SCL-90-R - Symptom Checklist 90-Revised
sec - second
SPSS - Statistical Program for the Social Sciences
UMDNJ - University of Medicine and Dentistry of New Jersey
WRAT-R - Wide Range Achievement Test-Revised
ww - wet weight

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Significant Findings

Aims 1 & 2: Iron Workers and Industrial/Structural Painters and Bridgeworkers have significantly higher body burdens of lead, as measured by K-XRF, than Painters and Drywallers/Tapers. However, 42% of the Ironworkers recruited for this study with > 5 years of work in the trade did not have a detectable bone lead indicating that exposure to lead is not uniform across this trade. On average, Industrial/Structural Painters and Bridgeworkers had higher bone lead values than Iron Workers. Bone and blood lead values were significantly but not highly correlated.

A minority of Iron Workers (9%) and Drywallers/Tapers (9%) had exposure to solvents which resulted in reclassification to a different exposure group. As a group, Industrial/Structural Painters and Bridgeworkers did not differ from Painters in lifetime solvent exposure estimates.

Aim 3: The tests of cognitive function most sensitive to the effects of exposure to lead and/or solvents were those of memory. Solvent exposed subjects had significant decrements in verbal memory while lead exposed subjects displayed slowing in digit symbol coding and a tendency to commit more errors in a complex information processing task. The combined exposure to lead and solvents (Lead/Solvent group) did not produce synergistic or additive effects. Stepwise regression analyses revealed bone lead to be a significant predictor of symbol digit performance and error in information processing while lifetime exposure to solvents was a significant predictor of verbal memory performance.

With regard to sensory function, solvent-exposed subjects had significant reductions in contrast sensitivity, a test of visual function while lead-exposed subjects had significant hearing loss relative to the other exposure groups. Also, Controls consistently had lower vibration thresholds indicative of greater peripheral sensitivity than the exposed groups.

Aim 4: For those highly exposed to lead, bone lead values were significantly reduced at two year followup. While both Lead and Control groups improved at re-testing, the Lead group improved significantly less than controls on a complex task of information processing. On simple tasks of visual and auditory reaction time, Controls did not show improvement on re-testing but the Lead group tended to show improvement or reduction in latency of responses. These preliminary results suggest that increased regulation of the construction trades has resulted in reduced body burden of lead as indicated by lower bone lead values.

Usefulness of Findings

Chronic exposure to low and moderate level lead and solvents is associated with some compromised higher level cognitive function (e.g. memory function). Solvent exposure appears to affect the visual system while workplace activities among Iron Workers adversely affect hearing. Therefore, continued efforts need to be made to reduce exposure to neurotoxicants and noise in the workplace.

Bone lead measurement is a useful tool to assess body burden and chronic exposure. Use of this index of exposure will help clarify neurobehavioral effects of chronic exposure since work history alone or blood lead is insufficient for this purpose. In this study bone lead declined based on re-evaluation over a 3 year period. Further, some improvement in neurobehavioral function has also occurred for subjects with evidence of lead exposure (i.e., bone lead).

Prospective studies and monitoring of exposure within the construction trades could reduce long-term adverse consequences and lost productivity. They also validate the effectiveness of exposure reduction attributable to extending regulations in construction.

Abstract

Construction workers are routinely exposed to hazards including neurotoxicants with little or no protection or medical monitoring of health effects. Neurobehavioral tests of cognition, sensory function, and mood were compared between the following four groups of construction workers who were members of the International Association of Bridge, Structural and Ornamental Iron Workers or International Brotherhood of Painters and Allied Trades (IBPAT): Lead (N= 38); Lead/Solvent (N=40); Solvent (N = 46); Controls (N= 42). Groups were matched on age, education, intellectual ability, alcohol and drug use, gender, and ethnicity. Average bone lead was comparable between the Lead and Lead/Solvent groups with a mean of 14.4 ppm (S.D. = 19.0) and 19.5 ppm (S.D. = 11.4), respectively. Lifetime solvent exposure estimates were significantly higher in the Solvent and Lead/Solvent groups which did not differ from each other. Memory function was significantly reduced for the exposed groups relative to the Controls. Relative to Controls, the Solvent group had reduced verbal memory while the Lead exposed group had increased latency of response on a coding task involving visuospatial memory. Lead and solvent exposure did not have a synergistic or additive effect on cognitive performance. Bone lead was a significant predictor of latency of response for the coding task while lifetime solvent exposure was a significant predictor of verbal memory performance. Sensory losses included reduced contrast sensitivity for the Solvent group relative to a matched group of Controls, while hearing loss was documented for the Lead group, composed primarily of Iron Workers. Significant reductions in bone lead were documented at a 2 year follow-up and some improvement in functions of attention/concentration were also seen.

Final Performance Report

General Aims:

1) To quantify the relationship between bone lead, as an indicator of cumulative exposure, and neurobehavioral performance; 2) to evaluate quantitative and qualitative differences in neurobehavioral performance of workers with three chronic exposure patterns: lead, lead and organic solvents, and organic solvents; and 3) to assess prospectively the impact of the OSHA lead standard, recently extended to construction, on bone lead and neurobehavioral performance.

Introduction:

Construction workers have a high rate of morbidity, disability and mortality (Kisner and Fosbroke, 1994). Among the hazards they face are routine exposure to the neurotoxicants, lead and organic solvents. Until May, 1993, construction work was exempt from the medical monitoring provision of the US Federal Occupational Safety and Health Administration General Industry Lead Standard, despite considerable evidence of excess exposure to lead (Fischbein et al., 1984; Waller et al., 1992; New Jersey Department of Health, 1993). In addition to being at high risk themselves, due to the intensity and combination of exposures to neurotoxicants, construction workers offer unique occupational groups to clarify our scientific understanding of three issues heretofore not adequately addressed in the literature: 1) reliable estimates of chronic lead exposure (*in vivo* k wave X-ray fluorescence) to identify levels of exposure at which neurobehavioral decrements occur; 2) assessment of differential neurobehavioral performance due to chronic exposure to both lead and organic solvents; and 3) prospective monitoring of lead body burden and neurobehavioral performance following mandated extension of the OSHA lead standards to construction workers.

This project was a cooperative venture between the Environmental and Occupational Health Sciences Institute (a joint program of Robert Wood Johnson Medical School and Rutgers University) and two unions: the International Brotherhood of Painters and Allied Trades (IBPAT) and the International Association of Bridge, Structural, and Ornamental Iron Workers (Iron Workers).

Hypothesis:

Workers with the highest levels of bone lead accompanied by a history of chronic exposure to organic solvents will have significantly greater decrements in neurobehavioral performance compared to those exposed to lead only, solvent only, and control group.

Specific Aims:

1) To develop four cohorts of subjects recruited from the construction trades: a) lead group - workers with an occupational history of ≥ five years of lead exposure and a current or past blood lead level (from the New Jersey lead registry)≥ 25 μg/dl and minimal solvent exposure; b) lead-solvent group - workers meeting the criteria for lead exposure in (a) and an occupational history ≥ five years of organic solvent exposure, validated with Union records, standard questionnaires (Occupational History Questionnaire) and current measurement of solvent exposure on three separate days during representative jobs; (c) solvent group - workers with an occupational history ≥ five years of organic solvent exposure but minimal lead exposure; and (d) control group - workers with minimal exposure to lead or organic solvents during the past five years. Subjects across the four groups will be of comparable age, sex, and baseline ability.

2) To estimate cumulative dose of lead and/or solvents using the following methods: a) body burden of lead using *in vivo* k wave X-ray fluorescence of bone lead levels along with history of past and current blood lead values, and b) lifetime solvent exposure based on occupational history, standardized questionnaire, union records, and current exposure measurement. The relative contribution of cumulative versus current exposure to neurobehavioral performance will be evaluated using these measurements.

3) To compare the groups' current performance on a standardized battery of neurobehavioral tests reflecting attention, learning, memory and psychomotor performance, mood (e.g. irritability, depression, fatigue) and psychological symptoms.

4) To evaluate the impact of extending the OSHA lead standard to construction workers by conducting a longitudinal study. Bone lead and neurobehavioral performance will be repeated for the subgroup (top tercile based on initial bone lead) of lead exposed workers compared to matched control workers with minimal exposure to lead or organic solvents.

Background and Significance

Lead is a well known neurotoxicant at high blood levels (>80 μg/dl) (Browder et al., 1973). Occupational Safety and Health Administration standards have required regular monitoring of lead levels within the lead industry and have required worker removal when blood lead exceeds 50 μg/dl. Until May of 1993 (OSHA 1993 Federal Register), this standard did not include the construction industry (e.g. painters, ironworkers) (Waller et al., 1992; Fischbein et al., 1978). As a consequence, several studies reported blood lead levels exceeding this value among construction workers in California (Waller et al., 1992), New York (Fischbein et al., 1978; Fischbein et al., 1984) and New Jersey (Mehta, 1990; New Jersey Department of Health, 1993). Despite documentation of high level exposure and inherent difficulty maintaining environmental controls during construction, no studies of lead exposure and its neurobehavioral consequences have been conducted with workers from the construction trades. Therefore, the first purpose of this study was to evaluate lead body burden (i.e., bone lead) and neurobehavioral performance among workers from the construction trades.

In addition to lead exposure, construction workers, particularly painters, are frequently exposed to more than one neurotoxicant (e.g. lead, solvents) during a job or during their career. These exposures may create quantitative as well as qualitative neurotoxic effects that differ from those occurring with lead or solvent exposure alone. While the neurobehavioral effects of lead and organic solvents have been more widely studied than many other neurotoxicants (Hogstedt et al., 1983; Baker et al., 1985; Campara et al., 1984; Stollery et al., 1989; Braun and Daigneault, 1991), few studies have evaluated neurobehavioral outcome from a combined exposure. Thus, a second purpose of the proposed study was to quantify exposure to lead and solvents and to contrast neurobehavioral performance of a cohort with primary exposure to lead with that of a cohort exposed routinely to both substances.

Human Neurobehavioral Studies of Lead:

High dose exposure to lead is universally recognized to be neurotoxic affecting both the peripheral and central nervous system. Low dose lead exposure produced cognitive deficits in young children. The effects of low level lead on adult CNS function are less clear. While the mechanisms continue to be debated, numerous studies have evaluated the neurobehavioral effects of lead (Repko and Corum, 1979; Haenninen et al., 1978; Valciukas and Lilis, 1982; Baker et al., 1985; Ryan et al., 1987; Braun and Daigneault, 1991). Among lead exposed workers, some studies documented significant reductions in memory, learning, verbal concept formation, psychomotor function, and/or mood (Grandjean et al., 1978; Baker et al., 1984). Others, however, found only marginal dose-response relationships or few significant differences between groups particularly when the lead exposure remained in the low to moderate range (i.e., blood lead below 70 μg/dl) (Haenninen et al., 1978; Ryan et al., 1987). For example, in both the Ryan et al. study (Ryan et al., 1987) and a study by Braun and Daigneault,(Braun and Daigneault, 1991) the only significant differences were on measures of motor as opposed to cognitive function.

Human Neurobehavioral Studies of Organic Solvents:

Relatively more studies have evaluated the neurobehavioral effects of chronic solvent exposure (Hanninen et al., 1976; Valciukas et al., 1985; Baker et al., 1985; Baker et al., 1988; Morrow et al., 1990; Bleecker et al., 1991; Hanninen et al., 1991) and one of these (Valciukas et al., 1985) was in painters. In fact, the Scandinavian literature has been most influential in documenting central nervous system effects of chronic solvent exposure to include reductions in memory and concentration, psychological symptoms, and reduced psychomotor speed (Gochfeld et al., 1992b; Anger and Johnson, 1992; Baker, 1988; Gamberale, 1985). However, other studies have found minimal effects due to solvent exposure and have questioned earlier conclusions (Errebo-Knudsen and Olsen, 1986; Gade et al., 1988).

Exposure Assessment in the Neurobehavioral Literature:

A number of factors may account for the discrepant findings within the neurobehavioral literature on lead and organic solvents. For example, studies differed in the method by which exposed subjects were selected. Among lead studies exposure was determined by blood lead levels either at the time of recruitment or over varied time periods during employment (e.g. time weighted average), as well as by a history of employment within a lead industry (e.g. battery factory) (Baker et al., 1984; Parkinson et al., 1986; Stollery et al., 1989). Therefore, the amount of exposure probably varied a great deal both within studies and between studies. For example, in an epidemiological study by Parkinson et al, (Parkinson et al., 1986) subjects had to be employed a minimum of one year. While this study and a follow-up one published by Ryan et al. (Ryan et al., 1987) were largely negative, the only group for which positive neurobehavioral findings were observed was the older group who had worked more years with lead. Undoubtedly, workers varied both in body burden and cumulative exposure history (years of exposure) which contributed to variation in the effects between studies. Our study addressed this issue by measuring bone lead as an objective indicator of cumulative body burden and, therefore, of exposure.

Assessing Exposure for Lead:

Lead is preferentially stored in bone from which it is slowly mobilized as an endogenous source of exposure (Erkkila et al., 1992). Hu et al., (Hu et al., 1991) documented that bone lead correlates better with cumulative (past) than with current lead levels of exposure.

Based on it's long half-life, the value of bone lead as an integrator of exposure has been reaffirmed (Silbergeld et al., 1993; Landrigan, 1991; Kosnett et al., 1994). By contrast, the half life of lead in blood after termination of exposure is estimated at 35 days, (Rabinowitz, 1991) while other markers such as erythrocyte protoporophyrin remain elevated only about two months (Hernberg, 1980). *In vivo* k Wave X-ray fluorescence (K-XRF), although still in the developmental stage (Wedeen, 1990), is being recognized as a way of estimating past exposure. It has gained rapid acceptance due to the need for an integrative measure of lead exposure and the use of the ^{109}Cd source has improved the sensitivity of XRF (Todd et al., 1992). Several studies have validated that bone lead reflects body burden and past exposure (Somervaille et al.,

1986; Somervaille et al., 1988; Somervaille et al., 1989; Gerhardsson et al., 1992). Our study is pioneering in applying bone lead in an investigation of health outcomes (Wedeen, 1988; Landrigan, 1991; Silbergeld et al., 1993). A recent study of unexposed individuals from a suburban community revealed that bone lead was significantly correlated with age, gender and cigarette smoking (Kosnett et al., 1994). This further indicates the importance in the proposed study of matching on age and gender across exposure groups. The study also provided a clear indication that 90% of people under 55 years of age have a bone lead <30 μg/g dry weight, thus verifying that we can detect cutpoints suitable for classifying exposed and unexposed workers.

Solvent Exposure:

Chronic solvent exposure has been determined in the literature by work history and records of industrial hygiene measurements, when available (Spurgeon et al., 1992; Bolla et al., 1990; Hanninen et al., 1991). As with studies of lead exposed subjects, exposure histories varied within and between studies. For example, Ryan et al. (Ryan et al., 1988) reported on a group of workers whose exposure to solvents ranged from 1 to 18 years. Industrial hygiene measurements are rarely available for construction workers. Some of these shortcomings cannot be dealt with since there are no good biomarkers of chronic solvent exposure. Recent studies, however, have benefitted from the use of a standardized solvent exposure questionnaire (Fidler et al., 1987).

Neurobehavioral Assessment:

Lead and solvent studies have varied in their neurobehavioral methods. Anger (Anger, 1990) and Anger and Johnson (Anger and Johnson, 1992) reviewed the neurobehavioral methods used to evaluate neurotoxic effects. Examples of functions assessed within the lead and solvent literature include general intelligence and overall cognitive ability (e.g. vocabulary, similarities, spatial relations (Block Design), psychomotor function (speed, coordination), sensory function (e.g.,vision), and mood (anxiety, depression) (Anger and Johnson, 1992). Studies evaluating the neurobehavioral effects of lead exposure included workers whose blood lead levels were relatively low (mean blood levels ranged from 30 to 60 μg/dl). Due to the variability in the tests, it is difficult to identify which functions are most sensitive to chronic low level lead or solvent exposure or which tests are most sensitive for detecting these effects. However, as has been suggested by other investigators (Williamson, 1990; Spurgeon et al., 1992), classical neuropsychological tests that are useful in characterizing the effects of head injuries may be less sensitive in detecting the subclinical effects of neurotoxicants. An overview of the neurobehavioral literature on lead and solvents suggests that, particularly among workers exposed to lower levels of neurotoxicants (e.g., mean blood lead = 30 - 60 μg/dl), measures of learning, information processing, and psychomotor speed may be more sensitive than measures of verbal abstraction and general intelligence (Ryan et al., 1987; Braun and Daigneault, 1991; Williamson, 1990; Spurgeon et al., 1992). In fact, Spurgeon et al. hypothesized, based on their findings, that learning processes, such as rate of acquisition in learning word pairs, may also be more sensitive to the subtle effects of solvent exposures. Animal studies also show that the learning process rather than overall performance, is more sensitive to lead effects (Burger and Gochfeld, 1995; Gochfeld et al., 1992a).

Finally, a number of confounding variables and biases have not been well controlled in the neurobehavioral literature. Ryan et al. (Ryan et al., 1987) observed that examiners were not always blind to the subjects' exposure history or did not control for other confounding factors such as alcohol and drug use as well as other medical disorders and exposures (e.g. pesticides). Also, subjects recruited as controls were often not demographically similar (e.g. socioeconomic status, education, age). A shortcoming in most cross-sectional studies is that baseline ability is not known. Therefore, education and current verbal intelligence are typically used as surrogates for baseline ability (Lezak, 1983). However, it is most desirable to obtain baseline or pre-exposure records of ability (e.g. school or military IQ or aptitude tests) rather than rely on these surrogates.

Methods

Subjects:

Subjects were recruited from the New Jersey Chapters of the International Association of Bridge, Structural and Ornamental Iron Workers (Iron Workers), the International Brotherhood of Painters and Allied Trades (IBPAT), Bridgeworkers Union 806 (IBPAT), and from construction workers identified from the New Jersey Department of Health (NJDOH) lead registry whose blood lead was >=25 μg/dl. Drywallers/Tapers were members of the IBPAT and were recruited as the minimally exposed or control group. Over the three year period of the grant, 2,665 screening questionnaires were sent: 715 to Iron Workers and 1950 to members of the IBPAT. Two-hundred and forty-seven (35%) of the Iron Workers and 402 (21%) of the IBPAT members returned the questionnaire. From this screening questionnaire, workers who reported any of the following significant medical conditions were not invited to participate (see Table 1): history of head injury which involved loss of consciousness for more than 30 minutes, neurological disorders, history of multiple hospitalizations for substance abuse, childhood history of learning disability, psychosis or manic depression, significant medical conditions (e.g.,heart disease, cancer, insulin dependent diabetes). In addition, subjects whose educational level was below the 9th grade or whose primary language was not English were not invited to participate. Subjects had to work in their trade for a minimum of 5 years and must have worked in the past year. A random subset of union members and all those identified from the New Jersey Lead Registry who did not meet exclusion criteria were invited to participate. Of 316 workers invited to participate, 34% (143) refused participation for logistic reasons (see Table 1). Thirty-one of 98 Ironworkers invited to participate refused (32%) and 76 of the 218 IBPAT members that were invited refused to participate (35%). Each of the subjects who completed the study protocol were paid a stipend of $200 and received a copy of their laboratory report with a personal feedback letter summarizing their medical and neurobehavioral results.

Aim 1: Subject Recruitment

Based on occupational history recruits were divided a priori into four groups: **Iron Workers (Lead):** 66 subjects with an average of 24.2 (S.D.=8.4) years employed as Ironworkers and minimal to no use of solvents; **Industrial/Structural Bridgeworkers & Painters (Lead/Solvent):** 62 subjects with an average of 20.8 (S.D.=10.8) years of work with lead and

solvents as Industrial/Structural Painters or Bridgeworkers; **Painters (Solvent):** 37 subjects with an average of 17.9 (S.D.=10.2) years work with solvents as Painters; **Drywallers/Tapers (Controls):** 43 subjects with an average of 20.8 (S.D.=10.0) years working in trades requiring minimal use of solvents and no lead exposure as Drywallers/Tapers. Thus, a total of 208 construction workers participated in the study.

Medical Evaluation:

Following recruitment, each subject completed a medical examination including detailed medical and occupational history, blood chemistry and urinalyses, and blood lead. The physical examination included measurement of blood pressure in both arms while sitting and lying down to assure accurate assessment of hypertension. As a screen for kidney performance, blood and blood urea nitrogen were measured. Blood tests included a complete blood count (CBC) to identify anemia or basophilic stippling, and blood chemistries (including liver function tests such as gamma glutamyl transpeptidase (GGTP)).

Substance Use:

In collaboration with the Center for Alcohol Studies of Rutgers University, a questionnaire was administered to assess the usual overall quantity and frequency and peak quantity and frequency of alcohol use during the past year and during periods in the subject's lifetime when use was significantly more or less than during the past year. For each illicit drug used in the subject's lifetime, a similar questionnaire was administered to assess the usual and peak frequency of use during the past year and during periods in the subject's lifetime when use was significantly more or less than during the past year (see Appendix for questionnaires). The alcohol questionnaire was completed by the subject prior to participation and then reviewed by the physician as a part of the medical examination. The drug questionnaires were administered by physician interview.

Alcohol Indices: Total alcohol use was calculated by multiplying the quantity and frequency of alcohol use during the past year times the number of years during the subject's lifetime of drinking. If the subject had periods of drinking a lot more or a lot less, the months/years of this drinking pattern were subtracted from the total years of drinking before the total alcohol use calculation was performed. Then, if the subject reported periods of drinking a lot more or a lot less during any period, the total amount (Time period X (quantity X frequency)) drank during these periods was calculated separately and added to the total alcohol use based on past year consumption. This score was the Total Lifetime Alcohol Index. Since peak exposure or periods of binge drinking may have more effect on neurobehavioral integrity than usual patterns of use, the quantity times frequency of peak use during the past year was calculated as a separate index (i.e, Current Peak Index). Also, alcohol use for periods of drinking which were a lot more than the past year was calculated as a separate index of peak consumption (Lifetime Peak Index). A similar process was conducted for drug use except only frequency of use was assessed. Due to the uncontrolled and therefore, unknown quantity of illicit drugs, quantity could not be assessed. For illicit drugs, the total frequency for all drugs reported was summed to create a Total Drug Index. Similarly, peak drug use included totals from periods when the subject used the drug a lot more than in the past year summed across all drugs reported (Lifetime Peak Drug Index) .

Values for these indices are presented after subjects are classified into exposure groups.

Premorbid Ability:

To estimate premorbid ability, school records were requested by asking each participant to complete an "Authorization to Release School Records" form which was sent to the individual's high school. Out of 208 possible records to request, 10 were not requested because high schools could not be found based on the information provided or because the subject refused permission to request. Out of 198 requests, 157 (79%) responses were received from schools. For schools that did not reply or whose records did not contain standardized test scores (N=26), follow-up telephone calls were made to obtain records. Of the 157 records received, 89 (57%) supplied standardized test scores that were used to estimate baseline ability. The remaining 68 responses that were received were not used because 46 records reported only grades, 21 records reported uninterpretable test scores and one transcript was illegible.

Since the tests of ability varied among the school systems, test scores were transformed to z-scores and then to deviation intelligence quotients (mean = 100; S.D. = 15) to place tests on the same numerical scale. While not ideal due to the varying normative groups for the tests, this method allowed some gross comparison among premorbid tests as well as comparison to the current estimate of ability, i.e., the Wide Range Achievement Test-Revised, Reading Subtest. Premorbid, standardized tests were the Henmon-Nelson Tests of Mental Ability, the Otis-Lennon Mental Ability Test, the Lorge Thorndike Intelligence Test, the Short Form Test of Academic Aptitude, the California Test of Mental Maturity, the Differential Aptitude Tests, and the Scholastic Aptitude Test.

Aim 2: Exposure Indices

Chronic Lead:

Body burden of lead was assessed by k wave X-ray fluorescence (K-XRF) of tibial bone and current blood lead values. Every subject was asked to recall previous blood lead values, but the majority of workers either had not had a blood lead level drawn because it was not mandated for construction trades prior to 1993 or subjects could not recall the value if a blood lead was evaluated. Bone lead was assessed on all lead and lead/solvent subjects and a random subset of one-third of Controls and one-third of solvent exposed subjects. Dr. Richard Weeden performed the bone lead measurements by K-XRF at the Doctor's Office Center, UMDNJ-New Jersey Medical School, Newark, N.J., and the results were quantified by Keith Jones, Ph.D., Brookhaven National Laboratory. Chronic exposure to lead was based on K-XRF values (Jones et al., 1987).

In vivo tibial (K-wave) X-ray fluorescence (K-XRF) using a 100 mCi ^{109}Cd (cadmium) sealed radioactive source was used to measure chronic exposure to lead. The INVILS 200 machine developed by Drs. Wedeen and Jones in 1982 was used (Jones et al., 1987; Wedeen et al., 1987). Bone lead is measured with a 5 cm diameter high-purity germanium detector, a computer-based pulse height analysis system, and a sealed ^{109}Cd radioactive source (Jones et al., 1987). The

bone lead concentration, expressed as μg/g wet weight (ww) is calculated by comparison of the lead:calcium ratio to values obtained from plaster-of-Paris calibration phantoms and the reported estimate for the mass % Ca in wet bone (14%). It is emphasized that the quantity actually measured is the mass ratio of lead to calcium. Lead concentration (wet weight) divided by 0.55 gives lead concentration for bone mineral.

