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Correlates of Chronic Volatile Substance Abuse in Juvenile Delinquents

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CORRELATES OF CHRONIC VOLATILE SUBSTANCE ABUSE IN JUVENILE DELINQUENTS

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VITA

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TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER I

INTRODUCTION

Oetting and Beauvais (1990) report from the National Drug Survey for Children and Adolescents that 5% to 43% of children and teenagers have tried volatile substances (VS) at some point. The incidence of use is higher in specific populations such as alternative schools and in extremely impoverished areas. This proposed study integrates neuroradiological, neurological, neuropsychological, psychological and social factors to predict cognitive deficits of volatile substance (VS) abusers and correlates of those deficits. The population under study consists of juvenile delinquents who have a history of severe polysubstance abuse; one group is VS abusers. The focus of this inquiry is the relationship between VS abuse and cognitive impairment. The advantages of this study compared to prior research on this topic include: 1) the presence of a control group; 2) examination of social, psychological and neuropsychological variables; 3) the control of abstinence in the population at the time of testing; and 4) the use of common standardized neuropsychological, psychological and intelligence measures.

Definition of Volatile Substances

VS are aromatic and aliphatic hydrocarbon compounds found

in a variety of products that are abused for their mood altering effects. They are found in spray paint, gasoline, white-out, hair spray, and other products with the primary elements being toluene, n-hexane and amyl or butyl nitrate. Their easy accessibility, low cost, and easy concealment make them a popular substance for children and adolescents to abuse.

Effects of VS Abuse

VS are neurotoxic and affect the central nervous system (CNS). In chronic cases (e.g., 10-15 years) of VS abuse the serious effects may be irreversible. Neuroradiological and neurological studies have revealed signs indicating diffuse damage to the CNS including the brain stem, cerebellum, and cerebral cortex related to severe inhalant abuse. Animal studies on the neurotoxic effects of VS have also found diffuse neurotoxicity of the brain. Animal studies support the conclusion that VS are neurotoxic, but the methods of inhalation are not identical to the method of abuse by humans. Neuropsychological studies have also suggested that chronic VS abuse is related to diffuse damage of the CNS. However, the results have been inconclusive partially because of difficulties inherent in such research and partially because of inconsistencies in measurements used and methodology across research.

Psychological and Social Factors of VS Abuse

VS abuse falls within the category of substance abuse and

the effects of such can be explained within models of substance abuse in adolescence. Personality variables as well as environmental variables have been related to substance abuse. Some studies have suggested that VS abusers experience more depression and have a greater frequency of disorganized families than other drug abusers. These factors can influence performance on neuropsychological tests and need to be accounted for when drawing conclusions regarding the effects of VS abuse.

Study of VS Abuse

The consequences of VS damage to the CNS (including behavior, personality and cognitive functioning) is well documented. However, the amount of damage necessary to cause morphological changes, the measurement of such changes, and the plasticity of the brain remain under study. In addition, the effects of environment and personality on behavior and cognitive functioning make them important factors to measure in relation to VS abuse. The evidence of diffuse CNS damage from VS abuse and the effect of environmental and personality factors on cognitive functioning require that a multi-modal model of cognitive functioning be applied to the relationship between VS abuse and cognitive functioning. The model constructed should also be used to evaluate past research on neuropsychological effects of VS abuse.

What This Study Presents

This study attempts to develop a multi-modal model of

cognitive functioning that can be used to assess the neuropsychological correlates of VS abuse in a juvenile delinquent population. Before such a model is presented the following will be discussed as a foundation for the rest of the study: 1) prevalence of VS use in children and adolescence; 2) the description of VS and their physiological effects; 3) neuroradiological evidence for the neurotoxic effect of severe VS abuse; 4) a new model of the role of the cerebellum in cognitive functioning; and 5) neurological evidence for the neurotoxic effect of severe VS abuse. Research on the relationship between personality and environmental factors on cognitive functioning then follows. From these areas a multi-modal model of cognitive functioning will be presented with a hypothesis that diffuse CNS impairment is to be expected from chronic VS abuse. The neuropsychological literature on VS abuse will be examined for support of diffuse impairment and to guide which neuropsychological tests to include. Several hypotheses will be offered as a conclusion of the literature review and a basis for the study reported here.

CHAPTER II

REVIEW OF RELATED LITERATURE

Prevalence of VS Abuse

The toxicity of inhalants suggests that any level of use is too high. National and local surveys suggest that anywhere from 5 to 43 percent of adolescents from the 4th to 12th grade report using inhalants at some time in their lives. Massengale (1962) documented an increase from several dozen to hundreds of reported cases of volatile substance (VS) or inhalants abuse by adolescents. The 1988-1989 American Drug and Alcohol Survey (Oetting and Beauvais, 1990) of adolescent drug use for lifetime prevalence found that 5.4 percent of children in the 4th grade had used inhalants. The percentage of children who used inhalants increased steadily through the 5th, 6th, and 7th grades, peaked at 18.8 percent of 8th graders and began a steady decline to 14.9 percent of 12th graders. For adolescents in alternative schools 43 percent reported a lifetime prevalence of inhalant use.

Oetting and Beauvais (1990) report that the prevalence of the most frequently used drugs among most adolescent minority groups and Caucasians is essentially similar. However, Native-American youth report a very high prevalence of drug use relative to the other groups. Padilla, Padilla, Morales,

Olmedo & Ramirez (1979) surveyed adolescents in local Los Angeles housing projects and found the highest prevalence of inhalant use to be 46.67 percent for 15 year old males. Prevalence of use across age was similar to the 1988-1989 national survey (Oetting & Beauvais, 1990) with younger youth reporting a lower prevalence of inhalant use but differed from the national survey in that reported use did not drop off as youth reached late adolescence. Oetting and Beauvais (1990) believe that these discordant findings may be a result of a greater frequency of drop outs residing in housing projects and a greater concentration of economically disadvantaged groups living in housing projects with concomitant impoverished living conditions. They believe the national survey accurately reflects the prevalence of inhalant use among minorities in general, and that local surveys of specific populations or areas reflect issues specific to those groups or areas, such as adolescents in alternative schools.

Description of Volatile Substances and Physiological Effects

Volatile substances include any aliphatic or aromatic hydrocarbon elements and are commonly found in products such as spray paints, glues, paint thinner, lacquer, markers, car products, gasoline, typewriter correction or thinner fluid, air fresheners, and Freon. Common volatile substances include: toluene, n-hexane, 1,1,1 trichlorethylene, and amyl and butyl nitrate. Although regional differences exist depending on supply, toluene is one of the most common

elements abused and can be purchased in large amounts in a 99% pure state.

The acute physical and neuropsychological effects of volatile substance abuse (VS abuse) have been well documented and described as being similar to alcohol intoxication and acute organic brain syndrome. For example, a person intoxicated by volatile substances may experience euphoria, drowsiness, drunkenness, nausea, casual hallucinations, poor muscle control, and amnesia. Intoxication by toluene, in contrast to alcohol, would occur quicker, last a shorter period of time and produce more perceptual distortions (Ron, 1986). In addition, toluene has a greater intoxicating effect as the dosage increases.

According to Hormes, Filley & Rosenberg (1986) the chronic VS abuser exposes her or himself to more than 1,000 ppm of toluene for extended periods as well as other possible compounds mixed with the toluene. Hormes et al. (1986) explain that the legal maximum amount of toluene allowed to be inhaled in the work place is 200 ppm. More than 200 ppm of toluene inhaled produces fatigue, headache, paresthesia and slow reflexes, more than 600 ppm results in confusion or delirium and more than 800 ppm causes euphoria.

In addition, VS abuse can result in sudden death through either direct or indirect mechanisms (Shepherd, 1989). VS cause global CNS depression including the respiratory center of the brain, and with enough inhalation could cause

respiratory arrest. VS can also "'sensitize' the myocardium, to the action of adrenaline and this 'sensitization' is more profound in the presence of hypoxia" (Shepherd, 1989). This sensitization to adrenaline results in arrhythmias which can be fatal given the correct situation such as being startled. Other mechanisms of death from VS abuse include anoxia and vagal inhibition (Shepherd, 1989).