The minimum detection limit (MDL) for these determinations is estimated to be +/- 1.0 μg/g (ww), although accurate quantification below 5 ppm is problematic. The K-XRF apparatus is calibrated daily prior to patient measurements using lead-acetate/Plaster-of-Paris phantoms (Wedeen et al., 1987). The bone measurement is made for 30 minutes. Whole body radiation dose from a 200 mCi source is estimated to be 0.3 mrem compared to natural background radiation of 186 mrem/yr, intraoral X-ray radiation of 0.1 mrem, or whole body exposure from a chest X-ray of 30 mrem. The absorbed organ equivalent dose for the skin is 178 mrem, gonads is 0.0056 mrem, and marrow, is 0.4 mrem (Wedeen, 1990). The technique is exempt from FDA regulation as long as it follows a protocol approved by a federally approved IRB. This is a non-invasive method of obtaining a bone lead sample that approximates results from a needle or surgical biopsy of bone (Wedeen et al., 1987).

Table 2 gives the mean, median, standard deviation, and range of bone lead values for each occupational group based on a priori criteria. Values are reported as ratios of lead to calcium, wet weight, and dry weight. The latter is given to compare to existing literature on bone lead values. As can be seen from the percentage of non-detects in Table 2, occupational history alone is insufficient to substantiate lead exposure. For example, 42% of Iron Workers, despite a lifetime history of working in the trade, had a non-detectable bone lead.

Chronic Solvent Exposure:

Workers' lifetime solvent exposure was assessed using three sources of information: self reports on a standardized occupational history questionnaires, (Fidler et al., 1987) union records and job descriptions, and direct field exposure measurements. The value of this approach has been emphasized by Kromhout et al. (Kromhout et al., 1987). The questionnaire was completed by every worker reporting any history of solvent use and was reviewed by the physician during the medical examination to assure that it was completed correctly. In addition, for those workers who were members of the IBPAT, union retirement records were obtained to ascertain the years worked and the hours worked in each year. All subjects reporting work with paint, one-third of controls, and one-third of lead exposed subjects were given three passive dosimeters to wear on three separate occasions during their usual work activities. These dosimeters were returned by mail with a brief questionnaire (see Appendix) outlining the products used and the activities during the time the dosimeter was worn. Finally, several sites were monitored by an Industrial Hygienist to determine solvent levels during typical work activities.

Analysis and Results of Dosimeters

Passive dosimeters (3M 3500 Organic Vapor Monitors - OVM) were used to collect volatile organic compounds to which the subjects were exposed while painting. The dosimeters were analyzed based on NIOSH Method 1500 for hydrocarbon extraction from charcoal. The badges were extracted with 1.5 ml of carbon disulfide containing 50 μg/ml of bromofluoro benzene (BFB) as an internal standard. The solvent was added directly into the badges through the port in the cap. The dosimeter was manually shaken and after five minutes approximately 1.0 ml was transferred to a glass GC autosample vial. During the initial stages of the project, samples were analyzed by gas chromatography/ mass spectrometry (GC/MS) to determine what classes of compounds were present. High levels of organic compounds were detected in badges worn by painters who used oil based paints. The predominant class of compounds identified in those samples was saturated alkanes rather than aromatic compounds. No individual compounds dominated the chromatograph. Rather, an envelope of hydrocarbon peaks starting with six carbon chain through fifteen carbon chain compounds were identified, with the majority of compounds having between nine and eleven carbons. Based on these results a quantification scheme was developed for analysis by gas chromatography with a flame ionization detector (GC/FID). Standards were prepared using a Wisconsin Diesel Standard which contains alkanes in the same molecular weight range and the relative response by GC/FID of each alkane to BFB was determined on a per Carbon basis. The relative responses for the alkane across the different molecular weight ranges were similar, since the GC/FID responds to each carbon within a molecule. The extracts from the badges worn by the subjects were analyzed by GC/FID and the total hydrocarbon air concentration on a per carbon basis calculated. This allowed for a relative scale of exposure to be developed for each of the subjects and activities that they participated in. Quality control procedures included analyzing 15% of the samples that showed the presence of hydrocarbons by GC/MS to confirm that they were predominantly alkanes. Two types of blanks were analyzed. Approximately 5% of the badges were used as blanks (kept sealed) and 10% of the analyses were solvent blanks. Also, duplicate injections of the extract were performed on 10% of the samples.

One-hundred and thirty-seven subjects were given 3 passive dosimeters each to wear during three separate work days. A total of 214 samples were analyzed for total volatile organics measured in mg/m^3 as hexane. Of the 214 samples analyzed, 88% (189) were personal samples from painters and controls, 9% (19) were personal samples collected by industrial hygienists, and 3% (6) were area samples collected by industrial hygienists while work was performed at 5 painting sites. Thus, 46% (63/137) of the subjects given dosimeters returned them.

The information from the passive dosimeters and industrial hygiene site monitoring, was then used to calculate average solvent exposures to subjects painting in four scenarios: commercial/residential interior and exterior and industrial/structural interior and exterior locations, consistent with the design of the lifetime exposure history questionnaire. Average solvent exposures during rolling, brushing as well as spray painting during indoor and outdoor paint activities were also determined from the samples. Sample data were stratified and analyzed based upon these categories using the Statistics Program for the Social Sciences (SPSS). Group comparisons were made using unmatched student t- tests and Wilcoxon ranked sum analysis

where substantial differences in the size of comparison groups existed. The exposure data, percent time per scenario, and duration were then used to compute a lifetime solvent exposure estimate for each study subject.

Solvent Exposure Index:

Total lifetime solvent exposure was calculated by applying the computed average exposures from the industrial hygiene sampling data described previously, to the self reported work history questionnaire responses for each of the study subjects. Specifically, the average exposures by category (industrial/structural vs. commercial/residential) and location (interior/exterior) of work, application methods (spray, roll, brush) used in each area, and solvent exposure in mg/m^3 were applied to each subject's work history profile. The work history or career hours was determined by multiplying the number of years in the occupation (Ironworker, Painter, Drywaller/Taper) by the average number of hours per year in that occupation. This was then multiplied by the fraction of time spent in each category and location. The average number of hours worked per year (680) was determined from Union records and was used for each subject's calculations. This lifetime exposure estimate was then modified by the type and percentage of time protective equipment was reportedly used during each application method in each area and location. Thus, for every worker who completed a solvent questionnaire, the following four exposure variables were computed: industrial/structural, exterior; industrial/structural, interior; commercial/residential, exterior; commercial/residential, interior. These values were summed to create a lifetime solvent exposure index in milligrams. Work was considered unprotected unless the subject reported using a respirator (single or double cartridge). When chemical cartridge or supplied air respirator was reported, a conservative protection factor of 0.90 was used. This protection reduced the exposure estimate by 90% for the estimated amount of time the protection was used.

Table 3 gives the results for the industrial hygiene sampling which includes the passive dosimeters worn by painters. Painters were exposed to an average 20.3 mg/m^3 solvent vapor as hexane versus an average 2.3 mg/m^3 for controls. From these samples, there were no statistically significant differences in solvent exposures based on application method (rolling and brushing versus spray painting) ($p=0.34$), but a significant increase between interior and exterior exposures was observed (22.3 mg/m^3 versus 14.3 mg/m^3, respectively; $p<.05$). Exposure during oil based painting was significantly higher than latex painting (30.6 mg/m3 versus 2.8 mg/m^3; $p<.05$). While the use of oil paint was minimal in Commercial/Residential painting, the use of oil based paint occurred more frequently during Industrial/Structural activities. Thus, the highest solvent exposure was observed for Industrial/Structural interior painting. Based on the data from the passive dosimeters and industrial hygiene samples, the following four exposure estimates were used to calculate solvent exposure in mg/hour for these work activities and locations: Industrial/Structural, exterior= 6.22 mg/m^3; Industrial/Structural, interior = 27.00 mg/m^3.; Commercial/Residential, exterior = 21.65 mg/m^3; Commercial/Residential, interior = 20.01mg/m^3. These estimates were then converted to mg/hr .based on average breathing rates per hour (2 m^3 /hour under moderate exercise conditions). The apparent inconsistency between the exposure estimates for Industrial/Structural and Commercial/Residential exterior work may be an artifact of the small number of exterior Industrial/Structural samples.

Table 4 gives the mean, standard deviation, median, and range for the solvent exposure index as calculated for every subject who completed the questionnaire. Note that 9 Iron Workers and 6 Drywallers/Tapers reported solvent use and therefore, completed a questionnaire. These statistics were then used to redefine exposure group as described below.

Subject Classification:

The most primitive exposure indicator is occupational history as a surrogate for exposure. To improve upon the ability to determine the effects of chronic lead and solvent exposure, the exposure indices outlined above were used to re-classify subjects post-hoc into the four new exposure groups used in the analyses. The following guidelines were used:

Lead: K-XRF >=1.0 ppm with no solvent exposure (N= 41)

Lead-Solvent: K-XRF >=1.0 ppm and Solvent Exposure

Index >= 10^{th} percentile (N= 44)

Solvent: K-XRF <1.0 ppm (non-detectable) and Solvent Exposure Index >=10^{th}

percentile; (N= 52)

Control: K-XRF <1.0 ppm (non-detectable) with no history of work with lead (i.e., not

an Ironworker by trade) and no history of solvent exposure; (N= 42)

Based on these exposure criteria, the following summarizes subject reclassification from their occupational group:

Ironworker : 3 reclassified to Lead-Solvent; 3 to Solvent. Twenty-seven

had K-XRF <=1.0 ppm (non-detectable) and were removed

from further group analyses.

Industrial/Structural Painters & Bridgeworkers: 22 reclassified to Solvent

(no K-XRF or K-XRF <=1.0 ppm (non-detectable)),

one to Lead, and 2 were removed from analyses (1 recruit from

N.J. Dept. Of Health Registry with elevated blood lead and less

than 4 years exposure; 1 subject had an invalid exposure questionnaire).

Solvent: 7 reclassified to Control, 3 to Lead-Solvent, one to Lead.

Control: 4 reclassified to Lead, 2 to Lead-Solvent, 2 to Solvent.

Lifetime Alcohol and Drug Indices:

Following classification by exposure indices, the distribution of Total Lifetime Alcohol and Total Lifetime Drug Indices were compared between the groups using one-way (group) analyses of variance on log transformed scores. The groups differed significantly in Total Lifetime Alcohol Index ($F= 3.27$; $df= 3,173$; $p<.02$). Post-hoc Duncan's test revealed that the lead group scored significantly higher than any of the other groups which did not differ from each other (Lead mean = 50,786; S.D. = 84,428; Lead-solvent mean = 27,679; S.D.= 40,437; Solvent mean = 22,058; S.D. = 40,149; Control mean = 19,033; S.D. = 23,641). Inspection of the distribution of scores on the Total Lifetime Alcohol Index revealed five high outliers. These subjects were removed from the subject groups. Analysis of variance between the groups on the Lifetime Drug Index revealed a significant overall difference ($F= 3.15$; $df = 3,81$; $p<.03$), with the Lead-Solvent group scoring significantly higher than the Control group while the remaining groups did not differ from each other (Lead mean = 1839; S.D. = 2092; Lead-solvent mean = 5529; S.D. = 7810; Solvent mean = 4078; S.D. = 5946; Control mean = 889; S.D.= 896). Inspection of the distribution of scores on the Total Lifetime Drug Index revealed nine outliers who were removed from the groups. After log transformation of the alcohol scores, re-analysis of the Total Lifetime Alcohol Index, Peak Consumption Past Year, and Total Lifetime Peak Consumption revealed no significant differences between the groups. Similarly, the Total Lifetime Drug Index with the outliers from both groups removed found no significant group differences (see Table 5). In total, 13 subjects with excessive alcohol and/or drug abuse were excluded from subsequent analyses.

Based on exposure re-classification and alcohol/drug exclusions, all subsequent analyses were performed on the following subject groups: **Lead** (N=38); **Lead/Solvent** (N=40); **Solvent** (N=48); **Controls** (N=42).

Statistical Analyses:

For variables highly intercorrelated (e.g., concentration) a MANOVA was conducted followed by univariate analyses of variance to explore intergroup differences. For normally distributed variables, one-way analyses of variance were used to compare groups followed by a Duncan's post-hoc test to assess group differences. If variables were not normally distributed, either data transformations were conducted before the analyses of variance or a non-parametric analysis of variance was performed using SAS (Statistical Analysis System) PROC NPAR1WAY with the Wilcoxon option. If overall differences among the four groups were detected at the .05 level, each exposure group was compared to the control group using the same procedure. This corresponds to the Kruskal-Wallis Test.

Demographics:

To assure matching between the exposure groups for demographic variables that could affect neurobehavioral performance, separate one-way (group) analyses of variance compared the groups on the following variables: age, education, years in occupation, premorbid ability, and current verbal ability (WRAT-R). No significant differences were observed for age, education, premorbid ability, or current verbal ability (see Table 6). The only demographic difference was in years served in the occupation with the Lead group having significantly more years in occupation than Controls. No other groups differed in respect to years in the occupation (see Table 7).

Pre-exposure Ability:

For those subjects with data on both pre-exposure ability and current verbal ability, a repeated measures analysis of variance was performed on the difference between these two measurements between the four groups. Though on a smaller subset of subjects, no significant difference was noted between the groups in this difference score, which adds further confidence to the assumption that no group suffered overall intellectual impairment differentially due to exposure or occupation.

Hearing and Visual Impairment:

Subjects whose corrected visual acuity was worse than 20/40 were eliminated from the Contrast Sensitivity and Lanthony D-15 Color Vision Test analyses: Lead (N=5); Lead/Solvent (N=12); Solvent (N=5); Control (N=9). Additionally, five subjects were color blind and did not complete the Lanthony D-15 test. Subjects who had one or more readings of >55 db in the right or left ear at 500 to 2000 Hz were eliminated from the hearing tests, hearing thresholds, SCAN-A (A Test for Auditory Processing Disorders in Adolescents and Adults), and auditory reaction time as follows: Lead (N=3); Lead/Solvent (N=1); Solvent (N=2); Control (N=1).

Exposure Indices:

Lead Exposure Indices: Analysis of variance comparing the groups on blood lead levels taken at the time of the examination, revealed a significant difference with the Lead/Solvent group significantly higher than all other groups while the Lead group only differed significantly from the Controls ($F=12.4$; $df = 3,164$; $p<.0001$). The Solvent and Control groups did not differ from each other. Both the Lead and Lead-solvent groups differed significantly from the Solvent and Control groups on K-XRF readings of bone lead ($F=8.7$; $df = 3,92$; $p<.0001$) (see Table 7). The Lead and Lead-solvent groups did not differ from each other and the Solvent and Control groups also did not differ in K-XRF values. Blood and bone lead were not highly but were significantly correlated ($r=.38$; $p<.0001$).

Solvent Index: For the Solvent and Lead-Solvent groups, Lifetime Solvent Exposure Index ranged from 35,411 to 1,137,742 with a mean of 427,332 (S.D. = 267,886) and 20,380 to 2,036,736 with a mean of 525,621 (S.D. = 507,664), respectively (see Table 8). These were not

significantly different (p=.91). Two subjects from the control group and four subjects from the lead group completed the solvent questionnaire and had a Lifetime Solvent Exposure Index. However, the values for this small subset were below the 10th percentile in the distribution of questionnaire scores. Therefore, these subjects were not classified within a solvent exposure group.

Acute Solvent and Alcohol Exposure: To the extent possible, painters were tested on a Monday after a weekend away from work. However, due to work scheduling conflicts, some painters were unwilling to come in during a week day. Therefore, rather than exclude these painters, they were scheduled on a Saturday for testing. To assure that painters scheduled on a Saturday were not under the acute influence of solvents, breath samples were taken before and after the neurobehavioral testing of painters (N=20), who reported working on the previous day, to document acute solvent burden. The following is a description of the method used for this sampling.

Breath Sampling: Exhaled breath samples were collected and analyzed for hydrocarbons prior to and after each painter participated in the neurobehavioral tests. The purpose was to determine acute body burden of these compounds during the time period of neurobehavioral testing. The breath samples were collected by having the subject breath through a clean, disinfected non-rebreathing valve which directs the breath to a temporary storage tube. The breath was withdrawn from the storage tube and passed through an adsorbent trap using an air sampling pump. The adsorbent trap contained Tenex, Carboxen 569 and Carbosieve SIII, which removed the hydrocarbons from the breath. The trap was then analyzed by thermal desorption coupled to GC/MS. None of the painters had elevated breath levels of the hydrocarbons that were found on dosimeters of the painters using oil based paint. This indicated that the subject had not been exposed to high concentrations of these compounds for several hours prior to participation.

Alcohol Sampling: All subjects were asked to abstain from alcohol for 48 hours prior to testing and a detailed 7-day drinking history was completed during the physician interview as part of the medical evaluation. To rule out acute effects of alcohol, every subject was given an alcohol saliva test (Q.E.D. A150 - STC Diagnostics, Bethelehem, PA) before neurobehavioral testing to ascertain that the subject was not under acute influence of alcohol at the time of testing. One subject had a positive alcohol saliva reading and was eliminated from the study. Otherwise, all subjects had a 0 alcohol saliva result.

Neurobehavioral Methods:

General Ability:

Wide Range Achievement Test, Reading subtest (WRAT-R) (Jastak and Wilkinson, 1984) - This is a test of reading ability which involves recognizing and pronouncing words out of context. One point is given to each correctly pronounced word. The total number of words correctly identified by the subject is converted to a standard score (mean =100; S.D.=15) to compare to pre-exposure ability tests (I.Q.).

Sensory Tests:

Visual Acuity with Visual Contrast Sensitivity - The OPTEC model 1000 (Stereo Optical) with testing plates containing a visual acuity test and contrast sensitivity was used. The visual acuity test was used to determine the ability of the subject to see tests requiring detail vision. The test of contrast sensitivity provides a comprehensive measure of visual acuity under conditions of varying contrast. If subjects wore corrective lenses, these were required for testing. For the contrast sensitivity test, presentation of the 5 grating frequencies (1.5, 3, 6, 12 and 18 cycles per degree - Patch A-E) were randomized and presented 4 times starting with the right then left eye and repeated to each eye. A contrast value for each patch on the test slides is provided by the manufacturer and is determined by identifying a patch by grating frequency (1.5-18) and limit (highest=9). The mean contrast score was determined for each of the two frequency presentations to each eye.

Color Vision - The Lanthony D-15 desaturated hue panel (Lanthony, 1978) was used because it has been shown to be sensitive to neurotoxin-induced color vision loss. With one eye covered (right then left eye is tested) the subject is required to arrange 15 randomly ordered caps in order of color similarity under standardized lighting provided by a "daylight" lamp placed above the caps. A chromaticity scoring program using SAS software was provided by Dr. A. Geller. This analysis program provides a color confusion index score for each eye (1 for perfect order) using the same table as Bowman (Bowman, 1982), as well as total error (the distance between chips along the color spectrum), major errors (errors in placement that are more than 2 chips apart), and minor errors (errors in placement that are less than 2 chips apart). In addition, a difference Color Confusion Index Score between the right and left eye was generated for each subject.

Audiometric Evaluation - Using a Maico Model MA-25 portable audiometer, subjects were tested with pure tones from 500 to 8000 Hz bilaterally using an automatic threshold paradigm. The audiometer was calibrated annually by Clove Instruments. The mean dB threshold reduction at 2000 to 5000 Hz range for each ear is reported.

SCAN-A - A Test of Auditory Processing Disorders in Adolescents and Adults (Keith, 1994) - The competing words subtest was used in which the subject hears two words simultaneously - one word presented to each ear. The subject is instructed to repeat the words presented in each ear, repeating the word heard in the right ear first. The same test is repeated for the left ear. Fifteen word pairs are presented to each ear and a total score (number of correct responses) is reported.

Vibration Threshold - The Vibratron II (Physitemp Instruments, 1991) was used to measure finger vibration threshold using the first and fifth finger of each hand. Each subject was asked to report any damage or injury to these fingers. If so, the test was conducted using the next undamaged finger. However, only data for the first and fifth fingers was used for analyses. The vibratron instrument was used as a "one pole unit" as recommended by ATSDR (ATSDR, 1991). In an effort to relieve the fatigue of subjects, only the ascending protocol was administered. The subject was instructed to leave their finger on the post and each time the examiner said "Now," the subject is instructed to say 'Yes" if they feel the vibration or 'No" if

they do not. The protocol begins at a setting of 0 and increases in increments of .05 until the subject answers "Yes" at two consecutive settings. The first of the two "Yes" responses is recorded on the data form. This procedure was repeated 7 times for each finger. The threshold score was determined for each finger by deleting the lowest and highest score for each finger and taking a mean of the 5 remaining scores.

Attention-Concentration:

Simple Reaction Time (Visual and Auditory) - To assess visual reaction time, the simple reaction time test from the NES^2 computerized battery (Letz, 1994) was administered. In this task, the subject is asked to press a button as quickly as possible when a square appears on the screen. The inter-trial interval is varied randomly to reduce the effects of stimulus anticipation. There are 9 blocks of 25 trials for each hand (dominant and non-dominant). The score reported is the mean latency of response in milliseconds for each hand omitting the first block of trials..

Auditory Reaction Time - In a manner similar to that used for visual reaction time, the subject is asked to press a button as quickly as possible after hearing an auditory stimulus. The test of auditory attention was adapted from a computerized Micro Experimental Laboratory (MEL) developed by Psychology Software Tools, Inc. (Pittsburgh, PA). The mean reaction time of 6 blocks of 25 trials for the dominant and non-dominant hand in msec is reported.

Paced Auditory Serial Addition Task (PASAT) (Levin et al., 1987) - For this test, the subject is asked to add a series of 49 number pairs over each of four trials. Each trial is presented at an increasing speed and with new numbers. The number of errors for each trial and the total number of errors are scored.

Motor Skills:

Dynamometer (Lafayette Instruments, 1986) - This test required that the subject pull a handle attached to a strain gauge. The Centers for Disease Control-NIOSH protocol was used in the administration of this test. The subject was instructed to hold the dynamometer at their side face down and squeeze for 3 sec. then raise it for reading of the score and resetting. This procedure was repeated 5 times for each hand. The highest score for each hand is presented in kilograms. The dynamometer measures grip strength and fatigue and was recommended by ATSDR.

Finger Tapping (Letz, 1994) - The NES^2 version of this test required that the subject tap a button as many times as possible within a specified interval for the dominant and nondominant hand, and with both hands alternately tapping the two buttons. The score reported is the number of taps.

Grooved Pegboard (Heaton et al., 1991) - This test required rotating and placing grooved pegs into slots using first the dominant and then the nondominant hand while being timed and the score is represented in the number of seconds needed to complete the task.

Learning and Memory:

Symbol Digit Substitution - NES^2 (Letz, 1994) - Nine symbols and 9 digits are paired at the top of the computer screen and the subject has to press the digit keys corresponding to a test set of the nine symbols scrambled. Six sets were presented in succession (the first is a practice set). The score is reported as the average response latency over 5 trials.

California Verbal Learning Test (CVLT) (Delis et al., 1987) - A list of 16 words was presented verbally in 5 separate trials. The subject was asked to recall as many of the words as possible after each presentation. An interfering list is presented and short and delayed recall of the original list (with and without cues) was assessed.

Continuous Visual Memory Test (Trahan and Larrabee, 1988) - In this test, seven abstract designs were repeated among 70 different complex, ambiguous designs. The subject was asked to identify the repeated designs. The total score is presented which represents the number of hits (correct recognition of a recurring item) plus the number of correct recognitions of new items.

Rey-Osterrieth Complex Figure Test (Visser, 1985) - For this test, a complex figure was presented to the subject who was asked to copy the figure. The figure was taken away, and the subject was asked to draw the figure from immediate memory and then 30 minutes later. Strict scoring criteria were used to assess organizational skills, visuospatial constructional ability and memory as opposed to visual recognition.

Mood:

Symptom Checklist -90-R (Derogatis, 1977) - This 90 item checklist asked the subject to rate each of the symptoms on a scale from one to five for symptom severity. The subject rated each symptom for the past seven days including today. This scale contains specific questions that relate to moods. For example, rather than asking the level of depression, this scale addresses behavioral indicators of depression or anxiety such as trouble sleeping and difficulty concentrating. Therefore, both overall mood and specific symptomatology was assessed. The following dimensions were included: Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, and Psychoticism. In addition, an overall distress score (GSI) and count of symptoms (Positive Symptom Total) are presented.

Results

Before presenting the results, it is necessary to emphasize that these subjects represent low to moderate exposure to lead and solvents. Very few subjects showed evidence of the high exposures sometimes reported. Only 10 subjects had blood lead levels above 25 μg/dl and only one subject was above 50 μg/dl. In addition, solvent exposures were in the low range of industrial exposure (see Appendix).

Medical Evaluation:

Attention was focused on GGTP as an indicator of both excessive solvent and alcohol toxicity (primarily acute toxicity), and on BUN and serum creatinine as measures of liver function. Red blood cell count (RBC), hemoglobin (Hgb), and hematocrit (Hct) and average systolic and diastolic blood pressure measurements were targeted for lead toxicity.

Two subjects had GGTP levels in excess of 900. Further evaluation revealed that both had multiple liver function abnormalities. There was no evidence of significant renal disturbance. The maximum BUN was 24 and the maximum creatinine 1.4. These variables were significantly correlated (Kendall tau=.15, p=.009) with each other, but not with blood lead, bone lead, or solvent exposure. There was no evidence of anemia. The lowest RBC was 3.06 with a hemoglobin of 12 and a hematocrit of 36, in the individual with the GGTP of 993. Aside from this individual the lowest values were RBC=4.28, Hgb=13.2, and Hct=38.3. These three values were highly intercorrelated (p=.0001), and hemoglobin (p=.01) and hematocrit (p=.003), but not RBC (p=.29) were correlated with blood lead. None were correlated with bone lead or cumulative solvent exposure.
Overall, 54 of 208 (26%) subjects had average systolic and diastolic pressure above 139 and 89 respectively, which compared reasonably with other data on hypertension in occupational groups. Only one subject had a systolic > 179 or diastolic > 109. Systolic pressure was marginally correlated with bone lead (tau=0.13, p=.062), and solvent exposure (tau=.14, p=.034), but not with blood lead (tau=.05, p=.36). Diastolic pressure was correlated with solvent (tau=.17, p=.01) but not with blood or bone lead.