Neuroradiological Studies

VS studies using computer tomography scans (CT) and magnetic resonance imaging (MRI) reveal widening of the cortical and cerebella sulci, enlarged lateral ventricles, diffuse atrophy of cortex and cerebellum and in a severe case (i.e., 14 years of abuse) diffuse atrophy of the brain stem (Boor & Hurtig, 1977; Ehyai & Freemon, 1983; Fornazzari, Wilkinson, Kapur, & Carlen, 1983; Hormes, Filley & Rosenberg, 1986; Lewis, Moritz, & Mellis, 1981; Metrick & Brenner, 1982; and Rosenberg, Kleinschmidt-DeMasters, Davis, Dreisbach, Hormes, & Filley, 1987). Almost all of the subjects in these studies were adults (a few were adolescents) with a long history of abuse (at least one year) who primarily abused toluene. Some were polydrug users.

A brain autopsy of a VS abuser with a 20-year history of abuse (primarily of toluene) revealed deterioration that included: mild ventricular enlargement, thinning of the corpus callosum, diffuse and ill defined myelin pallor (especially in cerebellar hemispheres relative to cerebral hemispheres), and

gliosis present in the white matter immediately adjacent to ventricles (Rosenberg et al., 1987). Together these studies suggest a relationship between VS abuse and global deterioration of the CNS that involves the brain stem, cerebellum and cerebral cortex and manifests itself in cognitive, personality, and behavioral changes. More will be said on this below in the neurological and neuropsychological sections.

Research on VS Effects Using Animals. Studies on the effects of VS on animals provide evidence to support the specific neurotoxicity of VS in the CNS. Schaumburg & Spencer (1976) studied the effects of n-hexane on rats and found degeneration of CNS and PNS in rats exposed to continuous inhalation or daily subcutaneous injection. They speculated that the PNS insult would be subject to recovery while the CNS insult would not because of the reparative ability of the PNS and the lack of reparation of neurons in the CNS.

Huang, Kato, Shibata, Hisanaga, Ono, & Takeuchi (1990) found that the effects of toluene exposure in rats is dose dependent and that subacute levels of prolonged toluene exposure can produce changes in brain marker proteins in the brainstem, cerebellum and cerebrum.

Slomianka, Edelfors, Ravn-Jonsen, Rungby, Danscher, and West (1990) found that both 100 ppm and 500 ppm daily exposure to toluene by rat pups produces specific neurotoxic effects on the CNS and that 500 ppm has a greater negative impact than

100 ppm which suggests a dose-response effect.

Summary. In sum, studies performed on animals and humans reveal a neurotoxic effect of chronic VS abuse or VS exposure in the PNS and CNS depending on the VS abused, duration of abuse and size of dose. Although there is compelling evidence to suggest a relationship between chronic VS abuse and diffuse CNS damage (e.g., brainstem, cerebellum, and cerebrum) there have been too few well-controlled studies to make unequivocal conclusions.

The Importance of the Cerebellum in Cognitive Functioning

The involvement of the cerebellum in VS abuse implies that simple motor functioning will be affected. However, recent research (Leiner, Leiner, & Dow, 1989) has implicated the cerebellum in several higher cortical functions that are important to consider in this study. The cerebellum is thought of a processing enhancer that allows for quicker processing of stimuli. Connections to the prefrontal and Broca's area suggest that the cerebellum is involved in mental and language skills, in addition to its well known connections to the frontal cortex that are associated with motor functioning (Leiner et al., 1989).

Leiner et al. (1989) present evidence that suggests that cerebellar lesions can also result in deterioration of mental and language skills (e.g., temporal planning) depending on the location of the lesion. Areas of functioning that have been implicated in the cerebellum-cerebral network include:

language, learning, word finding, silent arithmetic, planning, and judging time intervals.

A comparison between five patients with circumscribed cerebellar lesions and 10 controls on several neuropsychological tests supports the hypothesis that the cerebellum is involved in mental skills, specifically basic associative learning processes (Bracke-Tolkmitt, Linden, Canavan, Rockstroh, Scholz, Wessel, & Diener, 1989).

Subjects were matched on age and education. The five patients had significantly poorer performance than the Controls on the Wechsler Adult Intelligence Scale-Revised (Verbal, Spatial and General Ability IQs), verbal paired associates test, Benton (number correct and total errors), and conditional learning (total errors). The patients' mean performance on the WAIS-R for General, Verbal and Spatial Ability IQ were 75.6, 74.4, and 91.0, respectively. The Controls' mean performance on the WAIS-R for General, Verbal and Spatial Ability IQ were 95.0, 95.4 and 110.9, respectively. However, the patients did not differ from the Controls on tests of immediate and delayed recall of stories, Digit Span (forward or backward), block-tapping (forward and backward), Wisconsin Card Sorting Test (categories, random errors, perseverations), Street-plan (errors) and Rey figure (copy and recall).

The observed deficit in associative learning for patients was posited to be related to cerebellar lesions. The

patients' impaired performance on the Benton but not on the Rey was confusing and offered no parsimonious conclusion. The decline in IQ by the patients may be related to a general decline in mental functioning or a secondary result of disruption of mood or motivation. Since neither mood nor motivation were assessed, these factors can not be ruled out. Bracke-Tolkmitt et al. (1989) noted that the subjects appeared to be in good spirits and exhibited no signs of clinical depression. The authors further noted that the diffuse damage to the patients' cerebellum made it difficult to evaluate Leiner et al's (1989) hypothesis that different parts of the cerebellum are associated with different cognitive functions.

This new conceptualization of the cerebellum's involvement in mental functioning as well as motor functioning underscores the importance of neuroradiological and neurological findings that indicate atrophy or damage of the cerebellum. Subjects with cerebellar impairments would be expected to possess impairments in mental functioning including planning, associative learning, language, and an overall general decrement in intelligence as well as motor deficits. Location of the insult is of importance in determining what impairments would be expected.

Neurological Studies

The neurological signs of chronic VS abuse involve deficits in the brain stem, cerebellar and cerebral hemispheres and manifest in: gait or limb ataxia, nystagmus,

tremors, dysarthria, hearing loss, loss of vision, olfactory loss, tactile loss, memory loss, poor attention, impaired complex cognitions, and visuospatial dysfunctions (Boor & Hurtig, 1977; Ehyai & Freemon, 1983; Fornazzari et al., 1983; Grabski, 1961; Knox & Nelson, 1966; Lewis et al., 1981; Metrick & Brenner, 1982; and Rosenberg et al., 1988). Almost all of the subjects evaluated in the studies were adults, had long histories of VS abuse, (at least one year) and the primary VS abused was toluene. These studies are a collection of case histories and group studies with no comparison groups.

One report on two cases of VS toxicity highlights the issues of severity of abuse (i.e., duration, frequency, and quantity) and abstinence (prior to testing) in severity of symptoms and possible recovery. Boor & Hurtig (1977) report on a 59 year old optometrist's unintentional toluene poisoning and a 25 year old chronic VS abuser's intentional abuse of toluene for 10 years. The optometrist suffered nystagmus, mild dysarthria, mild hearing loss, and gait and limb ataxia. In the month after discharge and removal of toluene from his office, the optometrist had fully recovered. The chronic VS abuser, upon admission, was unable to ambulate without assistance, had dysarthria and nystagmus. With brief hospitalization the chronic VS abuser was able to ambulate without assistance but still suffered severe gait ataxia and the nystagmus decreased but was still persistent. The patient left the hospital against medical advice and showed no change

in condition nine months later when seen at the hospital for an unrelated reason.

Although it was impossible to quantify the optometrist's and chronic abuser's level of exposure to toluene for comparison and despite obvious differences in premorbid level of functioning, the optometrist's recovery is instructive. The data suggest that severity of VS abuse affects level of impairment and that recovery is possible depending on severity of abuse and abstinence.

Hormes et al. (1985) evaluated 20 adult chronic VS abusers, most of whom were in a recovery program and all of whom had abstained for at least four weeks, on neurological dysfunction (Kurtzke Functional System Scale), cognitive impairment (Orientation-Memory-Concentration test), neurobehavioral functioning (attention, memory, speech and language, and visuospatial), emotional and personality status (affect and thought content), and complex cognition (calculations and idiom/proverbs). They found a pattern of cognitive dysfunction that included: apathy, poor concentration, memory loss, visual spatial dysfunction, and impaired complex cognition. This pattern of cognitive dysfunction was a "frequent feature of toluene toxicity" (Hormes et al., 1985) despite there being no significant relationship found between neurologic impairment and the type or duration of exposure. They suggest that the lipophilic trait of VS leaves the CNS selectively vulnerable.