Initially, a four group non-parametric analysis of variance using first the a priori and then the a posteriori groupings was performed (Table 9 shows the mean values and the p value from the Kruskal-Wallis Chi Square).

The four groups were then compared in a pairwise fashion, using the *a posteriori* classification (Table 10). P values are shown for the Kruskal-Wallis one way analysis of variance. Median solvent exposure was highest in solvent and lead/solvent groups and bone lead was highest in the lead and lead/solvent groups. None of the three groups was significantly different from controls in GGTP, BUN, or Creatinine nor in average systolic or diastolic blood pressure.
In the *a posteriori* groups, the high GGTP values for Controls and Lead/Solvent groups (Table 10) were due to the single outlier values mentioned earlier. Without these outliers, the means reverted to 38.5 and 39.5 respectively. The elevated mean for the Lead group was due to several values above 200 which were not treated as outliers. Median values were between 25 and 30 for all four groups.

RBC counts were significantly lower in both the Lead and Solvent groups than in Controls but this was not true for the Lead/Solvent group. Hemoglobin and hematocrit were only significantly reduced in the Lead vs. Control group.

The Lead and Lead/Solvent groups both showed higher mean systolic pressure than the Controls and Solvents; this was true but less apparent for the diastolic pressure.

Table 11 shows the relationship of the clinical chemistry values to bone lead, lifetime solvent exposure, total and peak alcohol consumption and age. Analyses were performed using the PROC GLM procedure in SAS. The r-squared value for each regression model and the probability (P value) for each independent variable are shown. The r-squared values for most dependent variables were non-significant (p values > 0.10). BUN and serum creatinine were marginally significant (p=.09), and the alcohol variable rather than lead were the main contributors. However, GGTP, an enzyme marker often considered indicative of alcohol exposure, was not significantly predicted by either peak or total alcohol. This may reflect the fact that most participants abstained from alcohol in the days immediately preceeding their tests.

The red blood cell variables (RBC, hematocrit and hemoglobin) are to some extent redundant. These were expected to be reduced in lead exposure, since lead interferes with hemoglobin synthesis, but no relationship was apparent at the levels encountered in this study.

Lead is also known to cause hypertension. However, this was not apparent at the levels found in the subjects in this study. As expected, the average systolic blood pressure was significantly associated with age. This was much less marked for the average of the four diastolic measurements (p=.079).

Univariate regressions gave a somewhat different picture. GGTP was significantly affected by Total alcohol consumption. RBC and both systolic and diastolic BP were significantly associated with age and also with total alcohol consumption. Contrary to a reasonable expectation, none of the red blood cell markers were significantly predicted by known lead exposure. The blood pressure measures were also significantly associated with solvent exposure. Systolic blood pressure was related to bone lead (p=.05).

If any one of the four systolic BP measurements exceeded 139 mmHg, the subject was labelled as hypertensive (systolic), and if any of the four diastolic measurements exceeded 89 they were labelled as hypertensive (diastolic). The presence or absence of systolic hypertension and of diastolic hypertension was compared among the four exposure groups, using both the *a priori* and *a posteriori* group assignments (Table 12). None of the 2 x 4 contingency tables showed a positive association. However, comparing all lead-exposed subjects (Lead and Lead/Solvent) with all nonlead-exposed subjects (Solvent and Control), yielded a significant excess of both systolic (Chi square =4.58, p=.032) and diastolic (Chi Square = 3.90 p=.048) hypertension in the Lead subjects. Similarly, solvent-exposed with all nonsolvent-exposed subjects were compared, and no relationship with either systolic (Chi Square 0.11, p=.74) or diastolic (Chi Square =.76 p=.39) hypertension was found.

Attention/Concentration:

The overall MANOVA for tests of attention and concentration included the following variables: Paced Auditory Serial Addition Task (PASAT)- Total errors; Mean Simple Visual Reaction time - dominant and non-dominant hand; Mean Auditory Reaction time - dominant and non-dominant hand. The overall MANOVA was not significant for these variables ($F<1.0$). Table 13 gives the mean, standard deviation, and range for each of the individual variables and the significance tests for the univariate analyses. As can be seen from this Table, the only variable that approached significance was the PASAT Total error score. For this variable, the lead and lead-solvent groups had the highest number of errors with a trend toward significance between the lead group and the solvent group. Figure 1 shows the mean error scores for each group across the four trials. This Figure reveals that the groups had a similar pattern of performance from trials 1 through 4 with the lead group making the greatest number of errors. For the Auditory Reaction Time task, a repeated measures analysis was also conducted to compare performance between the groups on the repeated trials (6 trials) of this task. A significant main effect of Trial was noted for dominant and non-dominant hands, respectively ($F=9.22$; $p<.0001$; $F=5.44$; $p<.0001$) but no significant Trial by Group interaction ($F=1.03$; $p<.42$; $F<1.0$) confirming no effect of exposure on performance over repeated trials.

Memory:

The overall MANOVA for tests of memory included the following variables: Symbol Digit Average Latency; California Verbal Learning Test - Total raw score (CVLT-total); Continuous Visual Memory Test - Total raw score (CVMT); Rey Osterreith Complex Figure - Delayed total score (Rey-Delay). The overall MANOVA was significant ($F=2.71$; df= ; $p<.002$). Univariate analyses of these memory variables and subtest scores for each test are seen in Table 14 and 15.
For the Symbol Digit Average Latency, univariate analysis revealed that the Lead group performed significantly worse than the Control group, but did not differ from the other exposure groups. The Lead/Solvent and Solvent exposure groups did not differ from each other or from the Control group. In contrast, the Solvent group performed significantly worse on the CVLT-total than the control group while no other group differences were observed. Thus, on a measure of verbal learning, the Solvent group's overall acquisition of new information was lower than the Control group while the means for the other two exposure groups, Lead and Lead/Solvent, were not different. For the CVMT, the Lead/Solvent performed significantly worse than the Solvent or Lead groups. Examination of the individual components of this score revealed that the groups did not differ from each other in accurate identification of the target visual stimuli (i.e., Hits) but that the Lead/Solvent group committed significantly more False Alarms than the Lead or Solvent groups which did not differ from each other or from the Control group. This suggests that the Lead/Solvent group had more difficulty inhibiting responses to non-target stimuli. No significant differences between the groups were noted for the Rey Osterreith Complex Figure Test-Delay scores. Given the large number of tests, we cannot ascribe this performance to synergy.

To more carefully examine the results for the CVLT, individual univariate analyses compared the subscores for each of the performance variables. Table 15 shows these subscores and the significance tests for each variables. These results indicate that the Solvent group had significantly

more difficulty acquiring new information with practice as seen by the significantly worse performance on Trial 5 of List A after practicing List A five times. The Solvent group did not benefit from cues to aid in retrieval after a 30 minute delay (Cued Long Delay). Thus, cues did not help them improve relative to the Control group.

Regression Analyses:

For those variables that were significantly different between the groups, i.e., PASAT total errors, Symbol Digit Latency, and CVLT total, separate step-wise regressions were conducted using the following variables to predict performance for each dependent measure: age, WRAT-Reading, lifetime solvent exposure, bone lead, total lifetime alcohol, peak alcohol in past year, and peak lifetime alcohol. For the PASAT total errors, the overall model accounted for 11% of the variance with WRAT-Reading as the most significant predictor $r^2 = .07$; $p<.0008$) followed by bone lead ($r^2 = .03$; $p< .05$) and age ($r^2 = .02$; $p<.09$). For Symbol Digit Latency, the overall model accounted for 32% of the variance with age as the most significant predictor ($r^2 = .26$; $p<.0001$) followed by WRAT-Reading ($r^2 = .03$; $p<.008$) and bone lead ($r^2 = .03$; $p< .01$). For the CVLT total score, lifetime solvent exposure was the first significant predictor ($r^2 = .03$; $p<.02$) followed by age ($r^2 = .03$; $p< .04$) and WRAT-Reading ($r^2 = .04$; $p<.01$) with an overall r^2 of .10. Thus, in each case, the exposure score, as measured with bone lead or lifetime solvent exposure was a significant predictor of performance.

Sensory:

Hearing: After removing subjects who were hearing impaired according to the criteria listed previously, the overall MANOVA for hearing thresholds, right and left ear and the SCAN-A revealed an overall significant difference ($F=2.79$; df = $p<.004$). Separate univariate analyses compared the groups on the average hearing threshold for the right and left ear across 2000, 3000, and 4000 Hz and overall performance on the SCAN-A (Table 16). The Lead group had significantly higher thresholds than the Solvent group for the left ear and approached significance for the right ear with the Lead/Solvent group and Lead group showing higher thresholds. No significant differences were noted for the SCAN-A suggesting that despite different thresholds, no group had more difficulty with this discrimination task.

Vision: On the Lanthony D-15, no differences were observed between the groups for either the right or left eyes on any of the following indices: Color Confusion Index, Minor errors, Major errors, and Total errors (Table 17). To assess discrepancies in the Color Confusion Index between the right and left eye for each individual, an index thought to be indicative of acquired color vision loss, a paired t-test compared the difference between right and left eye within each group. No significant right-left eye differences were observed within the groups. In addition, no significant differences were observed (Kruskal-Wallis) when the average difference scores between right and left eye for each group, were compared.

To assess difference in Contrast Sensitivity, a matched pairs analysis was conducted using the Wilcoxon Signed Ranks test. A solvent exposed subject was matched with a control of similar age (+/- 5 years), education (+/- 2 years) gender (all male), and lifetime alcohol use. In a manner similar

to Hudnell et al. (Hudnell et al., 1996) and Mergler et al. (Mergler et al., 1991) a difference score between performance for the solvent-exposed and control of each matched pair was then computed for each patch (A,B,C,D,E) and for each eye. For the right eye, controls performed better than solvent-exposed for every patch except E for which the exposed performed better (see Table 18). However, none of these differences were significantly different. For the left eye, Controls again performed better than Solvent-exposed for every patch but C with significantly better performance on patches B and E. These findings suggest that solvent exposure may have impaired contrast sensitivity but in an inconsistent manner.

Motor:

The overall MANOVA for motor function which included Tapping dominant, Tapping non-dominant, Tapping Alternating, Grooved Pegboard-dominant, Grooved Pegboard-non-dominant, was not significant ($F= 1.1$; $p<.35$). Individual analyses comparing performance between the groups on each of the above variables (Kruskal-Wallis) revealed no significant differences on any of the above measures (Table 19). Thus, the present results do not suggest any significant reduction in fine motor speed or dexterity at the moderate exposure levels in our sample.

Peripheral Sensitivity: The Kruskal-Wallis tests comparing the vibratory threshold scores for the dominant index and fifth finger and non-dominant index and fifth fingers revealed no overall significant differences among the four groups for any finger of the dominant or non-dominant hands. However, inspection of the mean ranks shows that the Control group consistently scored below the exposure groups which indicates lower vibration thresholds for the Controls. Therefore, post-hoc pairwise comparisons of the Control group with each exposure group were conducted and are shown in Figure 2-5. The Controls had significantly lower thresholds than the Lead and Solvent groups for the dominant index finger and than the Lead group for the dominant fifth finger and lower thresholds than the Lead/Solvent and Solvent for the non-dominant index finger while no significant group differences were noted between the groups for the non-dominant fifth finger. Overall, Controls consistently had lower thresholds, and therefore, greater peripheral sensitivity than the exposed groups.

These vibration threshold results were explored further by comparing Controls to the most highly exposed subjects in each exposure group defined as follows: High Lead - K-XRF $\geq$ 5.4 ppm wet weight (median score); High Solvent - Lifetime Solvent Exposure $\geq$ 365,302 mg (median score); High Lead/Solvent - K-XRF $\geq$ 5.4 ppm wet weight and Lifetime Solvent Exposure $\geq$ 365,302 mg. These groups were comparable in age, education, WRAT-Reading, total lifetime alcohol use, peak alcohol use past year and in and lifetime drug use.

For the dominant index and fifth fingers and the non-dominant index finger, the groups differed significantly (Kruskal-Wallis - Chi Square = 10.65; $p < .01$; Chi Square = 7.68; $p<.05$; Chi Square = 9.21; $p<.03$, respectively). The Solvent and Lead groups had significantly higher thresholds than the Controls for the dominant index and fifth fingers and for the non-dominant index finger. Overall, there was a trend toward differences between the groups for the non-dominant fifth finger (Chi Square = 6.42; $p<.09$). The Lead group had a significantly higher threshold for the non-dominant fifth finger while the Solvent group did not differ from Controls for the non-dominant fifth finger.

The Lead/Solvent group did not differ significantly from the Controls for the dominant index or fifth fingers or for the non-dominant, fifth finger but were significantly higher for the non-dominant index finger. Again for both hands, the Controls had the lowest threshold scores while the Lead and Solvent groups had the highest threshold scores indicating lower peripheral sensitivity.

Mood:

Scores from the SCL-90 were compared between the groups. The overall MANOVA which included all subscale scores revealed no significant differences between the groups ($F=1.04$; $p<.41$). Table 20 shows the mean, standard deviation, and range for the scores on each of the subscales and the overall indices for this measure. These analyses revealed that the groups did not differ in psychiatric symptoms and/or distress.

Longitudinal Follow-up of Lead and Control Groups

The purpose of the longitudinal follow-up was to assess whether improved control of lead exposure in the construction industry through coverage under the OSHA lead standard would result in short-term benefits. The hypotheses were that blood and bone lead levels in construction workers would decline and that neurobehavioral performance would improve more for the lead group relative to controls on those tests where controls performed significantly better than the lead group at initial testing (Time 1).

To address these questions, 37 subjects from the Lead and Control groups were invited for re-evaluation in the final year of the project (Time 2). These included subjects whose initial K-XRF reading was in the top quartile. This re-evaluation occurred approximately 2 years after the subject's Time 1 testing. The goal of the project was to re-test 20 of the highest lead exposed based on K-XRF bone lead values measured at Time 1 and to select 20 age, gender, education, and intelligence matched controls. Although subjects were still available and working in the area, 14 refused to be re-tested despite our encouragement and 2 subjects were found to have significant solvent exposure, and were therefore, not asked to participate as lead-exposed. Overall, subjects found the testing demanding and did not want to take the time or put themselves through the same testing battery again despite of the stipend offered ($200). Eleven lead and 10 controls were re-evaluated rather than the full 20 subjects for each group. Therefore, the following results need to be regarded with caution due to the small sample size. However, the data provide some interesting preliminary findings that suggest some benefits from reduced bone lead values.

Subjects who had documented lead exposure based on K-XRF (Bone lead 1) or who were Controls with a K-XRF taken at the initial evaluation (Time 1) had a repeat K-XRF (Bone lead 2) reading at the time they were re-evaluated (Time 2). Control subjects who did not have a Time 1 K-XRF reading did not have a second reading performed. Table 21 shows the mean, median standard deviation, and range of values for the Bone lead 1 and Bone lead 2 readings. In addition, Table 21gives the results of the Wilcoxon sign rank test on the differences between these values and their correlations. Bone leads 1 and 2 were significantly correlated, and as predicted, bone lead readings were significan.ly lower at Time 2. This is consistent with reduction in exposure of these construction workers to lead in the mid-1990's compared to the early 1990's.

Neurobehavioral Re-evaluation

Difference scores from Time 1 to Time 2 were compared for each group (Lead and Controls) using the Wilcoxon sign rank test. These differences were then compared with Wilcoxon non-parametric analyses to identify Time X Group interactions. Since all subjects had a blood lead value, these values were compared between the groups and are shown in Table 22. Neither group differed significantly from Time 1 to Time 2 in blood lead and no significant Time X Group interaction was noted in blood lead. Therefore, unlike bone lead, blood lead did not change over the time period of this project. However, it should be noted that the blood lead values at both Time 1 and 2 were relatively low giving little opportunity for reduction. This is consistent with the fact that by the start of the project in 1995, lead exposure was already reduced.

Prior to examining changes between the groups on neurobehavioral performance, comparability of the groups on relevant demographic variables was determined (Table 23). Re-tested subjects in the Lead and Control groups showed no significant differences in age, education, WRAT-Reading scores, lifetime and peak alcohol use. There was a trend toward higher WRAT-reading scores for the Lead group but this difference was not regarded as clinically significant.

Attention/Concentration:

For the simple visual reaction time test, the Lead group tended to show improvement for the dominant hand only ($p<.08$) while the Control group did not improve on either hand. The Group X Time interaction was not significant for visual reaction time, dominant or non-dominant hands. For auditory reaction time, dominant and non-dominant hands, no significant differences were noted from Time 1 to Time 2 for the Lead and Control groups. However, for both hands, there was a trend toward a significant Time X Group interaction. As shown in Figure 6 and 7, the Lead group tended to improve while the Control group tended to show worse performance over time. Finally, for the more complex information processing task, the PASAT, both groups showed significant improvement from Time 1 to Time 2 and the Time X Group interaction was significant with the Control group showing relatively greater improvement than the Lead group. Table 24 shows the mean, standard deviation, and range of values for performance for Time 1 and Time 2, and the same statistics for the difference scores for each of the tests.

In summary, on simple tests of concentration (i.e., reaction time), the Lead group tended to show some improvement from Time 1 to Time 2 while the Control group did not. On the relatively more complex test of concentration and information processing, which is also more likely to be affected by learning (i.e., the PASAT) both groups showed improvement over time or with repeated exposure to the test.

While preliminary due to the low number of subjects who completed re-testing, these results suggest that reduced Lead exposure, as documented by lower K-XRF values, was associated with improved performance on simple tests of reaction time that appeared less affected by learning or practice over time (i.e., for Controls). However, for the test more vulnerable to the effects of learning or practice over time, the Lead group's improvement was less than the Control's. This could be due to the persistent (though reduced) body burden of lead or to persistent damage from past exposure.

Memory:

Table 24 shows the mean, standard deviation, and range of scores for Time 1 and Time 2 and for the differences between Time 1 and Time 2 for each group. The Control group improved significantly for the CVLT and the Copy, Immediate and Delayed Recall of the Rey-Osterreith complex figure. The Lead group did not improve significantly on the CVLT but improved significantly on the Copy but not the Immediate and Delayed Recall scores of the Rey-Osterreith complex figure. Despite differential improvement between the Lead and Control groups, no Time X Group interactions reached significance. Neither the Lead nor the Control group improved significantly on Symbol Digit or the Continuous Visual Memory Test. These results indicate that while the Control group improved on those tests most vulnerable to learning and practice effects (e.g. verbal and visual

memory), the Lead group did not show such improvement.

Motor:

Neither group improved significantly on any measure of motor speed or strength (see Table 24). Also, no significant Time X Group interaction was shown for any measure of motor function. Thus, these tests did not show change due to learning, practice, or changes in lead K-XRF.

Sensory:

Hearing: Neither group showed significant changes in hearing thresholds from Time 1 to Time 2 or in performance on a hearing discrimination task (SCAN-A). In addition, there were no Time X Group interactions for these tests suggesting that learning, practice, and decline in K-XRF did not significantly alter performance on tests of hearing.

Peripheral Sensitivity: Neither group showed significant changes in vibration thresholds from Time 1 to Time 2. In addition, no Time X Group interactions were significant suggesting that learning, practice, and changes in K-XRF did not significantly alter peripheral sensitivity.

Mood:

With the exception of one subscale, i.e., Obsessive-Compulsive, no significant changes were noted between Time 1 and Time 2 for the Lead or Control groups. The Control group reported significantly more symptoms indicative of obsessional and compulsive behavior. No Time X Group interactions were significant for any subscale or summary scale of the SCL-90 (see Table 24). Overall, these results do not suggest significant change over time in the mood symptoms for either group regardless of changes in K-XRF values.

Conclusions

With the exception of one individual, there was no evidence of anemia. However, the Lead group did have significantly lower red blood cell count and hematocrit. GGTP did not differ among exposure groups but was related to lifetime alcohol consumption. Hypertension increased with age but was also associated with exposure to lead. These findings are all consistent with the known effects of these agents. They also show that this population was grossly healthy.

Bone lead values for Iron Workers and Industrial/Structural Painters and Bridgeworkers were moderate to low and were not uniform across the trades. Thus, despite previous literature citing high blood lead values for Bridgeworkers and Iron Workers, the bone lead values in the present study do not reflect long-term high level exposure (Hu et al., 1991). This is partly due to the fact that many of the subjects were riggers rather than bridgeworkers and that exposure levels were already declining by the mid-1990's. The high blood lead values detected in the early 1990's may have been due to short-term exposures occurring in reconstructive bridge work. However, even though the initial bone lead levels detected in this study were relatively low, those with the highest values showed significant decline over a two year follow-up period. Thus, extension of the OSHA standard to the construction trades appears to have had a beneficial effect.

Consistent with the bone lead values found, only relatively subtle cognitive effects were observed for the lead exposed subjects. That is, lead exposed subjects had slowing in latency of response for a coding task involving memory and more errors in a complex information processing task. Contrary to the hypothesis, Industrial/Structural Painters and Bridgeworkers did not have greater relative cognitive deficits. In addition, the lead exposed group had more hearing loss than other groups from the construction trades. At follow-up, while the lead exposed subjects improved on the information processing task, their improvement was relatively less than a matched group of control subjects tested over the same time period.

For the solvent exposed group, subtle decrements were noted on a complex task of verbal memory. Relative to a matched control group, solvent exposed subjects also had some loss in contrast sensitivity. Finally, all exposed groups had higher vibration thresholds than the control subjects suggesting reduced peripheral sensitivity.

These findings indicate subtle decrements in performance between groups of workers from the construction trades matched on age, education, intellectual ability, and lifetime alcohol consumption. No differential changes in overall ability were noted between the groups based on comparison of pre- to post-exposure tests of ability. However, the subtle decrements in performance were associated with neurotoxicant exposure as opposed to lifetime or peak alcohol consumption or other potential confounders. Based on these results, continued vigilance regarding protection from exposure is warranted to reduce any adverse long-term effects. Finally, it must be emphasized that even in the lead exposed group, blood lead levels were only moderately elevated (10 were > 25 μg/dl, maximum=57) and solvent exposures were substantially lower than in many industrial settings.

Reference List

Anger, W.K. Worksite behavioral research. Results, sensitive methods, test batteries and the transition from laboratory data to human health. *NeuroToxicology* 11:627-670, 1990.

Anger, W.K. and Johnson, B.L. Human behavioral neurotoxicology: Workplace and community assessments. In: *Environmental and Occupational Medicine*, edited by Rom, W.N. Boston: Boston:Little, Brown & Co., 1992, p. 573-592.

ATSDR. Adult environmental neurobehavioral test battery. Examiner Training Manual. 1991. Atlanta, GA, Agency for Toxic Substances and Disease Registry.

Baker, E.L. Organic solvent neurotoxicity. *Ann.Rev.Public Health* 9:223-232, 1988.

Baker, E.L., Feldman, R.G., White, R.A., et al. Occupational lead neurotoxicity: a behavioural and electrophysiological evaluation. Study design and year one results. *British Journal of Industrial Medicine* 41:352-361, 1984.

Baker, E.L., Letz, R.E., Eisen, E.A., et al. Neurobehavioral effects of solvents in construction painters. *J Occupational Medicine* 30:116-123, 1988.

Baker, E.L., White, R.F. and Murawski, B.J. Clinical Evaluation of Neurobehavioral Effects of Occupational Exposure to Organic Solvents and Lead. *Int.J.Ment.Health* 14:135-158, 1985.

Bleecker, M.L., Bolla, K.I., Agnew, J., Schwartz, B.S. and Ford, D.P. Dose-related subclinical neurobehavioral effects of chronic exposure to low levels of organic solvents. *Amer J Industrial Medicine* 19:715-728, 1991.

Bolla, K. I., Schwartz, B.S., Agnew, J., Ford, P.D. and Bleecker, M.L. Subclinical neuropsychiatric effects of chronic low-level solvent exposure in US paint manufacturers. *J Occupational Medicine* 32:671-677, 1990.

Bowman, K.J. A method for quantitative scoring of the Farnsworth panel D-15. *Acta Ophthalmologica* 60:907-916, 1982.

Braun, C.M.J. and Daigneault, S. Sparing of cognitive executive functions and impairment of motor functions after industrial exposure to lead: a field study with control group. *Neuropsychology* 5:179-193, 1991.

Browder, A.A., Joselow, M.M. and Louria, D.B. The problem of lead poisoning. *Medicine* 52:121-139, 1973.

Burger, J. and Gochfeld, M. Comparisons of nine heavy metals in salt gland and liver of greater scaup (Aythya marila), black duck (Anas rubripes) and mallard (A. platryrnchos). *Comp.Biochem.Physiol.* 81C:287,1995.

Campara, P., D'Andrea, F., Micciolo, R., Savonitto, C., Tansella, M. and Zimmerman-Tansella, C. Psychological performance of workers with blood lead concentration below the current threshold limit value. *Int Arch Occup Environ Health* 53:233-246, 1984.

Delis, D.C., Kramer, J.H., Kaplan, E. and Ober, B.A. California Verbal Learning Test Manual. *The Psychological Corporation* San Antonio, TX:1987.

Derogatis, L.R. SCL-90-R administration, scoring and procedures manual-III. *Clinical Psychometric Research* Towson, MD:1977.

Erkkila, J., Armstrong, R., Riihimaki, V., et al. In vivo measurements of lead in bone at four anatomical sites: long term occupational and consequent endogenous exposure. *British Journal of Industrial Medicine* 49:631-644, 1992.

Errebo-Knudsen, E.O. and Olsen, F. Organic solvents and presenile dementia (the painters' syndrome). A critical review of the Danish literature. *The Science of the Total Environment* 48:45-67, 1986.

Fidler, A.T., Baker, E.L. and Letz, R.E. Estimation of long term exposure to mixed solvents from questionnaire date: a tool for epidemiological investigations. *British Journal of Industrial Medicine* 44:133-141, 1987.

Fischbein, A, Daum, S, Davidow, B, Slavin, G, Alvares, A, Sassa, S, Anderson, K, Kappa, A, Eisinger, J, Blumberg, W, Winicow, E, and Selikoff, I. Lead hazard among ironworkers. New York State Journal of Medicine (July). 1978.

Fischbein, A., Leeds, M. and Solomon, S. Lead exposure among iron workers in New York City. A continuing occupational hazard in the 1980's. *New York State Journal of Medicine* 84:445-448, 1984.

Gade, A., Mortensen, E.L. and Bruhn, P. "Chronic painter's syndrome". A reanalysis of psychological test data in a group of diagnosed cases, based on comparisons with matched controls. *Acta Neurol Scand* 77:293-306, 1988.

Gamberale, F. Use of behavioral performance tests in the assessment of solvent toxicity. *Scan J Work Environ Hlth* 65-74, 1985.

Gerhardsson, L., Attewell, R., Chettle, D.R., et al. Kidney effects in long-term exposed lead smelter workers. *Brit J Indus Med* 49:186-192, 1992.

Gochfeld, M, Buckler, G, and Rhoads, G. A quality assurance study of clinical laboratory performance for low level blood lead. 1992. Piscataway, NJ, Environmental & Occupational Health Sciences Institute.

Gochfeld, M., Fiedler, N. and Burger, J. Neurobehavioral toxicology. In: *Maxcy-Rosenau-Last's Public Health and Preventive Medicine*, edited by Last, J.M. and Wallace, R.B. Norwalk, CT: Appleton-Lange, 1992b, p. 325-332.

Grandjean, P., Arnvig, E. and Beckmann, J. Psychological dysfunctions in lead-exposed workers. *Scand J Work Environ & Health* 4:295-303, 1978.

Haenninen, H., Hernberg, S., Mantere, P., Vesanta, R. and Jalkanen, M. Psychological performance of subjects with low exposure to lead. *JOM* 20:683-689, 1978.

Hanninen, H., Antti-Poika, M., Juntunen, J. and Koskenvuo, M. Exposure to organic solvents and neuropsychological dysfunction: a study on monozygotic twins. *British Journal of Industrial Medicine* 48:18-25, 1991.

Hanninen, H., Eskelinen, L., Husman, K. and Nurminen, M. Behavioral effects of long-term exposure to a mixture of organic solvents. *Scand J Work Environ & Health* 4:240-255, 1976.

Heaton, R. K, Grant, I, and Matthews, C. G. Comprehensive norms for an expanded Halstead-Reitan battery: demographic corrections, research findings, and clinical applications. 1991. Psychological Assessment Resources, Inc.

Hernberg, S. Neurotoxic effects of long-term exposure to organic hydrocarbon solvents. Epidemiologic aspects. In: *In: Mechanisms of Toxicity and Hazard Evaluation*, edited by Holmstedt, B., Lauwerys, R., Mercier, M. and Roberfroid, M. Amsterdam: Elsevier/North Holland Biomedical Press, 1980, p. 307-317.

Hogstedt, C., Hane, M., Agrell, A. and Bodin, L. Neuropsychological test results and symptoms among workers with well-defined long-term exposure to lead. *British Journal of Industrial Medicine* 40:99-105, 1983.

Hu, H., Pepper, L. and Goldman, R. Effect of repeated occupational exposure to lead, cessation of exposure, and chelation on the levels of lead in bone. *Am J Ind Med* 20:723-735, 1991.

Hudnell, H.K, Otto, D.A. and House, D.E. The influence of vision on computerized neurobehavioral test scores: a proposal for improving test protocols. *Neurotoxicology and Teratology* 18:391-400, 1996.

Jastak, S. and Wilkinson, G.S. Wide Range Achievement Test Administation Manual. *Jastak Associates, Inc.* Wilmington, Delaware:1984.

Jones, K.W., Schidlovsky, G., Williams, F.H., Wedeen, R.P. and Batuman, V. In vivo determination of tibial lead by K x-ray fluorescence with a Cd-109 source. In: *In vivo Body Composition Studies*, edited by Ellis, K.J., Yamamura, S. and Morgan, W.D. London: Institute of Physical Sciences in Medicine, 1987, p. 363-373.

Keith, R. W. Scan-A A test for auditory processing disorders in adolescents and adults. 1-69. 1994. San Antonio, Texas, The Psychological Corporation.

Kisner, S.M. and Fosbroke, D.E. Injury Hazards in the construction industry. *JOM* 36:137-143, 1994.

Kosnett, M.J., Becker, C.E., Osterloh, J.D., Kelly, T.J. and Pasta, D.J. Factors influencing bone lead concentration in a suburban community assessed by noninvasive k x-ray fluorescence. *JAMA* 271:197-203, 1994.

Kromhout, H., Oostenderp, Y., Heedevik, D. and Beieij, J.S.M. Agreement between qualitative exposure estimates and quantitative exposure measurements. *American Journal of Industrial Medicine* 12:551-562, 1987.

Lafayette Instruments. Dynamometer. 1986. Lafayette, Indiana.

Landrigan, P.J. Strategies for epidemiological studies of lead in bone in occupationally-exposed populations. *Environmental Health Perspectives* 91:81-86, 1991.

Lanthony, P. The desaturated panel D-15. *Doc.Opthalmol.* 46:185-189, 1978.

Letz, R. NES2 User's Manual. 1-58. 1994. Atlanta, GA, Neurobehavioral Systems, Inc.

Levin, H.S., Mattis, S., Ruff, R.M., et al. Neurobehavioral outcome following minor head injury: a three-center study. *Journal of Neurosurgery* 66:234-243, 1987.

Lezak, M.D. *Neuropsychological Assessment*, New York:Oxford University Press, 1983.

Mehta, A. Lead exposure in the bridge construction industry. (Graduate Program in Public Health of EOHSI). 1990. MPH Field Work Report to the New Jersey Department of Health (M.Gochfeld, Supervisor).

Mergler, D., Huel, G., Bowler, R., Frenette, B. and Cone, J. Visual dysfunction among former microelectronics assembly workers. *Archives of Environmental Health* 46:326-334, 1991.

Morrow, L.A., Ryan, C.M., Hodgson, M.J. and Robin, N. Alterations in cognitive and psychological functioning after organic solvent exposure. *J Occupational Medicine* 32:444-450, 1990.

New Jersey Department of Health. Surveillance of occupational lead exposure in New Jersey: 1984-1991. 1993. Trenton, NJ, Report of the New Jersey State Department of Health.

Parkinson, D.K., Ryan, C., Bromet, E.J. and Connell, M.M. A psychiatric epidemiologic study of occupational lead exposure. *American Journal of Epidemiology* 123:261-269, 1986.

Physitemp Instruments. The Vibratron II. 1991. Clifton, NJ.

Rabinowitz, M.B. Toxicokinetics of bone lead. *Environmental Health Perspectives* 91:33-37, 1991.

Repko, J.D. and Corum, C.R. Critial review and evaluation of the neurological and behavioral sequelae of inorganic lead absorption. *CRC Critical Reviews in Toxicology* 6:135-185, 1979.

Ryan, C.M., Morrow, L., Parkinson, D. and Bromet, E. Low level lead exposure and neuropsychological functioning in blue collar males. *Intern J Neuroscience* 36:29-39, 1987.

Ryan, C.M., Morrow, L.A. and Hodgson, M. Cacosmia and neurobehavioral dysfunction associated with occupational exposure to mixtures of organic solvents. *American Journal of Psychiatry* 145:1442-1445, 1988.

Silbergeld, E.K., Sauk, J., Somerman, M., et al. Lead in bone: storage site, exposure source and target organization. *NeuroToxicology* 14:225-236, 1993.

Somervaille, L.J., Chettle, D.R., Scott, M.C., et al. Comparison of two in vitro methods of bone lead analysis and the implications for in vivo measurements. *Phys Med Biol* 31:1267-1274, 1986.

Somervaille, L.J., Nilsson, U., Chettle, D.R., et al. In vivo measurements of bone lead -- a comparison of two x-ray fluorescence techniques used at three different bone sites. *Phys Med Biol* 34:1833-1845, 1989.

Somervaille, L.J., Chettle, D.R., Scott, M.C., et al. In vivo tibial lead measurements as an index of cumulative exposure in occupationally exposed subjects. *Brit J Indus Med* 45:174-181, 1988.

Spurgeon, A., Gray, C.N., Sims, J., et al. Neurobehavioral effects of long-term occupational exposure to organic solvents: comparable studies. *Amer J Industrial Medicine* 22:325-335, 1992.

Stollery, B.T., Banks, H.A., Broadbent, D.E. and Lee, R.W. Cognitive functioning in lead workers. *Brit J Indus Med* 46:698-707, 1989.

Todd, A.C., McNeill, F.E. and Fowler, B.A. In vivo x-ray fluorescence of lead in bone. *Environmental Research* 59:326-335, 1992.

Trahan, D.E. and Larrabee, G.J. Continuous Visual Memory Test. *Psychological Assessment Resources, Inc.* Odessa, FL:1988.

Valciukas, J., Lilis, R., Singer, R. and et, al. Neurobehavioral changes among shipyard painters exposed to solvents. *Arch Environ Health* 40:47-52, 1985.

Valciukas, J.A. and Lilis, R. A composite index of lead effects. Comparative study of four occupational groups with different levels of lead absorption. *Int Arch Occup Environ Health* 51:1-14, 1982.

Visser, R. S. H. Manual of the complex figure test CFT. 1985. Lisse, Swets & Zeitlinger B.V.

Waller, K., Osorio, A.M., Maizlish, N. and Royce, S. Lead exposure in the construction industry: Results from the California occupational lead registry, 1987 through 1989. *American Journal of Public Health* 82:1669-1671, 1992.

Wedeen, R.P. Bone lead, hypertension, and lead nephrotoxicity. *Environmental Health Perspectives* 78:57-60, 1988.

Wedeen, R.P. In vivo tibial XRF measurement of bone lead. *Arch Env Health* 45:69-71, 1990.

Wedeen, R.P., Batuman, V., Quinless, F., et al. Lead nephropathy. In: *In Vivo X-Ray Composition Studies*, edited by Ellis, K.J., Yamamura, S. and Morgan, W.D. London: Institute of Physical Sciences in Medicine, 1987, p. 357-362.

Williamson, A.M. The development of a neurobehavioral test battery for use in hazard evaluations on occupational settings. *Neurotoxicology and Teratology* 12:509-514, 1990.

Acknowledgements

We would like to express our appreciation to the International Association of Bridge, Structural and Ornamental Iron Workers and the International Brotherhood of Painters and Allied Trades. Their help was instrumental in recruiting subjects for the study and in helping the research staff understand the work and exposures of these subjects. We would also like to make special note of the tireless efforts of Kathie Kelly-McNeil, our Research Coordinator, who made the project work from subject recruitment to the final report. Also, thanks is extended to the entire research staff for all their assistance and to Danielle LaVelle-McElwain and Joyce Kosmoski who helped prepare the report.

Planned Publications

Fiedler, N., McNeil, K., Gochfeld, M. Cognitive performance among lead and solvent exposed construction workers.

Fiedler, N. McNeil, K., Gochfeld, M., McWilliams, R. Sensory effects of neurotoxicant exposure and workplace conditions in the construction trades.

Wedeen, R., Fiedler, N., Gochfeld, M. Bone lead as a measure of chronic lead exposure in the construction trades.

Lynch, R., Eiring, J., Gochfeld, M. and Fiedler, N. Key parameters for estimating solvent exposure among professional painters.

Lynch, R., McNeil, K., Gochfeld, M. and Fiedler, N. Models for estimating lifetime exposure to solvents.

TABLE 1

CONSTRUCTION WORKER HEALTH STUDY

	LEAD*	SOLVENT, LEAD-SOLVENT, & CONTROL
PARTICIPATION		
	N	N
Mailed	715	1,950
Studied	67**	142
Excluded	149	184
Non-native English speaker	12	40
Head injury with LOC	34	22
Neurologic disorder	2	7
Learning disability	3	3
Psychiatric disorder	0	1
Substance use disorder***	5	1
<5 years exposure history	0	16
No work within last year	23	42
Educational level	4	5
Medical diagnosis	8	18
Quota met for group	57	0
No match for age & education	0	29
Refused	31	76
Work responsibilities	9	23
Decided not to participate	0	8
Didn't return message	7	17
Canceled	1	6
Could not contact	7	16
Too far to travel	7	4
No show	0	2

***includes New Jersey Department of Health (NJDOH) lead registry workers**
****1 Lead participant excluded for positive alcohol saliva**
*****Multiple drug abuse within the last year**

TABLE 2

ANALYSIS OF VARIANCE - YEARS OCCUPATION, BLOOD LEAD, AND BONE LEAD VALUES BASED ON OCCUPATIONAL GROUPS

Values	Ironworkers	Industrial/Structural Painters & Bridgeworkers	Painters	Drywallers/ Tapers	F	p
	N=66 Mean (SD) Median Range	N=62 Mean (SD) Median Range	N=37 Mean (SD) Median Range	N=43 Mean (SD) Median Range		
Years Occupation	24.2 (8.4) 25 6-43	20.8 (10.8) 20 3-45	17.9 (10.2) 15 2-45	20.8 (10) 20 3-44	3.48	.02
Bloodlead mcg/DL	8.6 (7.1) 6 2-34	11.7 (10.6) 7.5 2-57	4.5 (1.9) 4 2-9	3.8 (1.5) 4 2-8	13.81	.01
K-XRF Lead/Calcium Ratio	(N=65) 03 (.04) .01 0-.19	(N=45) .06 (.05) .05 0-.16	(N=7) .01 (.01) .01 0-.03	(N=12) .02 (.02) .004 0-.06	7.70	.01
ppm Wet Weight	4.9 (8.9) 2.1 0-57.1	8.9 (7.6) 7.9 0-4.5	2.2 (2.0) 1.7 0-5.2	2.4 (3.3) .59 0-10.5	3.98	.0001

TABLE 2 (cont'd.)

YEARS OCCUPATION, BLOOD LEAD, AND BONE LEAD VALUES BASED ON OCCUPATIONAL GROUPS

Values	Ironworkers	Industrial/Structural Painters & Bridgeworkers	Painters	Drywallers/ Tapers	F	p
ppm Dry* Weight	8.9 (16.1) 3.8 0-103.9	16.3 (13.9) 14.3 0-44.6	4.0 (3.7) 3.1 0-9.4	4.4 (6.1) 1.1 0-19.0	4.0	.0001
Non-detects - % (ratio) <1 ppm Wet Weight	42% (27/64)	24% (11/45)	43% (3/7)	50% (6/12)		

***Dry weight reading calculated from wet weight measurement X 1.82.**

TABLE 3

SUMMARY OF KEY INDUSTRIAL HYGIENE SAMPLING RESULTS

Painting Activity	Number of Samples	Mean Exposure mg/m3 as Hexane
Average Exposure to Control	64	2.3
Average Exposure to Painters	118	20.3
Average Exposure to Roller/ Brushers	96	19.0
Average Exposure to Sprayers	17	25.2
Average Indoor Exposure	96	22.3
Average Outdoor Exposure	23	14.3
Average Commercial/ Residential Exposure	92	20.2
Average Industrial/ Structural	23	14.7
Average Exposure to Oil Based Paint Solvents	50	30.6
Average Exposure to Latex Based Paint Solvents	50	2.8

Note: A total of 214 samples were obtained under various conditions. Each sample represents at least three conditions: indoor/outdoor, commercial/residential or industrial/structural, and oil or latex.

TABLE 4

SOLVENT EXPOSURE INDEX*
BASED ON OCCUPATIONAL GROUPS

Ironworkers	Industrial/Structural Painters & Bridgeworkers	Painters	Drywallers/ Tapers
N=9	N=61	N=30	N=6
Mean(S.D.)	Mean(S.D.)	Mean(S.D.)	Mean(S.D.)
Median	Median	Median	Median
Range	Range	Range	Range
205,657 (239,877)	478,081 (442,871)	431,385 (264,809)	279,134 (374,238)
102,691	366,859	444,022	124,232
5,815-680,340	8,459-2,036,736	25,512-11,37742	47,623-1,019,837

Note: Wilcoxon 2-Sample Test (Industrial/Structural Painters & Bridgeworkers and Painters), p=.72
***Values represent lifetime exposure in mg.**

TABLE 5

ANALYSIS OF VARIANCE - ALCOHOL AND DRUG USE FOR EXPOSURE GROUPS (LOG TRANSFORMED VALUES)

	LEAD N=38 Mean (S.D.) Range	LEAD/SOLVENT N=40 Mean (S.D.) Range	SOLVENT N=46 Mean (S.D.) Range	CONTROLS N=41 Mean (S.D.) Range	F	P
ALCOHOL						
TOTAL	9.04 (2.64) 0-11.99	8.26 (3.41) 0-11.66	8.51 (2.42) 0-11.44	8.55 (2.34) 0-11.50	.57	N.S.
PEAK PAST YEAR	3.29 (1.82) 0-6.84	2.73 (1.73) 0-5.51	3.26 (1.64) 0-6.8	3.45 (1.48) 0-6.6	1.43	N.S.
TOTAL LIFETIME PEAK CONSUMPTION	2.83 (4.51) 0-11.08	3.66 (4.59) 0-11.04	3.48 (4.45) 0-10.65	3.11 (4.43) 0-11.00	.27	N.S.
DRUGS	**N=13**	**N=17**	**N=24**	**N=20**		
LIFETIME PEAK DRUG INDEX	6.66 (1.82) 2.56-8.84	6.35 (2.13) 1.61-9.08	6.71 (1.92) 1.95-9.06	6.10 (1.41) 3.09-8.02	.48	N.S.

N.S.-Not significantly different

TABLE 6

ANALYSIS OF VARIANCE - DEMOGRAPHICS FOR EXPOSURE GROUPS

	LEAD N=38 Mean (SD) Median Range	LEAD/SOLVENT N=40 Mean (SD) Median Range	SOLVENT N=48 Mean (SD) Median Range	CONTROLS N=42 Mean (SD) Median Range	F	p
Age	47.1 (8.7) 48 26-63	45.6 (10.3) 45 27-62	43.6 (10.3) 40.5 24-62	43.7 (9.4) 40 30-65	1.19	N.S.
Years Education	12.5 (1.4) 12 9-16	12.2 (1.1) 12 10-15	12.4 (1.6) 12 9-18	12.4 (1.3) 12 10-18	.36	N.S.
Wide Range Achievement Test-Standard Score (WRAT)	91.2 (12.9) 92 62-115	91.6 (16.6) 93.5 50-118	88.6 (14.8) 90 46-116	87.9 (15.0) 89.5 48-116	.65	N.S.
Intelligence Quotient (IQ)*	**(N=15)** 94.2 (14.6) 93 63-124	**(N=11)** 94.5 (13.2) 96 78-113	**(N=19)** 88.9 (12.6) 89 56-118	**(N=20)** 95.7 (17.5) 96.5 65-140	.77	N.S.

TABLE 6 (cont'd.)

ANALYSIS OF VARIANCE-DEMOGRAPHICS FOR EXPOSURE GROUPS

	LEAD % (ratio)	LEAD/SOLVENT % (ratio)	SOLVENT % (ratio)	CONTROLS % (ratio)	p
Gender					
Male (N=64)	100 (38/38)	100 (40/40)	95.8 (46/48)	95.2 (40/42)	N.S.**
Female (N=4)	0 (0/38)	0 (0/38)	4.2 (2/48)	4.8 (2/42)	
Race					
Caucasian (N=149)	89.5 (34/38)	82.5 (33/40)	87.5 (42/48)	95.2 (40)	N.S.**
Black (N=10)	5.3 (2/38)	12.5 (5/40)	2.1 (1/48)	4.8 (2)	
Other (N= 9)	5.3 (2/38)	5.0 (2/40)	10.4 (5/48)	0 (0)	

***Pre-exposure values obtained from school records**
****Fisher's Exact Test**
N.S.-Not significantly different

TABLE 7

ANALYSIS OF VARIANCE - YEARS OCCUPATION, BLOOD, AND BONE LEAD FOR EXPOSURE GROUPS

Values	LEAD	LEAD-SOLVENT	SOLVENT	CONTROL	F	p
	N=38 Mean (SD) Median Range	N=40 Mean (SD) Median Range	N=48 Mean (SD) Median Range	N=42 Mean (SD) Median Range		
Years Occupation	24.8 (8.8) 25.5 6-44	23.2 (11.5) 20 5-45	20.2 (10.2) 18.5 5-45	18.8 (9.4) 18.8 2-40	3.02	.03
Bloodlead mcg/DL	8.3 (7.6) 5.5 2-34	13.3 (12.1) 7.5 2-57	5.8 (4.3) 5 2-26	4 (1.5) 4 2-8	12.44	.0001
K-XRF Lead/Calcium Ratio	(N=38) 04 (.04) .04 .007-.19	(N=37) .07 (.04) .06 .017-.16	(N=14) .001 (.002) .001 0-.005	(N=7) 0 (0) 0 0-0	16.28	.0001
ppm Wet Weight	7.9 (10.4) 5.4 1.0-57.1	10.7 (6.3) 9.2 2.9-23.8	.2 (.26) 0 0-.79	.08 (.2) 0 0-.57	8.69	.0001

TABLE 7 (cont'd.)

ANALYSIS OF VARIANCE - YEARS OCCUPATION, BLOOD, AND BONE LEAD FOR EXPOSURE GROUPS

Values	LEAD	LEAD-SOLVENT	SOLVENT	CONTROL	F	p
ppm Dry*	14.42 (18.96)	19.54 (11.37)	.23 (4.8)	.15 (.39)	8.69	.0001
Weight	9.89	16.78	0	0		
	1.89-103.89	5.44-43.30	0-1.44	0-1.04		
Non-detects - %(ratio) <1 ppm Wet Weight	0% (0/38)	0% (0/37)	100% (14/14)	100% (7/7)		

***Dry weight reading calculated from wet weight measurement X 1.82**

TABLE 8

SOLVENT EXPOSURE INDEX

	SOLVENT N=48	LEAD/SOLVENT N=39
MEAN (S.D.)	427,331 (267885)	525,620 (507664)
MEDIAN	433,653	301,348
RANGE	35,411-1,137,742	20,379-2,036,736

Notes:

- Wilcoxon 2-sample test, p=.91.
- Three Drywall/Tapers reclassified to Solvent (N=2) and Lead/Solvent (N=1); 6 Ironworkers reclassifed to Solvent (N=3) and Lead/Solvent (N=3).

TABLE 9

Mean ± SE for Lead, Solvent, Lead/Solvent & Control Groups of Construction Workers Based on *a priori* Grouping

	Lead N=66	Solvent N=37	Lead/Solvent N=62	Controls N=43	Kruskal-Wallis p=
GGTP[a]	45.3 ± 8.59	64.2 ± 29.3	54.5 ± 16.2	43.1 ± 8.64	.68
BUN	15.2 ± 0.53	15.5 ± 0.57	16.3 ± 0.56	16.2 ± 0.62	.42
Creat	1.4 ± 0.34	1.0 ± 0.22	1.0 ± 0.02	1.03 ± 0.02	.46
RBC	4.97 ± 0.05	4.94± 0.56	4.92± 0.06	5.06 ± 0.05	.37
Hgb	15.3 ± 0.11	15.1 ± 0.14	15.3± 0.15	15.4 ± 0.41	.22
Hct	45.0 ± 0.35	44.4 ± 0.37	45.7± 0.85	45.2 ± 0.43	.31
Systolic	132 ± 1.67	127 ± 2.48	130 ± 2.17	127 ± 1.84	.21
Diastolic	84 ± 1.11	81 ± 1.19	83 ± 1.32	83 ± 1.41	.55

Mean ± SE for Lead, Solvent, Lead-Solvent and Control Groups of Construction Workers Based on *a posteriori* Grouping. Reclassification Based on Exposure Data and Deletion of Persons with Heavy Alcohol or Drug Use

	Lead N=38	Solvent N=48	Lead/Solvent N=40	Controls N=42	Kruskal-Wallis p=
GGTP[a]	52.4 ±13.49	33.5 ± 4.21	63.0 ± 24.7	65.3 ± 27.5	.76
BUN	15.2 ± 0.74	17.2 ± 0.53	15.3 ± 0.67	16.4 ± 0.60	.17
Creat	1.1 ± 0.03	1.0 ± 0.03	1.0 ± 0.02	1.05 ± 0.02	.041
RBC	4.86± 0.06	4.93± 0.05	4.95± 0.07	5.09 ± 0.05	.05
Hgb	15.0 ± 0.16	15.3 ± 0.14	15.3± 0.08	15.5 ± 0.15	.191
Hct	43.9 ± 0.44	45.5 ± 0.93	44.9 ± 0.47	45.5 ± 0.45	.083
Systolic	130 ± 2.13	126 ± 2.21	133 ± 2.43	126 ± 1.87	.079
Diastolic	83 ± 1.37	82 ± 1.24	84 ± 1.51	82 ± 1.38	.65

Notes:

GGTP=gamma glutamyl transpeptidase
BUN=blood urea nitrogen
Creat=serum creatinine
Hgb=hemoglobin
Systolic=Average of four systolic blood pressure readings (right and left arm, sitting and reclining)
Diastolic=Average of four diastolic blood pressure readings (right and left arm, sitting and reclining)
a: Two high outliers of 1136 (solvent) and 993 (lead/solvent) elevate these means.

TABLE 10

Pairwise Comparison of *a posteriori* Groups versus Controls, and all Lead versus all Non-Lead and all Solvent versus all Non-Solvent.

	Lead/Solvent vs Controls	Solvent vs. Control	Lead vs Control	All Lead vs. All Non-Lead	All Solvent vs. All Non-Solvent
GGT	.21	.26	.71	.95	.34
BUN	.98	.72	.14	.03*	.64
Creatinine	.86	.11	.36	.19	.01*
RBC	.19	.04*	.007**	.25	.78
Hemoglobin	.92	.21	.03	.24	.98
Hematocrit	.83	.19	.012	.22	.72
Ave Systolic	.54	.65	.118	.01	.93
Ave Diastolic	.98	.86	.47	.21	.92

TABLE 11

Relationship of Clinical Chemistry Values to Bone Lead, Solvent, Alcohol Exposure and Age for all Groups.

Top of table shows multivariate regression; bottom shows univariate regression. All using SAS GLM Procedure and Type III Models.

----------Multivariate Regression Models----------

Variable	Overall Model r-sq	p=	Bonelead p=	Solvent p=	Total EtOh p=	Peak EtOH p=	Age p=
GGTP	.088	.47	.046	.33	.82	.48	.99
BUN	.176	.09	.120	.032	.88	.095	.50
Creat	.178	.09	.24	.109	.056	.88	.94
RBC	.054	.74	.36	.17	.61	.96	.32
Hct	.043	.83	.74	.44	.41	.52	.43
Hgb	.077	.55	.47	.43	.38	.25	.51
Avgsyst	.217	.04	.57	.42	.63	.11	.015
Avgdias	.155	.16	.80	.23	.68	.23	.079

Variable	---Age--- r-sq	p=	-----Alcohol Total---- r-sq	Total p=	Peak p=	-----Solvent--- r-sq	p=	----Bone Lead--- r-sq	p=
GGTP	.001	.59	.08	.001	.69	.0001	.88	.0014	.85
BUN	.0005	.75	.04	.096	.17	.020	.15	.0001	.98
Creat	.013	.10	.009	.42	.37	.038	.044	.002	.54
RBC	0.020	.045	.004	.47	.55	.011	29	.0001	.94
Hct	0.011	.13	.012	.52	.34	.001	.70	.013	.21
Hgb	.006	.26	.045	.14	.094	.0004	.85	.017	.14
Avgsyst	.166	.0001	.043	.02	.65	.090	.002	.020	.05
Avgdias	.074	.0001	.038	.02	.81	.090	.002	.012	.22

GGTP=gamma glutamyl transpeptidase
BUN=blood urea nitrogen
Creat=serum creatinine
RBC=Red blood cell count
Hct=hematocrit (packed red cell volume)
Hgb=hemoglobin
Avgsyst=Mean of sitting and reclining systolic pressure in both arms
Avgdias=Mean of sitting and reclining diastolic pressure in both arms

TABLE 12

Frequency Cross Tabulations of Systolic and Diastolic Hypertension among Exposure Groups

A priori Group Assignments

	Average Systolic Pressure		Average Diastolic Pressure	
	Normal	Elevated	Normal	Elevated
Lead	46	20	47	19
Solvent	30	8	32	6
Lead/Solvent	45	17	44	18
Control	34	9	33	10
	Chi Square 1.76 p = .63		Chi Square = 2.79 p = .43	

A posteriori Group Assignments

	Systolic Pressure		Diastolic Pressure	
	Normal	Elevated	Normal	Elevated
Lead	29	12	30	11
Solvent	44	10	43	11
Lead/Solvent	29	16	29	16
Control	34	8	35	7
	Chi Square 5.03 p = .17		Chi Square = 4.94 p = .18	

The 4 x 2 tables (df=3), showed no significant association between the four groups and hypertension for either the a priori or a posteriori analyses. We then compared all of the lead-exposed workers (LEAD and LEAD/SOLVENT) groups versus all of the non-lead exposed (SOLVENT and CONTROL groups). Likewise we compared all of the solvent exposed workers (SOLVENT and LEAD/SOLVENT) in one run and all of the lead exposed workers (LEAD and LEAD/SOLVENT) versus non-lead (SOLVENT and CONTROLS) in another run.

	Systolic Pressure		Diastolic Pressure	
	Normal	Elevated	Normal	Elevated
All lead[a]	58	28	59	27
Non-Lead[b]	78	18	78	18
	Chi Square = 4.58 p=.032		Chi Square = 3.90 p=.048	
All Solvent[c]	73	26	72	27
Non-Solvent[d]	63	20	65	18
	Chi Square 0.11 p=.74		Chi Square =.76 p=.39	

a: Lead and Lead/solvent group combined
b: Solvent and Control groups combined
c: Solvent and Lead/Solvent groups combined
d: Lead and Control groups combined.

TABLE 13

ANALYSiS OF VARIANCE - MEASURES OF ATTENTION/CONCENTRATION

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	F	p
	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range		
ATTENTION/CONCENTRATION						
Simple Reaction Time*	**(N=38)**	**(N=40)**	**(N=47)**	**(N=42)**		
Dominant	267.76 (67.29) 251 184-592	266.23 (40.36) 260.5 204-379	263.26 (40.69) 258 210-391	263.71 (47.46) 258.5 206-508	.66	N.S.**
Non-Dominant	277.64 (58.34) 262.5 222-534	286.69 (63.20) 273 222-527	277.04 (44.53) 267 219-382	273.79 (36.37) 273.5 208-347	.94	N.S.**
Auditory Reaction Time*	**(N=32)**	**(N=38)**	**(N=43)**	**(N=39)**		
Dominant	274.58 (70.20) 251.69 100.49-497.83	294.91 (66.99) 277.76 178.59-425.44	277.04 (72.67) 255.84 205.37-582.45	281.39 (69.30) 271.19 188.25-501.86	2.63	N.S.**
Non-Dominant	273.26 (69.90) 248.31 177.58-507.07	285.32 (69.43) 269.54 173.27-512.77	263.05 (47.07) 252.79 205.18-401.21	258.32 (47.36) 256.85 183.33-423.09	2.63	N.S.**

TABLE 13 (cont'd.)

ANALYSIS OF VARIANCE - MEASURES OF ATTENTION/CONCENTRATION

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	F	p
Paced Auditory Serial Addition Test*						
	(N=37)	(N=39)	(N=41)	(N=45)		
Total Errors	94.59 (35.83) 94 40-180	84.05 (34.79) 82 28-153	75.56 (31.91) 70 7-145	79.66 (31.11) 76 26-154	2.39	.07
Trial 1 Errors	18.27 (12.85) 18 1-42	16.08 (12.30) 14 0-45	11.44 (9.73) 8 0-32	12.63 (10.13) 9 0-37	7.25	.06**
Trial 2 Errors	22.28 (10.48) 22 3-46	19.55 (10.33) 18.5 5-40	16.67 (9.02) 15 2-35	17.73 (9.60) 18 0-40	2.44	.07
Trial 3 Errors	25.47 (8.93) 26 5-44	21.70 (8.63) 22 6-39	20.27 (9.42) 20 0-39	21.98 (9.22) 23 3-45	2.28	.08
Trial 4 Errors	30.69 (7.30) 31 15-49	28.76 (7.86) 30 11-45	27.18 (8.52) 27 3-46	27.56 (7.51) 28 12-46	1.57	.20

*** Lower score indicates better performance**
****Kruskal-Wallis Chi-Square Approximation**
N.S.-Not significantly different

TABLE 14

ANALYSIS OF VARIANCE - MEMORY TESTS-TOTAL SCORES

	LEAD (N=38) Mean (SD) Median Range	LEAD/SOLVENT (N=40) Mean (SD) Median Range	SOLVENT (N=48) Mean (SD) Median Range	CONTROL (N=42) Mean (SD) Median Range	F	p
MEMORY						
Symbol Digit Substitution-Average Latency (msec)*+	2.79 (.50) 2.86 1.84-4.02	2.77 (.51) 2.74 1.91-4.09	2.59 (.48) 2.56 1.68-3.57	2.56 (.40) 2.47 1.88-3.54	2.63	.05.**
California Verbal Learning Test Raw Score	42.82 (8.02) 43 28-61	42.75 (10.26) 43 22-64	40.13 (11.00) 41 10-65	45.88 (7.58) 45 32-63	2.79	.04
Continuous Visual Memory Test Total Score	72.42 (7.45) 73.5 50-87	69.35 (7.35) 70 55-84	72.90 (5.88) 73 55-86	70 (6.25) 69 58-83	2.90	.04
Rey-Osterrieth Complex Figure Delay Raw Score	35 (14.29) 34.5 0-56	36.6 (13.58) 40 0-62	33.72 (13.06) 34 4-59	35.45 (10.48) 37 8-59	.37	N.S.**

*** Lower score indicates better performance**
****Kruskal-Wallis Chi-Square Approximation**
+No data for 1 Lead/Solvent and 2 Solvent
N.S. - Not significantly different

TABLE 15

ANALYSIS OF VARIANCE - MEMORY TEST SUBSCORES

	LEAD (N=38) Mean (SD) Median Range	LEAD/SOLVENT (N=40) Mean (SD) Median Range	SOLVENT (N=48) Mean (SD) Median Range	CONTROL (N=42) Mean (SD) Median Range	F	p
MEMORY						
California Verbal Learning Test Raw Scores						
List A Trial 1	6.23 (1.68) 6 3-10	6.2 (2.00) 6 3-10	5.71 (1.64) 6 2-9	6.5 (1.67) 6.5 4-11	4.3	N.S.*
List A Trial 5	10.37 (2.15) 10.5 6-15	10.28 (2.36) 10 5-15	9.28 (3.29) 9.5 .5-16	10.95 (2.22) 11 7-15	7.9	.05*
List B	6.21 (1.9) 6 2-10	5.93 (1.83) 6 3-11	5.38 (1.76) 5 1-10	5.29 (1.97) 5 2-10	7.2	.06*
List A Short-Delay Free Recall	8.5 (2.51) 8 5-14	8.7 (3.24) 8 0-15	8.06 (2.86) 8 1-16	8.83 (2.70) 9 3-14	.64	N.S.

TABLE 15 (cont'd.)

ANALYSIS OF VARIANCE-MEMORY TEST SUBSCORES

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	F	p
List A Short-Delay Cued Recall	9.39 (2.39) 9 5-15	10.25 (2.52) 11 7-16	9.33 (3.09) 10 0-16	10.36 (2.38) 11 5-14	1.81	N.S
List A Long-Delay Free Recall	8.5 (2.66) 8.5 3-15	9.13 (2.93) 9 4-15	8.5 (3.22) 9 0-16	9.43 (2.90) 10 0-14	1.05	N.S.
List A Long-Delay Cued Recall	9.37 (2.40) 9.5 4-16	9.6 (3.07) 10 0-16	9.19 (3.06) 9 3-16	10.5 (2.54) 11 4-15	1.86	N.S.
Perseverations (Free and Cued Recall Totals)	5.95 (6.44) 4 0-29	5.65 (4.24) 4 0-20	6.90 (6.30) 5.5 0-32	7.36 (6.74) 5.5 0-29	1.91	N.S.*
Intrusions (Free and Cued Recall Totals)	4.68 (3.97) 4 0-16	5.25 (5.48) 4.5 0-29	5.15 (4.80) 4 0-20	4.14 (4.51) 3 0-19	2.30	N.S*
Continuous Visual Memory Test Raw Scores						
Hits	36.39 (3.23) 37 28-41	37.53 (3.38) 38 29-42	36.79 (2.88) 37 29-41	36.24 (4.73) 37.5 16-42	3.20	N.S.*

TABLE 15 (cont'd.)

ANALYSIS OF VARIANCE - MEMORY TEST SUBSCORES

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	F	p
False Alarms	18.76 (6.33) 18 10-35	22.2 (8.02) 21 8-40	17.90 (6.18) 17 5-40	19.98 (7.44) 20 1-38	7.66	.05*
d-Prime	1.62 (.59) 1.64 .17-3.09	1.66 (.48) 1.64 .53-2.49	1.69 (.41) 1.62 1.05-2.57	1.59 (.48) 1.59 .67-3.29	.31	N.S.
Delayed Recognition	3.79 (1.26) 4 2-6	3.9 (1.65) 3.5 1-7	3.80 (1.59) 4 1-7	3.38 (1.40) 3 1-6	.99	N.S.
Rey-Osterrieth Complex Figure Test						
Copy Raw Score	64.63 (6.21) 66.5 46-72	64.2 (7.86) 65.5 24-72	63.30 (6.40) 64 40-72	62.10 (8.95) 65 26-72	.92	N.S.
Immediate Raw Score	35.92 (14.36) 37 0-61	37.05 (14.25) 38 2-63	34.64 (13.74) 34 1-60	36.26 (11.19) 37.5 5-65	.25	N.S.

***Kruskal-Wallis Chi Square Approximation**
N.S.-Not significantly different

TABLE 16

ANALYSIS OF VARIANCE - HEARING TESTS

HEARING	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	Kruskal-Wallis Chi Square	p
	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range		
	(N=35)	(N=39)	(N=46)	(N=41)		
Hearing Threshold (dB) for Normal Frequency Range*:						
Right Ear	19.62 (13.33) 18.33 0-50	22.01 (16.95) 15 0-71.67	16.85 (11.35) 15 (-5)-60	14.31 (9.97) 11.67 (-1.67)-40	4.68	N.S.
Left Ear	25.24 (16.22) 21.67 5-56.67	22.44 (16.90) 16.67 0-68.33	15.51 (9.55) 15 3.33-48.33	18.05 (14.88) 15 0-55	7.79	.05
SCAN-A: Competing Words Raw Score**	(N=34) 47.29 (6.36) 48 32-59	(N=38) 48.03 (7.97) 50 26-58	(N=46) 46.41 (6.67) 47.5 26-56	(N=40) 46.43 (6.78) 47 27-55	3.04	N.S.

***Lower score indicates better performance**
****SCAN-A: A Test for Auditory Processing Disorders in Adolescents and Adults**
N.S.-Not significantly different

TABLE 17

ANALYSIS OF LANTHONY D-15 TEST

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	Kruskal-Wallis Chi Square	p
	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range		
VISION						
Color Vision	(N=32)	(N=27)	(N=42)	(N=31)		
Right Eye						
Color Confusion Index	1.36 (.54) 1.17 1.0-3.23	1.37 (.35) 1.35 1.0-2.19	1.32 (.35) 1.25 1.0-2.63	1.40 (.48) 1.25 1.0-3.23	1.23	N.S.
Total Errors	76.96 (30.33) 66.10 56.40-182.37	77.43 (19.88) 76.39 56.40-123.73	74.32 (19.82) 70.55 56.40-148.25	78.97 (27.08) 70.37 56.40-182.0	1.23	N.S.
Minor Errors	2.25 (2.26) 2 0-8	3.44 (2.74) 4 0-9	3 (2.44) 2 0-9	3.32 (2.64) 2 0-11	4.21	N.S.
Major Errors	2.66 (4.36) 0 0-13	2.26 (3.0) 1 0-10	2 (3.26) 0 0-13	2.06 (3.83) 0 0-15	.93	N.S.

TABLE 17 (cont'd.)

ANALYSIS OF LANTHONY D-15 TEST

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	Kruskal-Wallis Chi Square	p
Left Eye						
Color Confusion Index	1.40 (.46) 1.25 1.0-2.82	1.46 (.49) 1.18 1.0-2.59	1.40 (.40) 1.31 1.0-2.43	1.34 (.30) 1.28 1.0-1.96	.07	N.S.
Total Errors	78.77 (25.73) 70.23 56.40-158.98	82.34 (27.90) 66.50 56.40-145.98	78.86 (22.80) 73.66 56.40-137.25	75.70 (16.66) 72.08 56.40-110.74	.07	N.S.
Minor Errors	3 (2.36) 3 0-9	3.48 (2.91) 3 0-9	3.10 (2.74) 2 0-11	3.58 (2.41) 4 0-9	1.54	N.S.
Major Errors	2.5 (4.02) 0 0-12	2.41 (3.35) 0 0-12	2.64 (4.18) 0 0-14	2.35 (3.43) 0 0-12	.07	N.S.

Note: Lower scores indicate better performance
N.S.-Not significantly different

TABLE 18

SOLVENT EXPOSED/CONTROL MATCHED PAIRS ANALYSIS OF CONTRAST SENSITIVITY

		Mean Difference	Standard Deviation	Wilcoxon Sign Rank p
Contrast Sensitivity				
Patch A (1.5 cpd*):	**right eye**	5.07	30.11	N.S.
	left eye	5.75	31.66	N.S.
Patch B (3.0 cpd*):	**right eye**	13.64	50.61	N.S.
	left eye	14.71	39.01	.03**
Patch C (6.0 cpd*):	**right eye**	1.21	51.66	N.S.
	left eye	-1.17	61.59	N.S.
Patch D (12.0 cpd*):	**right eye**	4.39	44.03	N.S.
	left eye	4.46	44.34	N.S.
Patch E (18.0 cpd*):	**right eye**	-5.04	20.91	N.S.
	left eye	6.75	23.74	.08**

*** Cycles per degree**
****Difference score indicates that controls performed better**
N.S.-Not significantly different

TABLE 19

ANALYSIS OF VARIANCE - MOTOR TESTS

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	F	p
	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range	Mean (SD) Median Range		
MOTOR SKILLS						
Dynamometer-Highest Score	**(N=34)**	**(N=40)**	**(N=46)**	**(N=42)**		
Dominant (kg)	52.68 (9.72) 55 23-68	53.61 (10.52) 51.5 38-80	49.94 (9.84) 52 18.2-70	48.88 (9.38) 50.5 26-66	1.16	N.S.*
Non-Dominant (kg)	51.06 (9.35) 52 22-64	50.68 (10.71) 52 30-80	48.65 (10.01) 48 20-69	50.83 (10.15) 52 32-70	.61	N.S.
Finger Tapping	**(N=38)**	**(N=40)**	**(N=48)**	**(N=42)**		
Dominant	174.32 (34.0) 175.5 92-264	164.5 (33.42) 165.5 55-220	182.96 (45.64) 175.5 82-326	163.21 (33.74) 165.5 55-212	4.65	N.S.
Non-Dominant	161.68 (31.67) 164.5 87-253	158.5 (34.14) 158.5 65-218	162.48 (32.12) 156.5 74-242	154.74 (35.72) 151.5 76-269	.48	N.S.
Alternating	207.66 (54.89) 210.5 87-331	211.73 (59.52) 222.5 29-315	217.06 (52.67) 217 93-325	216.19 (51.65) 214 103-305	.26	N.S.

TABLE 19 (cont'd.)

ANALYSIS OF VARIANCE - MOTOR TESTS

	LEAD	LEAD/SOLVENT	SOLVENT	CONTROL	F	p
Grooved Pegboard**						
Dominant	73.62 (11.84)	75.86 (16.68)	70.65 (10.28)	73.95 (11.60)	2.97	N.S*
	71.75	72	69.5	72		
	59-107	52-140	54-100	56-107		
Non-Dominant	80.28 (14.49)	79.65 (17.24)	74.32 (11.80)	75.13 (12.61)	5.44	N.S.*
	79	75.5	73	72		
	63-144	55-130	56-108	55-120		

***Kruskal-Wallis Chi-Square Approximation**
****Lower score indicates better performance**
N.S.-Not significantly different

TABLE 20

ANALYSIS OF VARIANCE-SCL-90-R* PRIMARY SYMPTOM DIMENSIONS AND GLOBAL INDICES OF DISTRESS

	LEAD N=37 Mean (SD) Median Range	LEAD/SOLVENT N=40 Mean (SD) Median Range	SOLVENT N=48 Mean (SD) Median Range	CONTROLS N=42 Mean (SD) Median Range	F	p
SCL-90-R Raw Scores**						
Somatization	.499 (.57) 0 0-1.86	.55 (.40) 0 0-.43	.65 (.50) .59 0-2.33	.49 (.38) .42 0-1.67	1.15	N.S.
Obsessive-Compulsive	.74 (.66) .6 0-3.8	.78 (1.14) .45 0-7	.64 (.5) .5 0-2.5	.51 (.48) .35 0-1.7	1.07	N.S.
Interpersonal Sensitivity	.37 (.36) .22 0-1.33	.43 (.45) .22 0-2.11	.45 (.56) .33 0-3	.27 (.29) .17 0-1.33	1.51	N.S.
Depression	.50 (.58) .38 0-2.84	.41 (.36) .38 0-1.54	.47 (.43) .32 0-1.53	.35 (.39) .23 0-1.85	.87	N.S.
Anxiety	.34 (.48) .2 0-2	.30 (.35) .2 0-1.6	.38 (.43) .25 0-2.1	.24 (.30) .1 0-1	1.02	N.S.

TABLE 20 (cont'd.)

ANALYSIS OF VARIANCE-SCL-90-R* PRIMARY SYMPTOM DIMENSIONS AND GLOBAL INDICES OF DISTRESS

	LEAD N=37 Mean (SD) Median Range	LEAD/SOLVENT N=40 Mean (SD) Median Range	SOLVENT N=48 Mean (SD) Median Range	CONTROLS N=42 Mean (SD) Median Range	F	p
Hostility	.44 (.56) .17 0-2.16	.36 (.39) .17 0-1.67	.41 (.46) .17 0-1.5	.32 (.47) .17 0-2.17	.48	N.S.
Phobic Anxiety	.19 (.37) 0 0-1.86	.07 (.12) 0 0-.43	.11 (.26) 0 0-1.43	.06 (.17) 0 0-.86	2.06	N.S.
Paranoid Ideation	.39 (.45) .33 0-1.83	.40 (.55) .25 0-3	.50 (.55) .33 0-2.3	.33 (.40) .17 0-1.66	.93	N.S.
Psychoticism	.25 (.33) .1 0-1.2	.18 (.24) .1 0-1.1	.25 (.26) .2 0-1.2	.17 (.25) .1 0-.9	1.03	N.S.
Global Severity Index (GSI)	.43 (.42) .3 0-2.11	.39 (.31) .34 .04-1.36	.45 (.38) .38 .02-1.7	.33 (.31) .26 0-1.18	.94	N.S.

TABLE 20 (cont'd.)

ANALYSIS OF VARIANCE-SCL-90-R* PRIMARY SYMPTOM DIMENSIONS AND GLOBAL INDICES OF DISTRESS

	LEAD N=37 Mean (SD) Median Range	LEAD/SOLVENT N=40 Mean (SD) Median Range	SOLVENT N=48 Mean (SD) Median Range	CONTROLS N=42 Mean (SD) Median Range	F	p
Positive Symptom Distress Index (PSDI)	1.29 (.43) 1.17 0-2.75	1.38 (.41) 1.29 1-3	1.46 (.78) 1.25 1-6	1.20 (.39) 1.20 0-2	1.85	N.S.
Positive Symptom Total (PST)	26.54 (17.64) 24 0-69	25.10 (17.61) 20.5 .11-65	27.41 (20.13) 20.5 .47-73	22.07 (16.67) 17.5 0-66	.72	N.S.

*** Symptom Check List-90-Revised**
****Lower scores indicate less symptomatology**
N.S.-Not significantly different

TABLE 21

LONGITUDINAL FOLLLOW UP OF LEAD AND CONTROL GROUPS

K-XRF*				
			Sign Rank	Spearman's
Time 1 N=13 Mean (SD) Median Range	Time 2 N=13 Mean (SD) Median Range	Difference N= 12 Mean (SD) Median Range	p**	r
9.67(9.53) 9.18 0 - 35.00	6.29 (4.70) 8.51 0 - 12.72	4.44 (8.5) 0.58 -1.8 - 28.6	0.03	0.58

Notes:

* ppm Wet Weight

**Wilcoxon

TABLE 22

BLOOD LEAD RESULTS FOR RE-EVALUATION GROUPS

	LEAD			CONTROL			
	Time 1 Mean (SD)	Time 2 Mean (SD)	Difference Mean (SD)	Time 1 Mean (SD)	Time 2 Mean (SD)	Difference Mean (SD)	p*
Blood Lead (dL)	6.5 (4.3)	6.4 (3.7)	.09 (1.9)	3.9 (1.6)	3.7 (2.0)	.2 (1.1)	N.S.

*Wilcoxon (Time X Group)
N.S. - Not significantly different

TABLE 23

DEMOGRAPHICS FOR RE-EVALUATION GROUPS

	LEAD N=11 Mean (SD) Range	CONTROLS N=10 Mean (SD) Range	p*
Age	51.4 (8.3) 36-62	50.0 (9.9) 35-65	N.S.
Years Education	13.2 (1.8) 12-16	12.3 (0.7) 12-14	N.S.
Wide Range Achievement Test-Standard Score (WRAT)	99.4 (9.9) 85-115	92.4 (8.5) 81-106	N.S.
ALCOHOL INDICES			
Total	9.5 (2.4) 4.2-12.0	8.8 (1.9) 5.4-11.0	N.S.**
Peak - Past Year	3.2 (1.7) 0-5.3	3.1 (1.3) 1.6-6.4	N.S.**
Total Lifetime Peak Consumption	4.7 (5.4) 0-11.1	7.5 (4.1) 0-11.0	N.S.**

*** Wilcoxon Rank Sum**
****Wilcoxon Rank Sum of log transform**
N.S.-Not statistically significantly different

TABLE 24

NEUROBEHAVIORAL RESULTS FOR RE-EVALUATION GROUPS

	LEAD			CONTROL			
	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	p[1]
MOTOR SKILLS							
Dynamometer-Highest Score							
Dominant	51.0 (7.0) 40-60	51.1 (8.3) 40-64	-.2 (6.0) -6-16	47.5 (11.3) 32-70	46.8 (13.4) 29-72	.70 (6.4) -8-14	N.S.
Non-Dominant	50.2 (8.3) 36-64	46.5 (6.6) 36-60	3.7 (7.6) -9-14	45.1 (10.5) 26-60	45.2 (15.0) 10-70	-.1 (9.5) -14-20	N.S.
Finger Tapping							
Dominant	162.5 (50.7) 55-221	186.2 (64.2) 62-309	-23.7 (51.6) -102-68	143.5 (54.4) 55-212	189 (28.2) 131-224	-45.5 (73.9) -164-21	N.S.
Non-Dominant	159.4 (47.7) 65-222	162 (37.4) 109-226	-2.6 (31.2) -63-43	148.3 (41.5) 80-204	165.5 (18.9) 122-189	-17.2 (37.8) -87-34	N.S.
Alternating	179.8 (86.5) 29-314	197.4 (55.2) 96-324	-17.6 (68.7) -168-39	221 (69.7) 103-302	200.6 (49.9) 152-314	20.4 (58.7) -71-119	N.S.
Grooved Pegboard++							
Dominant	77.1 (12.1) 59-96	75.5 (11.4) 64-99	1.6 (7.7) -10-17	86.1 (12.0) 73-107	92.5 (26.4) 64-158	-6.4 (25.3) -69-20	N.S.

TABLE 24 (cont'd.)

NEUROBEHAVIORAL RESULTS FOR RE-EVALUATION GROUPS

	LEAD			CONTROL			
	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	p[1]
Non-Dominant	78.9 (9.9) 64-95	77.8 (10.6) 62-93	1.1 (8.9) -10.5-15	86.8 (16.0) 64-120	84.4 (13.4) 60-104	2.4 (12.8) -14-23	N.S.
MEMORY							
Symbol Digit Substitution-Average Latency (msec)++	2.6 (.4) 2.2-3.3	2.6 (.4) 2.1-3.4	.04 (.3) -.3-.5	2.9 (.5) 2.1-3.5	2.8 (.5) 2.1-3.7	.1 (.5) -.9-.9	N.S.
California Verbal Learning Test Raw Score	42.2 (8.7) 31-61	45.9 (10.3) 32-63	-3.7 (10.1) -25-12	43.5 (6.0) 37-55	47.4 (8.9) 35-62	-3.9 (5.5)* -13-4	N.S.
Continuous Visual Memory Test Total Score	73.8 (8.0) 59-85	70.6 (13.2) 39-83	3.3 (14.9) -25-12	70.7 (6.6) 58-80	71.7 (8.1) 55-79	-1 (4.8) -10-5	N.S.
Rey-Osterrieth Complex Figure							
Delay Raw Score	33.1 (16.6) 0-56	39.5 (15.2) 20-65	-6.4 (10.4) -20-13	33 (13.4) 8-51	42.5 (9.1) 24-52	-9.5 (10.1)** -26-4	N.S.
Copy Raw Score	65.91 (7.58) 46-72	62.6 (7.5) 50-69	3.4 (5.3) -6-14	64.1 (4.0) 56-70	61 (7.2) 45-68	3.1 (4.4)* -3-11	N.S.

TABLE 24 (cont'd.)

NEUROBEHAVIORAL RESULTS FOR RE-EVALUATION GROUPS

	LEAD			CONTROL			
	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	p[1]
Immediate Raw Score	35.7 (18.1) 0-61	41 (13.3) 20-61	-5.3 (11.9) -21-14	32.3 (12.9) 5-52	40.5 (10.3) 26-56	-8.2 (9.0)** -23-3	N.S.
ATTENTION/CONCENTRATION							
Simple Reaction Time++							
Dominant	274.6 (57.1) 226-375	250.5 (31.4) 208-316	24.1 (38.2) -17-93	286.5 (83.5) 206-508	256.1 (27.4) 218-312	30.4 (95.8) -38-290	N.S.
Non-Dominant	268.5 (35.9) 229-347	279.5 (69.3) 212-458	-11 (61) -170-80	282.1 (38.3) 210-331	279.9 (65.6) 214-450	2.2 (68.4) -133-117	N.S.
Auditory Reaction Time++							
Dominant	280.2 (42.1) 219.4-343.2	265.6 (61.5) 186.3-383.7	14.6 (73.6) -133.6-85.2	260.9 (35.3) 194.6-312.9	285.2 (58.8) 210.2-396.5	-24.3 (6) -133.6-85.2	N.S.
Non-Dominant	306.3 (59.9) 224.0-378.3	272.1 (59.9) 199.6-379.1	34.2 (104.6) -138.9-157.3	275.8 (46.5) 215.0-366.0	315.8 (76.9) 200.7-480.5	-40.0 (81.8) -192.7-113	.08
Paced Auditory Serial Addition Test++							
Total Errors	80.4 (26.3) 51-143	63.5 (19.8) 41-112	16.9 (17.2) -2-62	95.7 (34.2) 53-154	68.8 (26.2) 20-111	26.9 (16.9)** 2-63	.05

TABLE 24 (cont'd.)

NEUROBEHAVIORAL RESULTS FOR RE-EVALUATION GROUPS

	LEAD			CONTROL			
	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	p[1]
SENSORY							
SCAN-A*: Competing Words Raw Score**	47.3 (6.1) 36-54	46.4 (5.4) 36-54	.9 (2.9) -4-5	44.2 (7.0) 29-54	46.3 (6.3) 35-56	-2.1 (4.1) -9-5	.09
Hearing Threshold (dB) for Normal Frequency Range:							
Right Ear	28.3 (18.8) 5-73.3	28.2 (20.1) 6.7-65	.1 (.3) 0-1	23.8 (11.6) 6.7-40	24 (16.1) 0-46.7	.1 (.3) 0-1	N.S.
Left Ear	30 (21.7) 6.7-68.3	30.9 (22.9) 5-73.3	-.9 (4.8) -8.3-5	31.7 (16.7) 13.3-55	32.2 (21.7) 5-63.3	-.53 (6.7) -15-8.3	N.S.
Vibratron++							
Dominant Hand							
Finger 1	1.5 (.6) .8-2.4	1.5 (.4) 1.0-2.2	-.1 (.4) -.6-.4	1.1 (.3) .8-1.5	1.4 (.6) .5-2.4	-.3 (.4)* -1.0-.3	N.S.
Finger 2	1.7 (.8) .5-3.6	1.9 (.6) 1.1-2.8	-.2 (.7) -.8-1.8	1.3 (.7) .9-3.0	1.3 (.5) .7-2.0	.01 (.5) -.7-1.0	N.S.

TABLE 24 (cont'd.)

NEUROBEHAVIORAL RESULTS FOR RE-EVALUATION GROUPS

	LEAD			CONTROL			
	Time1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	Time 1 Mean (SD) Range	Time 2 Mean (SD) Range	Difference Mean (SD) Range	p[1]
Non-Dominant Hand							
Finger 1	1.8 (.8) 1.0-3.8	1.6 (.5) 1.0-2.5	.2 (.9) -.9-2.6	1.4 (.5) .7-2.3	1.5 (.5) 1.0-2.5	-.2 (.5) -1.5-.5	N.S.
Finger 2	1.7 (.5) 1.0-2.5	1.6 (.7) 1.0-3.0	.02 (.4) -1-.5	1.8 (.9) .9-3.9	1.6 (.7) 1.0-3.3	.2 (1.1) -.8-2.9	N.S.
MOOD							
SCL-90-R Summary Scores							
Global Severity Index	.4 (.4) .04-1.3	.4 (.4) .05-1.3	0 -.2-.1	.3 (.4) 0-1.1	.3 (.3) .07-1.0	0 -.4-.7	N.S.
Positive Symptoms Distress Index	1.3 (.4) 1.0-2.3	1.3 (.5) 1.0-2.6	0 -.3-.3	1.1 (.6) 0-2.0	1.5 (.5) 1.0-2.4	-.5 -2.0-.5	N.S.
Positive Symptoms Total	22.5 (15.8) 4.0-52.0	22.8 (16.4) 1.0-2.6	-.3 -16.0-8.0	20.8 (18.6) 0-48.0	20.1 (16.9) 4.0-60.0	.7 -17-24	N.S.

TABLE 24 (cont'd.)

NEUROBEHAVIORAL RESULTS FOR RE-EVALUATION GROUPS

Notes:

[1]Wilcoxon (Time X Group)

***p<.10-.05 Wilcoxon Sign Rank Test**

****p<.05 Wilcoxon Sign Rank Test**

*****SCAN-A: A Test for Auditory Processing Disorders in Adolescents and Adults**

+cpd= Cycles per degree

++ Lower score indicates better performance

N.S.-Not significantly different

FIGURE 1
PASAT Error Scores by Trial

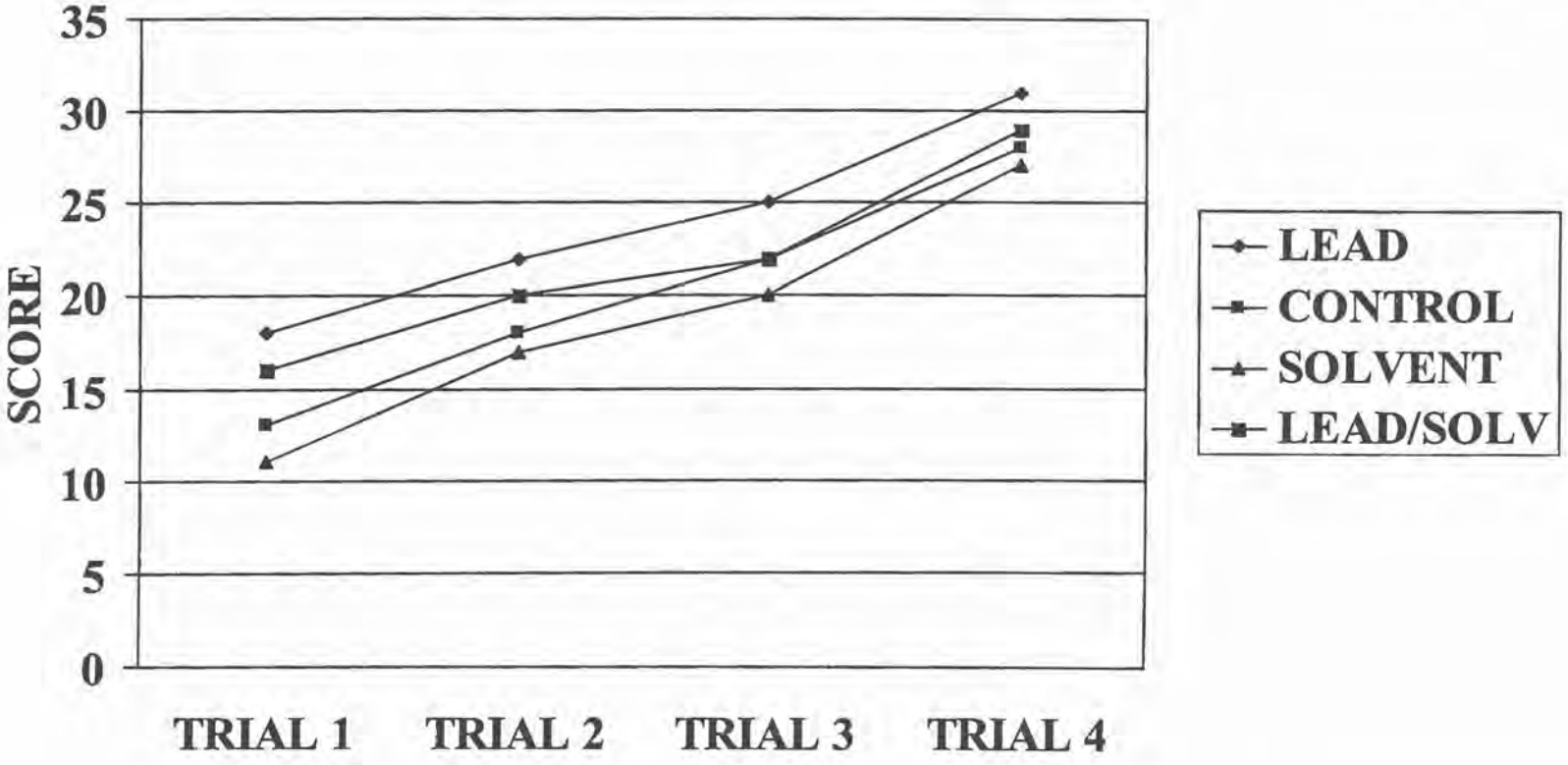
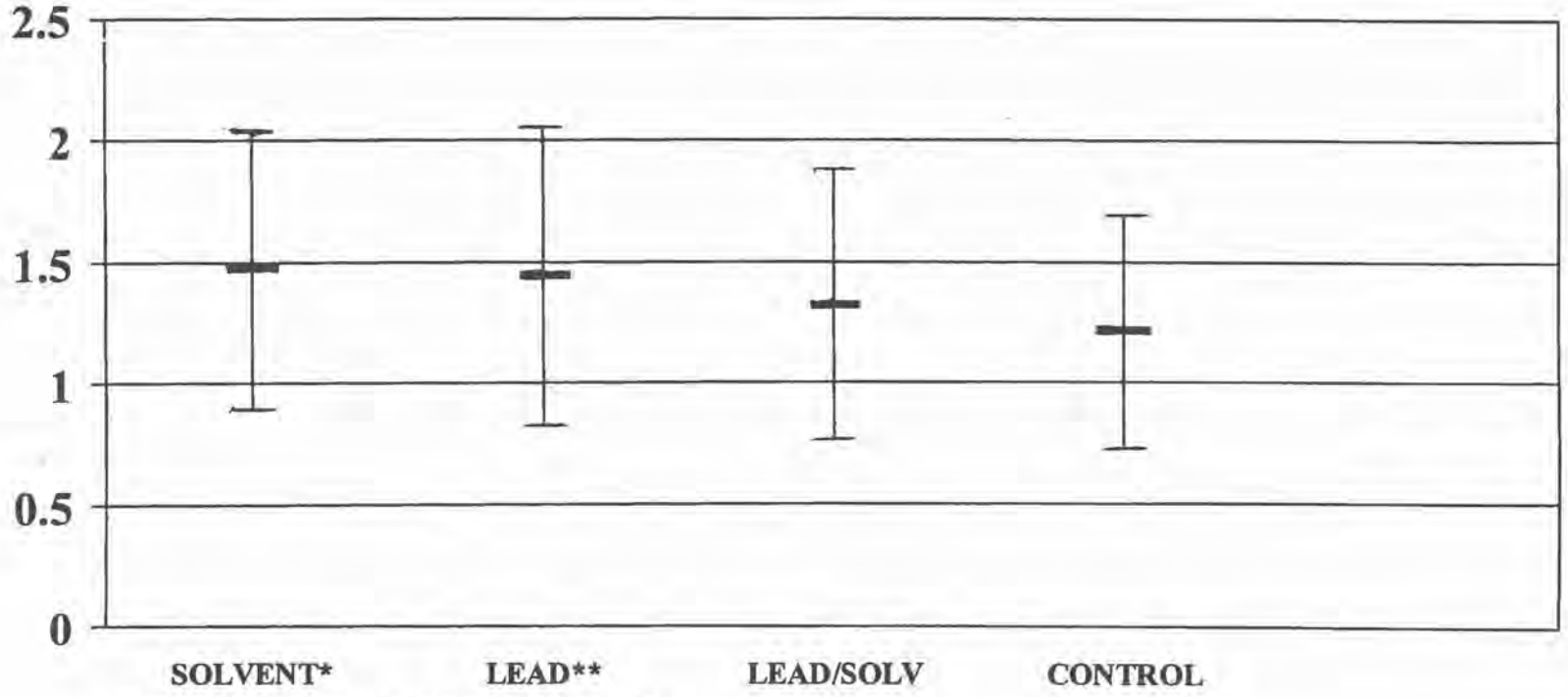
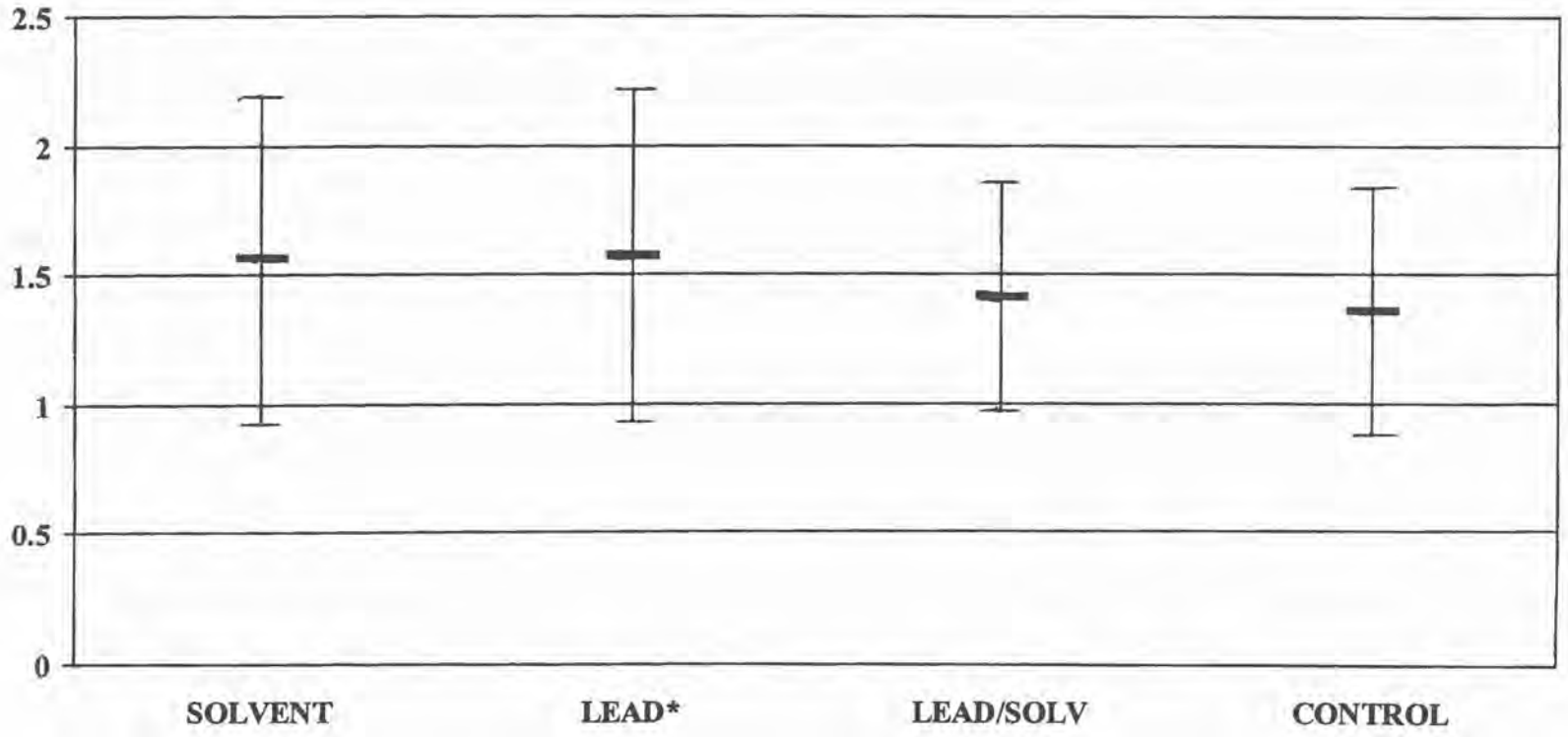


FIGURE 2
VIBRATRON MEAN SCORES -- DOMINANT INDEX FINGER



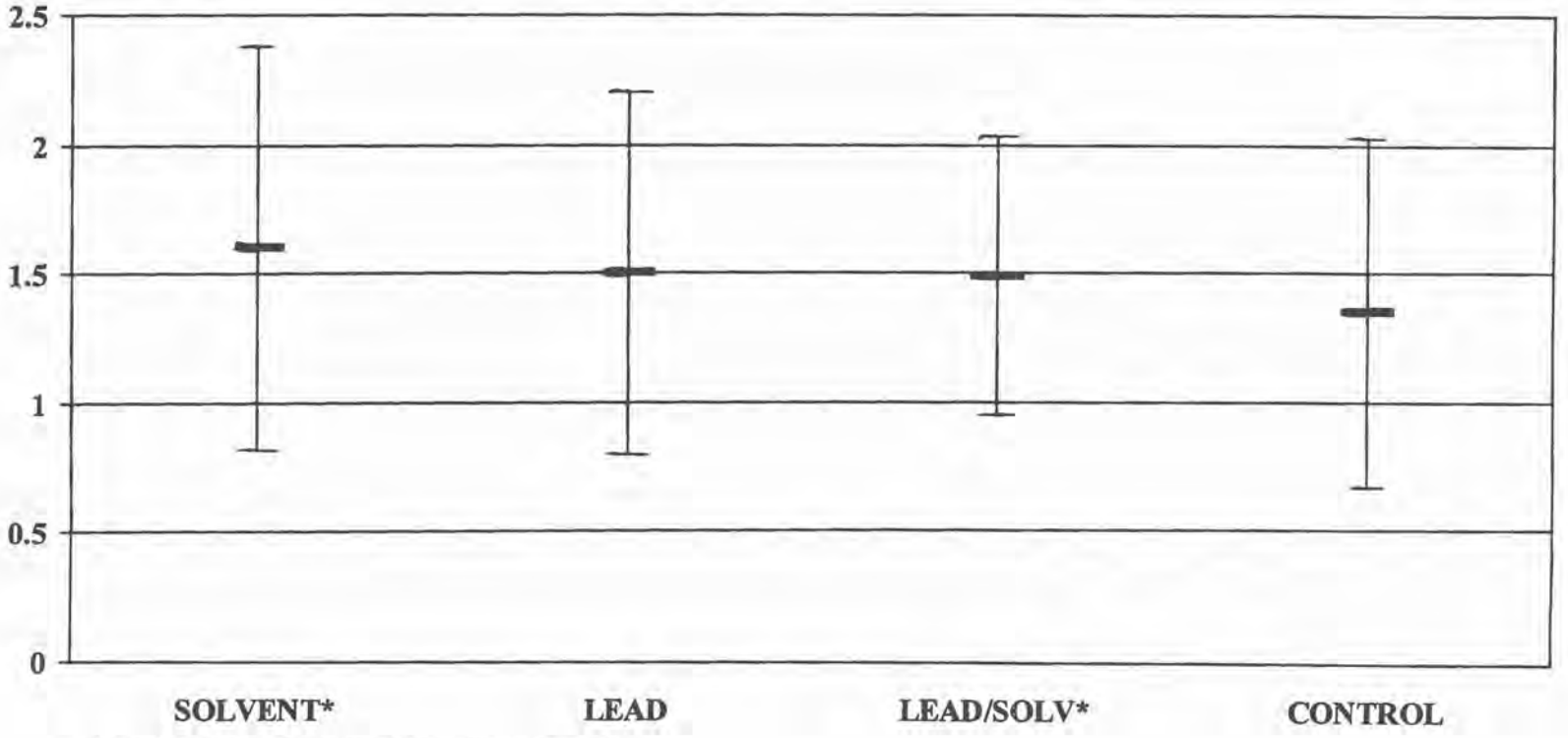
*SIGNIFICANTLY HIGHER THAN CONTROL (p< .05)
**SIGNIFICANTLY HIGHER THAN CONTROL (p<= .10)

FIGURE 3
VIBRATRON MEAN SCORES -- DOMINANT 5TH FINGER



*SIGNIFICANTLY HIGHER THAN CONTROLS (p< .10)

FIGURE 4
VIBRATRON MEAN SCORES -- NON-DOMINANT INDEX FINGER



*SIGNIFICANTLY HIGHER THAN CONTROL (p<= .10)

FIGURE 5
VIBRATRON MEAN SCORES -- NON-DOMINANT 5TH FINGER

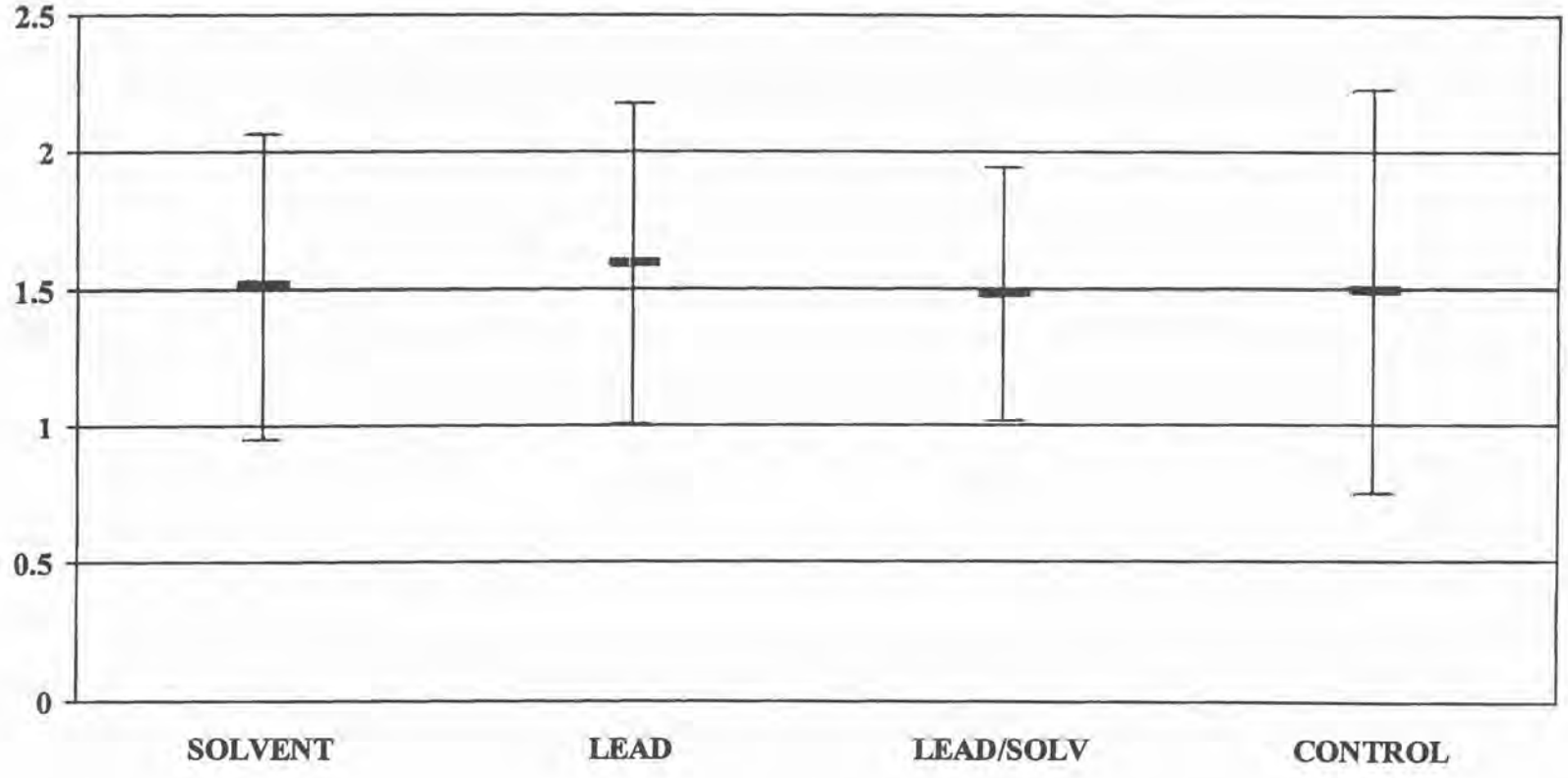


FIGURE 6
SIMPLE REACTION TIME - DOMINANT HAND

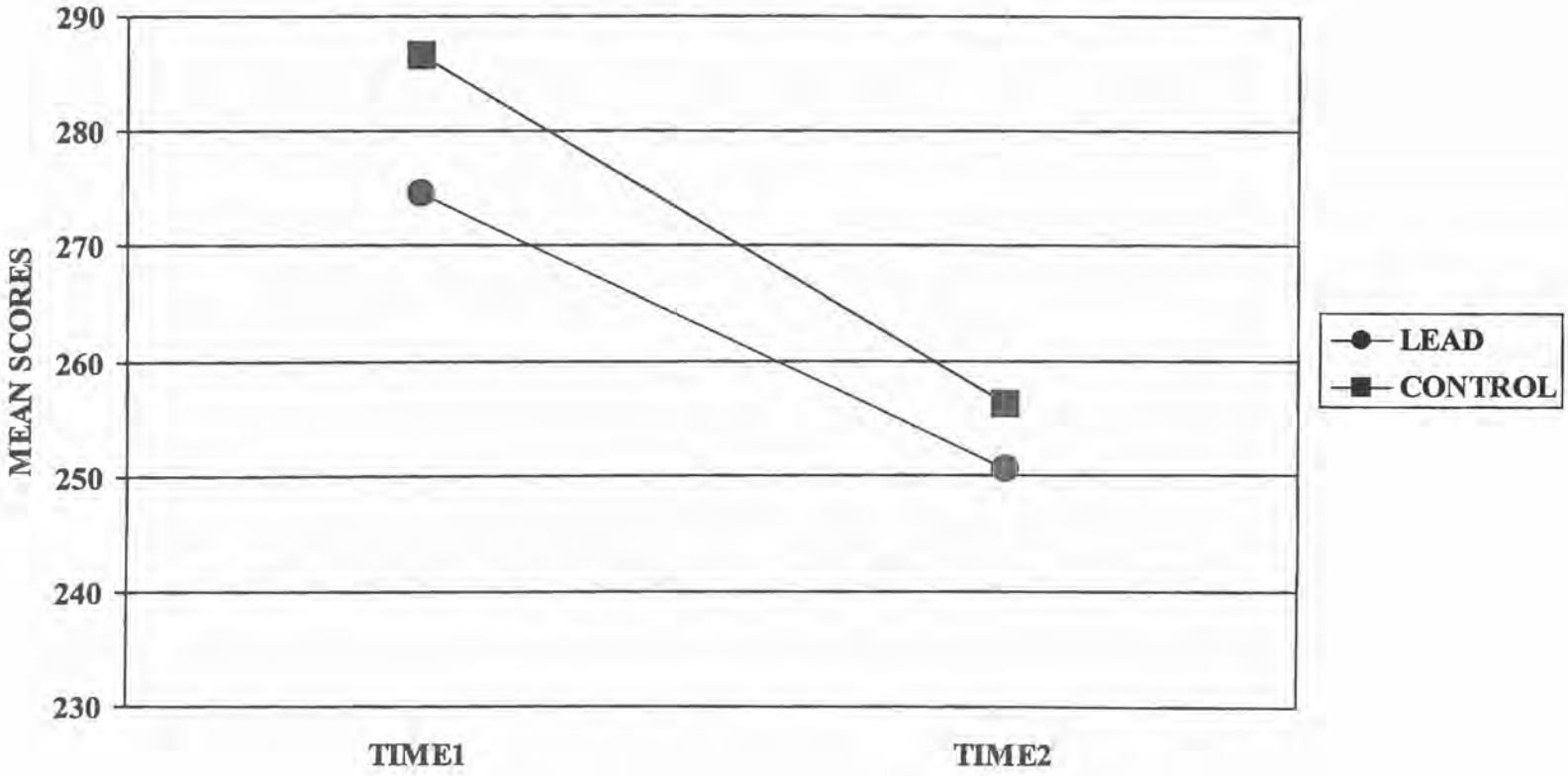
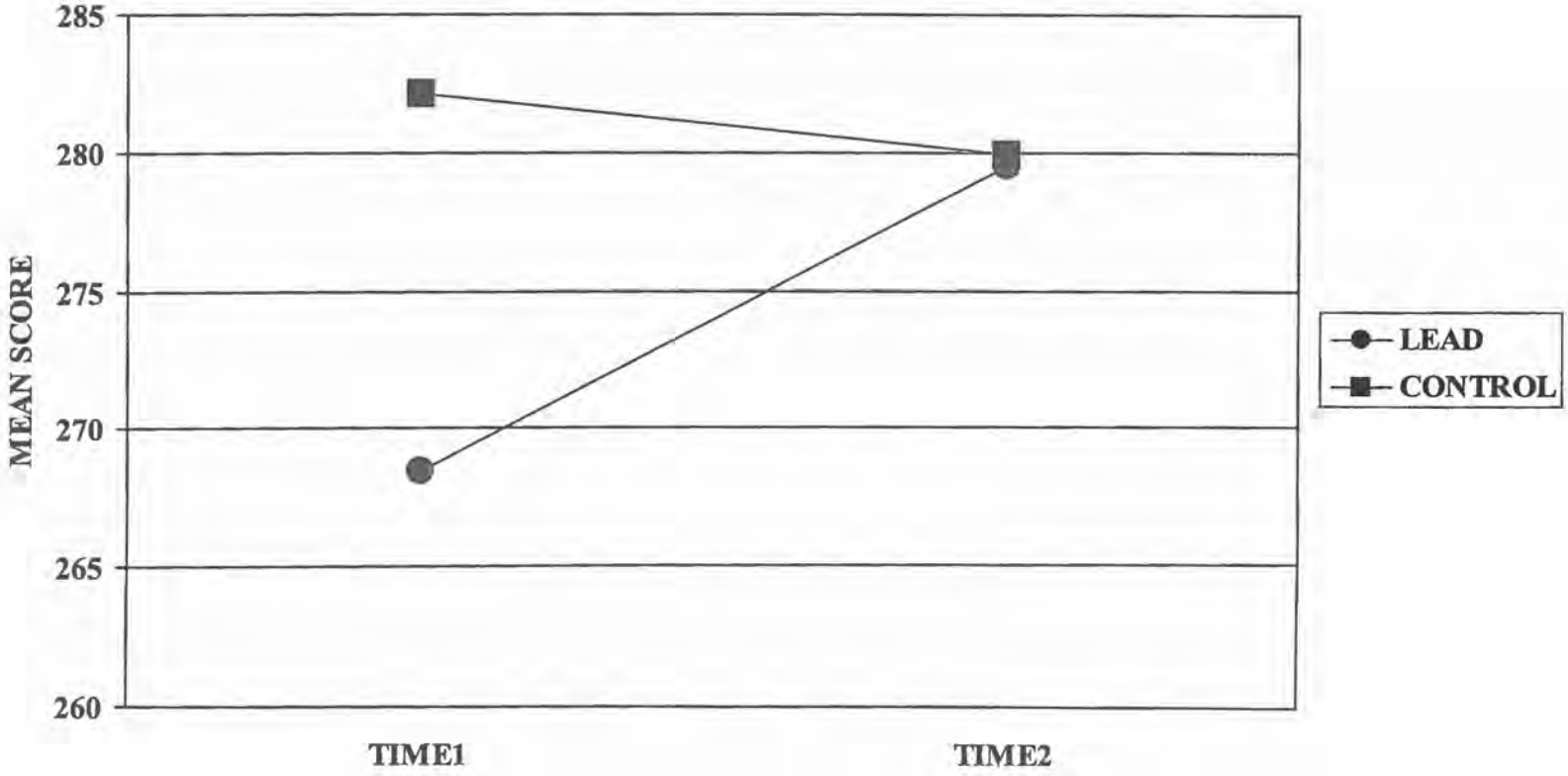


FIGURE 7
SIMPLE REACTION TIME - NON-DOMINANT HAND



APPENDIX

To compare solvent exposure values with those in the present study with those that might be encountered in an industrial setting, four commonly used industrial solvents were selected (toluene, xylene, tetrachlorethylene and trichlorethylene). Lifetime exposure to solvents was calculated (see table below) using an average respiratory rate of 15 breaths per minute (resting value is about 12/min) and a tidal volume of 500 cc per breath. An inhalation rate of 0.45 m^3/hour was calculated as well. The U.S. Environmental Protection Agency uses a value of 20 m^3/day in its Risk Assessment Guidance Manual, which yields a value close to 1 m^3/hour.

Assuming that a worker might be exposed at the Action Level (which is generally 50% of the TLV) or at a lower level (10% of the TLV), the lifetime exposure was estimated at between .54 and 15 million mg of solvent per lifetime (median = 2.84).

Not surprisingly the present solvent exposed workers (mainly painters) were comparable to the low end of the industrial exposure spectrum, with median exposures of .43 (Solvent) and .30 (Lead/Solvent) million mg of solvent per lifetime (about an order of magnitude lower than our median value).

In conclusion, solvent exposed construction workers had light to moderate exposure compared to solvent-exposed workers in industrial settings. The present results provide evidence concerning exposure only at these levels, and cannot be adduced as evidence relevant to more highly exposed (or for that matter, to more lightly exposed) workers.

LIFETIME SOLVENT EXPOSURE IN INDUSTRY

	TLV[a]	inhale	Hours/	Total solvent exposure in 10^6 mg/life			
				--.45 m^3/hours--		-----1 m^3/hour----	
	mg/m^3	m^3/hour[b]	working life[c]	@1/10th TLV	@Action Level[d]	@1/10th TLV	@Action Level[d]
Tetrachlorethylene	170	0.45 - 1	70400	.54	2.69	1.20	5.98
Toluene	188	0.45 - 1	70400	.59	2.98	1.32	6.62
Trichlorethylene	269	0.45 - 1	70400	.85	4.26	1.89	9.47
Xylene	434	0.45 - 1	70400	1.37	6.87	3.05	15.28

a: TLV: Threshold Limit Value established by ACGIH (1997)

b: Assumptions		c: Assumptions	
breaths/min	15	Hours/working life	70400
min/hour	60	Hours/day	8
cc/breath	500	days/year	220
cc/m3	1000000	years/life	40

d: Action Level= 50% of TLV

HEALTH STUDY FOR THE CONSTRUCTION TRADES

MEDICAL/OCCUPATIONAL QUESTIONNAIRE

CONFIDENTIAL

Please complete this questionnaire and bring it with you to your appointment.

NAME: _____ ID: _____
Last First Middle

NAME OF UNION: _____

MARITAL STATUS: _____Married _____Never married _____Separated

_____Divorced _____Widowed _____Living as married

_____Number of prior marriages

AGE: _____

MEDICAL HISTORY

HOSPITALIZATIONS - LIST ALL PREVIOUS HOSPITALIZATIONS, INCLUDING SURGERY AND PSYCHIATRIC HOSPITALIZATIONS.

	REASON FOR ADMISSION (DIAGNOSIS)	DATE	HOSPITAL NAME/CITY	TREATMENT
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

_____ _____
REVIEWED, M.D. DATE

Date Revised: 3/21/95
MEDOCC.QUS

MEDICATION HISTORY

1. Please list all prescription medications you have taken in the past two years. (including prescribed vitamins). If none, so state.

2. List all over-the-counter medications you have taken in the past two years (including vitamins). If none, so state.

3. List all prescription medications you are currently taking/using (including vitamins). If none, so state.

4. List all over-the-counter medications you are currently taking (including vitamins). If none, so state.

SMOKING

DO YOU USE:

	YES	NO	FORMERLY	AVERAGE AMOUNT CONSUMED PER DAY	NUMBER OF YEARS
CIGARETTES	___	___	_____	_____	_____
CIGARS	___	___	_____	_____	_____
PIPE	___	___	_____	_____	_____

IF APPLICABLE, AT WHAT AGE DID YOU START SMOKING? _____

IF YOU ARE A FORMER SMOKER, WHEN DID YOU QUIT? ____ YEAR ____ AGE

MEDICAL HISTORY BY ORGAN SYSTEMS

Have you ever been told by a doctor that you had any of the following conditions?

Cardiovascular

Heart murmur	[ ]yes	[ ]no
Angina	[ ]yes	[ ]no
Heart attack	[ ]yes	[ ]no
High blood pressure	[ ]yes	[ ]no
Vascular disease in arms/legs	[ ]yes	[ ]no
Atypical chest pain	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Gastrointestinal

Peptic ulcer	[ ]yes	[ ]no
Hiatus hernia	[ ]yes	[ ]no
Hepatitis	[ ]yes	[ ]no
Gall bladder disease	[ ]yes	[ ]no
Liver disease	[ ]yes	[ ]no
Cirrhosis	[ ]yes	[ ]no
Pancreatitis	[ ]yes	[ ]no
Irritable Bowel Syndrome	[ ]yes	[ ]no
Colitis	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Skin

Hives	[ ]yes	[ ]no
Psoriasis	[ ]yes	[ ]no
Eczema	[ ]yes	[ ]no
Contact dermatitis	[ ]yes	[ ]no
Oher allergic skin reactions	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Genitourinary

Nephritis	[ ]yes	[ ]no
Kidney disease	[ ]yes	[ ]no
(indicate type: _____)		
Repeated urinary infection	[ ]yes	[ ]no
Kidney/bladder stones	[ ]yes	[ ]no
Vasectomy	[ ]yes	[ ]no
Blood/protein in urine	[ ]yes	[ ]no
Venereal disease	[ ]yes	[ ]no
D.E.S./son or daughter	[ ]yes	[ ]no
Yeast infections	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Blood

Anemia	[ ]yes	[ ]no
Problems with blood clotting/bleeding	[ ]yes	[ ]no
Sickle cell	[ ]yes	[ ]no
Thalassemia	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Eye

Require glasses	[ ]yes	[ ]no
Glaucoma	[ ]yes	[ ]no
Cataracts	[ ]yes	[ ]no
Optic neuritis	[ ]yes	[ ]no
Eye infections	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

MEDICAL HISTORY BY ORGAN SYSTEMS (cont'd)

Have you ever been told by a doctor that you had any of the following conditions?

Pulmonary

Pneumonia	[ ]yes	[ ]no
Pleurisy	[ ]yes	[ ]no
Asthma (as a child)	[ ]yes	[ ]no
Asthma (as an adult)	[ ]yes	[ ]no
Bronchitis	[ ]yes	[ ]no
Emphysema	[ ]yes	[ ]no
Tuberculosis	[ ]yes	[ ]no
Silicosis	[ ]yes	[ ]no
Asbestosis	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Ear, Nose and Throat

Chronic sinusitis	[ ]yes	[ ]no
Impaired hearing	[ ]yes	[ ]no
Easy nasal bleeding	[ ]yes	[ ]no
Nasal allergies	[ ]yes	[ ]no
Tonsillectomy	[ ]yes	[ ]no
Hay fever	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Musculoskeletal

Rheumatoid arthritis	[ ]yes	[ ]no
Other arthritis	[ ]yes	[ ]no
Lupus	[ ]yes	[ ]no
Back injury	[ ]yes	[ ]no
Low back syndrome	[ ]yes	[ ]no
Neck pain/injury	[ ]yes	[ ]no
Degenerative disc disease	[ ]yes	[ ]no
Sciatica/disc herniation	[ ]yes	[ ]no
Bone lesion/infections	[ ]yes	[ ]no
History of broken bones	[ ]yes	[ ]no
Other, specify	[ ]yes	[ ]no

_____

_____

Nervous System

Seizure disorders	[ ]yes	[ ]no
Migraine	[ ]yes	[ ]no
Other headache syndrome	[ ]yes	[ ]no
Multiple Sclerosis	[ ]yes	[ ]no
Neuritis	[ ]yes	[ ]no
Peripheral neuropathy	[ ]yes	[ ]no
Head injury with loss of consciousness	[ ]yes	[ ]no
Other, specify:	[ ]yes	[ ]no

_____

_____

Cancer

Please list site:	[ ]yes	[ ]no

_____

_____

_____

_____

_____

General

Hypoglycemia	[ ]yes	[ ]no
Infectious Mononucleosis	[ ]yes	[ ]no
Breast lumps	[ ]yes	[ ]no
Thyroid disease/ goiter	[ ]yes	[ ]no
Diabetes	[ ]yes	[ ]no
Gout	[ ]yes	[ ]no
Hemorrhoids	[ ]yes	[ ]no
Hernia, specify type:	[ ]yes	[ ]no

_____

Skin cancer/non-melanoma	[ ]yes	[ ]no

Specify site:_____

_____

Dental/gum problems	[ ]yes	[ ]no

Specify:_____

_____

Mumps, age_____	[ ]yes	[ ]no
Adverse reactions to exposure to heat (i.e. heat exhaustion, or heat stroke)	[ ]yes	[ ]no
Frequent night sweats/fever	[ ]yes	[ ]no
Other, specify:	[ ] yes	[ ]no

_____

CURRENT REVIEW OF SYSTEMS

Please check off any symptoms which have troubled you in the past 12 months:

RESPIRATORY SYSTEM		
Dry cough	[ ]yes	[ ]no
Cough with phlegm	[ ]yes	[ ]no
Wheezing	[ ]yes	[ ]no
Shortness of breath	[ ]yes	[ ]no
Pain with breathing	[ ]yes	[ ]no
Persistent nasal congestion	[ ]yes	[ ]no
Persistent runny nose	[ ]yes	[ ]no
Other, specify: _____	[ ]yes	[ ]no
_____		
GENITOURINARY SYSTEM		
Bloody urine	[ ]yes	[ ]no
Brown urine	[ ]yes	[ ]no
Frequent urination	[ ]yes	[ ]no
Pain on urination	[ ]yes	[ ]no
Difficulty starting urination	[ ]yes	[ ]no
Dribbling at end of urination	[ ]yes	[ ]no
Loss of sex drive	[ ]yes	[ ]no
Males only:		
Decreased ability to have an erection	[ ]yes	[ ]no
Females only:		
Irregular menstruation	[ ]yes	[ ]no
Excessive menstrual bleeding	[ ]yes	[ ]no
Bleeding between periods	[ ]yes	[ ]no
Use of oral contraceptives	[ ]yes	[ ]no
Last menstrual period (date)	_____	
Other, specify: _____	[ ]yes	[ ]no
_____		
MUSCULOSKELETAL SYSTEM		
Back pain	[ ]yes	[ ]no
Muscle or joint pain	[ ]yes	[ ]no
Swollen or stiff joints	[ ]yes	[ ]no
Pain or color change in fingers on exposure to cold (Raynauds)	[ ]yes	[ ]no
Other, specify: _____	[ ]yes	[ ]no
_____		
SKIN		
Changes in hair or nails	[ ]yes	[ ]no
Dry skin	[ ]yes	[ ]no
Change in skin pigmentation	[ ]yes	[ ]no
Easy bruising	[ ]yes	[ ]no
Problems with wound healing	[ ]yes	[ ]no
Itching	[ ]yes	[ ]no
Jaundice (yellow skin)	[ ]yes	[ ]no
Other, specify: _____	[ ]yes	[ ]no
_____		

CURRENT REVIEW OF SYSTEMS (CONT'D)

Please check off any symptoms which have troubled you in the past 12 months:

NERVOUS SYSTEM

Headaches (more than 2 per month)	[ ]yes	[ ]no
Dizziness	[ ]yes	[ ]no
Loss of consciousness	[ ]yes	[ ]no
Loss of balance	[ ]yes	[ ]no
Unusual fatigue	[ ]yes	[ ]no
Visual problems (other than glasses)	[ ]yes	[ ]no
Numbness or tingling in hands or feet	[ ]yes	[ ]no
Ringing in ears	[ ]yes	[ ]no
Unusual weakness	[ ]yes	[ ]no
Other, specify: _____	[ ]yes	[ ]no

_____

GASTROINTESTINAL

Recent weight loss	[ ]yes	[ ]no
Unexplained weight gain	[ ]yes	[ ]no
Change in appetite	[ ]yes	[ ]no
Difficulty swallowing	[ ]yes	[ ]no
Nausea or vomiting	[ ]yes	[ ]no
Abdominal pain	[ ]yes	[ ]no
Change in bowel habits	[ ]yes	[ ]no
Blood in stool	[ ]yes	[ ]no
Black or tarry stool	[ ]yes	[ ]no
Other, specify: _____	[ ]yes	[ ]no

_____

CARDIOVASCULAR

Chest pain	[ ]yes	[ ]no
Palpitations	[ ]yes	[ ]no
Swelling of hands and feet	[ ]yes	[ ]no
Leg pain with exercise	[ ]yes	[ ]no
Varicose veins	[ ]yes	[ ]no
Waking at night to urinate	[ ]yes	[ ]no
Waking at night because you can't breathe	[ ]yes	[ ]no
Other, specify: _____	[ ]yes	[ ]no

_____

OTHER

Have you ever felt a need to cut down on your drinking?	[ ]yes	[ ]no
Have you ever felt annoyed by criticism of your drinking?	[ ]yes	[ ]no
Have you had guilty feelings about your drinking?	[ ]yes	[ ]no
Have you ever taken a morning eye-opener?	[ ]yes	[ ]no

OCCUPATIONAL HISTORY

1. Have you ever had an exposure that made you so ill that you had to leave the job you were working on?

   Yes _____ No _____

   If Yes, how many times has this happened? _____

	TIME 1	TIME 2	TIME 3
How old were you each time?	___	___	___
For each time, make a check for the kind of exposure.			
a. Lead	___	___	___
b. Solvents	___	___	___
c. Lead and solvents	___	___	___
d. Other (Specify)	___	___	___
_____			

2. Have exposure(s) at work made you so ill that you consulted a physician?

   Yes _____ No _____

   If yes, how many times did you consult a Physician? _____

	TIME 1	TIME 2	TIME 3
How old were you each time?	___	___	___
For each time, make a check for the kind of exposure.			
a. Lead	___	___	___
b. Solvents	___	___	___
c. Lead and solvents	___	___	___
d. Other (Specify)	___	___	___
_____			

3. Have exposure(s) at work made you so ill that you had to go to the hospital/Emergency Room?

   Yes _____ No _____

   If yes, how many times did this happen? _____

	TIME 1	TIME 2	TIME 3
How old were you each time?	___	___	___
For each time, make a check for the kind of exposure.			
a. Lead	___	___	___
b. Solvents	___	___	___
c. Lead and solvents	___	___	___
d. Other (Specify)	___	___	___
_____			

LIST ALL JOBS HELD FOR AT LEAST 6 MONTHS. DO NOT LIST JOBS ASSIGNED THROUGH YOUR UNION (IBPAT/IRON WORKERS). START WITH YOUR FIRST JOB AND CONTINUE UP TO AND INCLUDING YOUR PRESENT POSITION.

EMPLOYER'S NAME & CITY	DATES FROM/TO	BRIEF JOB DESCRIPTION	MATERIALS HANDLED	TYPE OF SAFETY EQUIPMENT USED

OTHER ACTIVITIES

List all non-work activities (e.g., hobbies, sports). Include all chemicals or toxic substances used with these activities. If none, so state.

	ACTIVITY	CHEMICALS OR EXPOSURES	YEAR STARTED	YEAR STOPPED (OR CURRENT)
1)	_____	_____ YES _____ NO List: _____ _____	_____	_____
2)	_____	_____ YES _____ NO List: _____ _____	_____	_____
3)	_____	_____ YES _____ NO List: _____ _____	_____	_____
4)	_____	_____ YES _____ NO List: _____ _____	_____	_____
5)	_____	_____ YES _____ NO List: _____ _____	_____	_____

ALCOHOL USE

THE FOLLOWING QUESTIONS ASK ABOUT ALCOHOL USE DURING YOUR LIFETIME. IT IS IMPORTANT THAT WE BE AS ACCURATE AS POSSIBLE IN OUR ASSESSMENT OF YOUR USE OF ALCOHOL. THIS WILL HELP US ACCURATELY INTERPRET THE RESULTS OF THIS STUDY. BE ASSURED THAT EVERYTHING YOU REPORT HERE IS STRICTLY CONFIDENTIAL. WE WILL NOT REPORT ANY OF YOUR INDIVIDUAL INFORMATION TO ANYONE. IN FACT, THE ONLY INDIVIDUALS WHO WILL HAVE ACCESS TO THIS INFORMATION WILL BE THOSE ON OUR RESEARCH TEAM. THANK YOU FOR TAKING THE TIME TO THINK BACK OVER YOUR LIFETIME. IF ANY OF THE QUESTIONS ARE UNCLEAR TO YOU, FEEL FREE TO ASK FOR ASSISTANCE. WE WILL REVIEW THIS QUESTIONNAIRE WITH YOU WHEN YOU HAVE YOUR EXAMINATION.

ALL INFORMATION IS STRICTLY CONFIDENTIAL

BEER: includes REGULAR BEER, LIGHT BEER, and such beverages as ALE and COLT 45.
WINE: includes SANGRIA, ROSE, BURGUNDY, COLD DUCK, MANISCHEWITZ, CHAMPAGNE, etc.
HARD LIQUOR: includes WHISKEY, VODKA, GIN, RUM, TEQUILA, SCOTCH, etc. and MIXED DRINKS such as a MARTINI, SCREW DRIVER, WHISKEY SOUR, etc.

1. About how old were you when you first started drinking, disregarding small tastes of alcohol beverages? (Mark 0 years if you never drank or only had small tastes of these).

BEER	WINE	HARD LIQUOR
I was ____ yrs. old	I was ____ yrs. old	I was ____ yrs. old

PAST YEAR ALCOHOL USE:

Please think about the period of the past year -- from today back to one year ago. Describe your use of alcohol during the **PAST YEAR** and answer these questions by circling the best choice:

2. How **OFTEN** did you drink alcohol during the **PAST YEAR**?

a. I didn't drink in the past year
b. One or two days during the year
c. Several days during the year
d. One day a month
e. Two or three days a month
f. One day a week
g. Two or three days a week
h. Four to six days a week
i. Every day
j. More than once a day

3. In a **TYPICAL** drinking occasion (more than half of the time) during the **PAST YEAR**, how many drinks did you **USUALLY** consume?

1 drink = 12 ounces (one regular bottle) of beer
= 5 ounces of wine
= 1 1/2 ounces of 80 proof hard liquor

a. I didn't drink in the past year
b. 1 drink
c. 2 drinks
d. 3 drinks
e. 4 drinks
f. 5 drinks
g. 6 drinks
h. 7 drinks
i. 8 drinks
j. 9 drinks
k. 10 drinks
l. 11 drinks
m. 12 drinks
n. 13-15 drinks
o. 16-18 drinks
p. 19 or more drinks

4. What is the **LARGEST NUMBER** of drinks that you had during one drinking occasion in the **PAST YEAR**?

a. I didn't drink in the past year
b. 1 drink
c. 2 drinks
d. 3 drinks
e. 4 drinks
f. 5 drinks
g. 6 drinks
h. 7 drinks
i. 8 drinks
j. 9 drinks
k. 10 drinks
l. 11 drinks
m. 12 drinks
n. 13-15 drinks
o. 16-18 drinks
p. 19 or more drinks

5. How many **TIMES** did you drink the amount that is circled in Question 4, during the **PAST YEAR**?

   a. I didn't drink in the past year
   b. 1-2 times
   c. 3-9 times
   d. 10-19 times
   e. 20-49 times
   f. 50 or more times

6. Was there ever a period of time that lasted **6 months or longer** that you drank a **LOT MORE** than during the past year (other than when you started drinking)? (Note: If you did not drink in the past year, but have consumed alcohol in the past, be sure to answer these questions).

   a. Yes, a lot more
   b. No

   If you answered No, go to Ques. 12.

7. If you answered **YES, A LOT MORE**, to Question 6, give the ages during which your drinking was a lot more and answer the following questions.

   From age _____ to age _____

8. When you drank **A LOT MORE** alcohol, how **OFTEN** did you drink?

   a. One or two days
   b. Several days
   c. One day a month
   d. Two or three days a month
   e. One day a week
   f. Two or three days a week
   g. Four to six days a week
   h. Every day
   i. More than once a day

9. In a **TYPICAL** drinking occasion (more than half of the time) when you drank a **LOT MORE**, how many drinks did you **USUALLY** consume?

1 drink = 12 ounces (one regular bottle) of beer
= 5 ounces of wine
= 1 1/2 ounces of 80 proof hard liquor

a. 1 drink
b. 2 drinks
c. 3 drinks
d. 4 drinks
e. 5 drinks
f. 6 drinks
g. 7 drinks
h. 8 drinks
i. 9 drinks
j. 10 drinks
k. 11 drinks
l. 12 drinks
m. 13-15 drinks
n. 16-18 drinks
o. 19 or more drinks

10. What is the **LARGEST NUMBER** of drinks that you had during one drinking occasion when you drank a **LOT MORE**?

a. 1 drink
b. 2 drinks
c. 3 drinks
d. 4 drinks
e. 5 drinks
f. 6 drinks
g. 7 drinks
h. 8 drinks
i. 9 drinks
j. 10 drinks
k. 11 drinks
l. 12 drinks
m. 13-15 drinks
n. 16-18 drinks
o. 19 or more drinks

11. How many **TIMES** did you drink the amount checked in Question 10, when you drank a **LOT MORE**?

a. 1-2 times
b. 3-9 times
c. 10-19 times
d. 20-49 times
e. 50 or more times

12. Was there ever a period of time that lasted **6 months or longer** that you drank a **LOT LESS** than during the past year (other than when you started drinking)?

a. Yes, a lot less
b. No

If you answered No, you have finished this questionnaire.

13. If you answered **YES, A LOT LESS**, to Question 12, give the ages during which your drinking was a lot less and answer the questions below.

From age _____ to age _____

14. When you drank **A LOT LESS** alcohol, how **OFTEN** did you drink?

a. One or two days
b. Several days
c. One day a month
d. Two or three days a month
e. One day a week
f. Two or three days a week
g. Four to six days a week
h. Every day
i. More than once a day

15. In a **TYPICAL** drinking occasion (more than half of the time) when you drank a **LOT LESS**, how many drinks did you **USUALLY** consume?

1 drink = 12 ounces (one regular bottle) of beer
= 5 ounces of wine
= 1 1/2 ounces of 80 proof hard liquor

a. 1 drink
b. 2 drinks
c. 3 drinks
d. 4 drinks
e. 5 drinks
f. 6 drinks
g. 7 drinks
h. 8 drinks
i. 9 drinks
j. 10 drinks
k. 11 drinks
l. 12 drinks
m. 13-15 drinks
n. 16-18 drinks
o. 19 or more drinks

16. What is the **LARGEST NUMBER** of drinks that you had during one drinking occasion when you drank a **LOT LESS**?

a. 1 drink
b. 2 drinks
c. 3 drinks
d. 4 drinks
e. 5 drinks
f. 6 drinks
g. 7 drinks
h. 8 drinks
i. 9 drinks
j. 10 drinks
k. 11 drinks
l. 12 drinks
m. 13-15 drinks
n. 16-18 drinks
o. 19 or more drinks

17. How many **TIMES** did you drink the amount checked in Question 16, when you drank a **LOT LESS**?

a. 1-2 times
b. 3-9 times
c. 10-19 times
d. 20-49 times
e. 50 or more times

NAME: _____ ID: _____

LOG INSTRUCTIONS: Please think back to one week ago from today. Note any significant events that happened over this period (for example: parties, gatherings with family or friends, celebrations, etc.). Write two of these events in the appropriate day column on the calendar. Then think back one week from today and record the kind (beer, wine, liquor) and amount (number of drinks) of alcohol you drank on each day of the week.

	SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
WEEK 1							
WEEK 2							

DESCRIPTIONS OF DRUGS

Refer to the following for alternative names for the drugs listed in the questions below.

MARIJUANA is sometimes called **POT, GRASS, WEED, REEFER, THC,** etc., and also includes **HASHISH** and **HASH OIL**

INHALANTS include **SOLVENTS AND DRUGS THAT YOU INHALE,** such as **NITROUS OXIDE, LAUGHING GAS, WHIPPETS, GLUE, CHLOROFORM, AEROSOL CANS, SNAPPERS, AMYL NITRATE, POPPERS, AND THE LIKE**

PCP is **PHENECYCLINDINE,** which is also referred to as **ANGEL DUST, BOAT, SHERMS**

NON-PRESCRIPTION DRUGS include **PILLS AND DRUGS YOU CAN BUY IN A DRUGSTORE WITHOUT A PRESCRIPTION,** such as **COMPOZ, COPE, NYTOL, SOMINEX, NO DOZ, COUGH SYRUP, DEXETRIM,** etc. **WE ARE INTERESTED ONLY IN YOUR USE OF THESE DRUGS FOR NON-MEDICAL PURPOSES, THAT IS, WHEN YOU USE THEM JUST TO SEE HOW THEY WORK OR TO ENJOY THE FEELING THEY GIVE.**

ANALGESICS include **OPIUM AND OTHER DRUGS CONTAINING OPIUM AND ITS DERIVATIVES.** They are usually in the form of **PRESCRIPTION COUGH SYRUPS, PAIN KILLERS,** or **STOMACH MEDICINES**--things like **MORPHINE, CODEINE, DILAUDID, DEMEROL, PERCODAN,** and **PAREGORIC. METHADONE** is also included.

STIMULANTS are drugs that doctors sometimes prescribe to help people lose weight or to make them feel wide-awake, peppy, energetic, or alert. These drugs are sometimes called **"UPS," "UPPERS," "SPEED,"** or **"BENNIES."** Stimulants included drugs such as **DEXAMYL, DEXEDRINE, METHEDRINE, BENZEDRINE, RITALIN, AMPHETAMINE, "BLACK BEAUTY," "WHITE CROSS,"** etc.

SEDATIVES OR BARBITURATES are drugs that doctors sometimes prescribe to help people relax during the day or to get a better night's sleep. They are sometimes called **"DOWNS"** or **"DOWNERS." SEDATIVES** include drugs such as **SECONAL, PHENOBARBITAL, NEMBUTAL, TUINAL, QUAALUDE, "714," "CIBA,"** etc.

TRANQUILIZERS are drugs that doctors sometimes prescribe to help people calm down or to get a better night's sleep. **TRANQUILIZERS** include drugs such as **VALIUM, LIBRIUM, MILTOWN, MEPROBAMATE, EQUANIL,** etc.

PSYCHEDELICS are also referred to as **HALLUCINOGENS** and include such drugs as **LSD (ACID), ECSTASY, MESCALINE, PEYOTE, PSILOCYBIN, DMT, STP, MAGIC MUSHROOMS, MORNING GLORY SEEDS,** etc.

COCAINE is also referred to as **COKE, SISTER, WHITE POWDER, TOOT, ICE, SNOW, SNUFF,** and **NOSTRIL CANDY.**

HEROIN is also referred to as **HORSE, SKAG, H, BOY,** etc.

ID _____

1. Have you used any of the following drugs as they are **PRESCRIBED** for a specific **MEDICAL CONDITION?**

   Circle one answer for each drug listed.

	Never Used it	Used it, But Not in Past Year	Used in Past Year
Analgesics	a	b	c
Stimulants	a	b	c
Sedatives	a	b	c
Tranquilizers	a	b	c

2. Have you ever used any of the following drugs more than they were prescribed - in other words, ever overused or abused?

	Never Used it	Used it Once or Twice	Used it, But Not in Past Year	Used in Past Year
Analgesics	a	b	c	d
Stimulants	a	b	c	d
Sedatives	a	b	c	d
Tranquilizers	a	b	c	d

3. Have you ever used any of the following drugs (this means recreationally)?

	Never Used it	Used it Once or Twice	Used it, But Not in Past Year	Used in Past Year
Marijuana	a	b	c	d
Cocaine	a	b	c	d
Heroin	a	b	c	d
PCP	a	b	c	d
Non-prescription drugs	a	b	c	d
Psychedelics	a	b	c	d
Inhalants	a	b	c	d

If you have used any of the drugs listed in Questions 2 and/or 3, please respond to the questions below.

If you have <u>not</u> used any of the drugs listed above, you have completed this questionnaire.

SUBSTANCE _____ ID: _____

3. About how old were you the first time you ever used this substance?

   Age _____

4. Did you ever use this substance **EVERY DAY FOR TWO WEEKS** (10-14 days)?

   a. Yes
   b. No

   If yes, give age _____

5. How often did you use this substance within the past year?

   a. Did not use in the past year
   b. One or two days during the year
   c. Several days during the year
   d. One day a month
   e. Two or three days a month
   f. One day a week
   g. Two or three days a week
   h. Four to six days a week
   i. Every day
   j. More than once a day

6. If you used this substance within the past year, when was the **LAST TIME** you used it?

   a. A month ago
   b. Two to three weeks ago
   c. A week ago
   d. A few days ago
   e. Yesterday
   f. Today

7. Was there ever a period of time that lasted **6 months or longer** that you used this substance **A LOT MORE** than during the past year? (Note: If you did not use this substance in the past year, but have used it in the past, answer these questions).

   a. Yes, a lot more
   b. No

   If answered No, go to Ques. 11.

8. Give the ages during which your use of this substance was **A LOT MORE** and answer the questions below.

   From age _____ to age _____

9. When you used this substance **A LOT MORE**, how **OFTEN** did you use it?

   a. One or two days
   b. Several days
   c. One day a month
   d. Two or three days a month
   e. One day a week
   f. Two or three days a week
   g. Four to six days a week
   h. Every day
   i. More than once a day

10. How many **TIMES** did you use this substance during the time that you used it **A LOT MORE**?

   a. 1-2 times
   b. 3-9 times
   c. 10-19 times
   d. 20-49 times
   e. 50 or more times

11. Was there ever a period of time that lasted **6 months or longer** that you used this substance **A LOT LESS** than during the past year?

   a. Yes, a lot less
   b. No

   If answered No, go to NEXT SUBSTANCE

12. Give the ages during which your use of this substance was **A LOT LESS** and answer the questions below.

   From age _____ to age _____

13. When you used this substance **A LOT LESS**, how **OFTEN** did you use it?

   a. One or two days
   b. Several days
   c. One day a month
   d. Two or three days a month
   e. One day a week
   f. Two or three days a week
   g. Four to six days a week
   h. Every day
   i. More than once a day

14. How many **TIMES** did you use this substance during the time that you used it **A LOT LESS**?

a. 1-2 times
b. 3-9 times
c. 10-19 times
d. 20-49 times
e. 50 or more times

WORK PROFILE

For **EACH** of the **FOUR** kinds of work below, check if you've **EVER** done work like that. If yes, answer **ALL** questions under that kind of work **FOR THE TIME YOU DID I**
Try to be as accurate and complete as you can. (Disregard italicized numbers; they are for office use only.)

FOR EACH KIND OF WORK	INDUSTRIAL AND STRUCTURAL 1. EXTERIORS	 2. INTERIORS	COMMERCIAL AND RESIDENTIAL 3. EXTERIORS	 4. INTERIORS
ANSWER QUESTIONS BELOW	New and maintenance painting EXTERIORS of towers, tanks, industrial buildings, structural metal, ships, bridges, etc.	New and maintenance painting INTERIORS of tanks, ship compartments, vessels, sewage treatment plants, industrial plants; also assembly line, spray booth, etc.	New and maintenance painting EXTERIORS of schools, supermarkets, offices, businesses, homes, etc.	New and maintenance painting INTERIORS of schools, supermarkets, offices, businesses homes, etc.
a. Have you ever done this kind of work?	__ No, Go to next work __ Yes, Answer questions below:	__ No, Go to next work __ Yes, Answer questions below:	__ No, Go to next work __ Yes, Answer questions below:	__ No, Go to next work __ Yes, Answer questions below:
b. What fraction of your paint career has been spent doing this work?	*1* __ Under 1/4 *2* __ 1/4 + to 1/2 *3* __ 1/2 + to 3/4 *4* __ Over 3/4	*1* __ Under 1/4 *2* __ 1/4 + to 1/2 *3* __ 1/2 + to 3/4 *4* __ Over 3/4	*1* __ Under 1/4 *2* __ 1/4 + to 1/2 *3* __ 1/2 + to 3/4 *4* __ Over 3/4	*1* __ Under 1/4 *2* __ 1/4 + to 1/2 *3* __ 1/2 + to 3/4 *4* __ Over 3/4
c. You did this work for how many years?	*1* __ Under 1 year *2* __ 1 + to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years	*1* __ Under 1 year *2* __ 1 + to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years	*1* __ Under 1 year *2* __ 1+ to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years	*1* __ Under 1 year *2* __ 1 + to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years
d. How many years ago did you last do this work?	*1* __ Under 1 year *2* __ 1 + to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years	*1* __ Under 1 year *2* __ 1 + to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years	*1* __ Under 1 year *2* __ 1+ to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years	*1* __ Under 1 year *2* __ 1 + to 5 years *3* __ 5 + to 10 years *4* __ Over 10 years
e. Fraction of time using spray(S), roll(R), brush(B) while doing this work?	(S) (R) (B) Never __ __ __ *1* Under 1/4 __ __ __ *2* 1/4 + to 1/2 __ __ __ *3* 1/2 + to 3/4 __ __ __ *4* Over 3/4 __ __ __ *5*	(S) (R) (B) Never __ __ __ *1* Under 1/4 __ __ __ *2* 1/4 + to 1/2 __ __ __ *3* 1/2 + to 3/4 __ __ __ *4* Over 3/4 __ __ __ *5*	(S) (R) (B) Never __ __ __ *1* Under 1/4 __ __ __ *2* 1/4 + to 1/2 __ __ __ *3* 1/2 + to 3/4 __ __ __ *4* Over 3/4 __ __ __ *5*	(S) (R) (B) Never __ __ __ *1* Under 1/4 __ __ __ *2* 1/4 + to 1/2 __ __ __ *3* 1/2 + to 3/4 __ __ __ *4* Over 3/4 __ __ __ *5*
f. Average application rate for this work in gallons/hour for spray(S), roll(R), brush(B):	(S) (R) (B 1/2 + to 1 __ __ __ *1* 1 + to 2 __ __ __ *2* 2 + to 4 __ __ __ *3* 4 + to 6 __ __ __ *4* 6 + to 9 __ __ __ *5* Over 9 __ __ __ *6*	(S) (R) (B) 1/2 + to 1 __ __ __ *1* 1 + to 2 __ __ __ *2* 2 + to 4 __ __ __ *3* 4 + to 6 __ __ __ *4* 6 + to 9 __ __ __ *5* Over 9 __ __ __ *6*	(S) (R) (B) 1/2 + to 1 __ __ __ *1* 1 + to 2 __ __ __ *2* 2 + to 4 __ __ __ *3* 4 + to 6 __ __ __ *4* 6 + to 9 __ __ __ *5* Over 9 __ __ __ *6*	(S) (R) (B) 1/2 + to 1 __ __ __ *1* 1 + to 2 __ __ __ *2* 2 + to 4 __ __ __ *3* 4 + to 6 __ __ __ *4* 6 + to 9 __ __ __ *5* Over 9 __ __ __ *6*
g. Respirator you wore most for this work for spray(S), roll(R), brush(B):	(S) (R) (B) *1* None __ __ __ *2* Dustmask __ __ __ *3* Single Cartridge __ __ __ *4* Double Cartridge __ __ __ *5* Airline (mask/hood) __ __ __	(S) (R) (B) *1* None __ __ __ *2* Dustmask __ __ __ *3* Single Cartridge __ __ __ *4* Double Cartridge __ __ __ *5* Airline (mask/hood) __ __ __	(S) (R) (B) *1* None __ __ __ *2* Dustmask __ __ __ *3* Single Cartridge __ __ __ *4* Double Cartridge __ __ __ *5* Airline (mask/hood) __ __ __	(S) (R) (B) *1* None __ __ __ *2* Dustmask __ __ __ *3* Single Cartridge __ __ __ *4* Double Cartridge __ __ __ *5* Airline (mask/hood) __ __ __
h. Fraction of time you wore this respirator for spray(S), roll(R), brush(B):	(S) (R) (B) *1* Near Never __ __ __ *2* About 1/4 __ __ __ *3* About 1/2 __ __ __ *4* About 3/4 __ __ __ *5* Near Always __ __ __	(S) (R) (B) *1* Near Never __ __ __ *2* About 1/4 __ __ __ *3* About 1/2 __ __ __ *4* About 3/4 __ __ __ *5* Near Always __ __ __	(S) (R) (B) *1* Near Never __ __ __ *2* About 1/4 __ __ __ *3* About 1/2 __ __ __ *4* About 3/4 __ __ __ *5* Near Always __ __ __	(S) (R) (B) *1* Near Never __ __ __ *2* About 1/4 __ __ __ *3* About 1/2 __ __ __ *4* About 3/4 __ __ __ *5* Near Always __ __ __
i. Fraction of past year you did this kind of work:	*1* __ Never *2* __ Under 1/4 *3* __ 1/4 + to 1/2 *4* __ 1/2 + to 3/4 *5* __ Over 3/4	*1* __ Never *2* __ Under 1/4 *3* __ 1/4 + to 1/2 *4* __ 1/2 + to 3/4 *5* __ Over 3/4	*1* __ Never *2* __ Under 1/4 *3* __ 1/4 + to 1/2 *4* __ 1/2 + to 3/4 *5* __ Over 3/4	*1* __ Never *2* __ Under 1/4 *3* __ 1/4 + to 1/2 *4* __ 1/2 + to 3/4 *5* __ Over 3/4

NAME: _____ ID: _____

LOG INSTRUCTIONS: Please think back to one week ago from today indicate the number of hours worked each day. From the following list of substances, indicate those used on each day;

Solvent based paint; paint thinner, wood stripper, latex paint, degreasers, gasoline, etc.

Note on the chart below the last day and hour that you worked before coming to this appointment.

	SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
WEEK 1							
WEEK 2							

Would you be willing to wear a monitor while working for three days. This monitor will fit on your shirt pocket and does not require you to do anything except wear it while working.

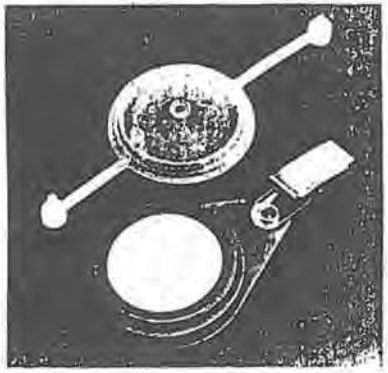
Yes _____

No _____

III. Monitoring Instructions

1. The monitor and closure cap are packaged in an aluminum can. The original shipping carton can be used to send exposed monitors to a laboratory for analysis. Individual #3510 monitors can be sent to 3M in the mailing envelopes supplied.

2. Remove the plastic can lid. Open the can by pulling up on the ring tab.



3. Remove the monitor from the can.

4. Before monitoring, record the following information in your data log or on the plastic can lid:
   1) Monitor serial number
   2) Sampling date
   3) Employee or area I.D.
   4) Temperature and relative humidity
   5) Compounds to be analyzed for

5. Record start time on back label of the monitor. MOVE TO STEP 6 IMMEDIATELY.

6. Attach monitor to employee as near to the breathing zone as possible. DO NOT REMOVE WHITE FILM AND PLASTIC RING.

7. After sampling period is ended, remove plastic ring and white film. MOVE TO STEP 8 IMMEDIATELY.

8. Snap closure cap firmly onto monitor body. Be sure the two port plugs are firmly seated. SAMPLING IS NOW TERMINATED.

9. Record END TIME on back label of the monitor and on your data log.

10. Record on can lid and Diary the date used for each monitor.

WORK DIARY

NAME:_____ DATE:_____

Check what kind of work you did today:

INDUSTRIAL & STRUCTURAL _____ COMMERCIAL & RESIDENTIAL _____

Please provide the number of hours badge was worn while engaging in the following activities:

Oil based paint		_____	# hours used
Latex (water) based paint		_____	# hours used
Spraying	Interior	_____	# hours
	Exterior	_____	# hours
Rolling	Interior	_____	# hours
	Exterior	_____	# hours
Brushing	Interior	_____	# hours
	Exterior	_____	# hours
Cleaning Supplies (paint thinner - solvents)	Interior	_____	# hours
	Exterior	_____	# hours
Total Hours Worked Wearing Badge		_____	# hours
Respirator Worn		_____	# hours

If working inside, were windows open? _____ Yes _____ No

Provide approximate number of gallons used:

Spraying	_____	# gallons
Rolling	_____	# gallons
Brushing	_____	# gallons

AFTER WEARING THE MONITOR FOR EACH OF THE 3 WORK DAYS, RETURN THEM TO THEIR CONTAINERS AND CAP THEM. RETURN THE 3 CONTAINERS WITH THE DIARIES IN THE STAMPED ADDRESSED ENVELOPE PROVIDED.