Rosenberg et al. (1987) did a follow-up on six adult patients reported on in Hormes et al.'s (1986) study, who had abused VS, mainly toluene and methyl chloride, for at least seven years but had abstained for two months while in a drug treatment program. All of the patients scored in the dementia range on the Orientation-Memory-Concentration test and MRI scans of all patients revealed mild to marked diffuse cerebral atrophy and increased ventricular size.

Fornazzari et al. (1983) studied the effects of long-term VS abuse on neurological and neuropsychological tests. They assessed 24 adult chronic VS abusers at intake and then followed 11 of them who remained in the hospital for two weeks. The subjects' mean duration for abuse was 6.3 years +/- 3.9 years and an average daily amount of 425 +/- 366 mg. (or 1.0 +/- .53 can [10 oz]). Toluene was the main solvent abused. Fornazzari et al. (1983) categorized the subjects as impaired or unimpaired according to the number of indicators on a neurological exam. Nine subjects were classified as unimpaired (less than 4 positives) and 15 subjects were classified as impaired. The impaired group had a significantly greater duration of abuse than the unimpaired group (6.93 +/- 3.92 years with daily use of 333 +/- 242.7mg/day and 4.56 +/- 3.2 years with 195.7 +/- 281.1 mg/day, respectively) The unimpaired subjects had no abnormal scores on the WAIS-R (Verbal and Performance IQ), WMS mental quotient, Halstead-Reitan Average Impairment Rating and Heath

Rail Walking. Impaired subjects had abnormal scores on all tests.

Fornazzari et al. (1983) found that the neuropsychological test scores correlated with the neurological and morphological scores. See Table 1.

They interpreted the pattern of results "as indicating a syndrome of functional impairment resulting from profound disturbance of fine motor control, with some concomitant impairment of short-term memory" (p. 327).

No relationship was found between chronicity and level of current abuse and the behavioral and neuroradiological scores. However, Fornazzari et al. (1983) offered that the lack of correlations might be due to the fact that two of the unimpaired subjects were chronic heavy users. They concluded that impairment from chronic use may be related to some factor associated with heavy use or an interaction of factors or erroneous self-report.

Fornazzari et al. (1983) concluded from their study that:

> The principal findings of this study are that long-term chronic inhalation of products containing toluene is associated, in some users, with a behavioral syndrome showing profound impairment of motor control and associated impairment of some intellectual and memory capacity. These behavioral deficits are accompanied by marked brain atrophy, particularly in the cerebellum, but also noted in the cerebral ventricles and cortical sulci" (p. 327).

Table 1.

Correlations Between Neurological, Neuropsychology and IQ Measures

	VIQ	PIQ	MQ	AIR	HEATH	MENTAL	MOTOR
NEURO							
TOTAL	-.23	-.70***	-.52**	.83***	-.82***	.82***	.67***
VIQ		.45*	.57**	-.26	.12	-.22	-.13
PIQ			.62***	-.82***	.61**	-.34	-.67***
MQ				-.67***	.26	-.39*	-.35
AIR					-.65***	.44*	.84***
HEATH						-.50**	-.73***
NEUROMENTAL							.24 *

Note: p<.05, ** p<.01, *** p<.001, (+)=Correlation of opposite sign to prediction, VIQ=Verbal IQ, PIQ=Performance IQ, MQ=Mental Quotient, AIR=Average Impairment Rating, Mental=Neuromental indicators, Motor=Neuromotor indicators.

The small sample size and poor match on other important variables (e.g., SES, education, and age) limit the interpretability of these findings. Of interest is that, with the subjects split according to neurological impairment, the groups differed on neuropsychological tests but no relationship was found between severity of abuse and impairment. Thus it is difficult to understand the relationship between VS abuse and cognitive impairment from these results. No measures of psychological status were obtained. A major strength of this study is the correlation of morphological, neurological and neuropsychological measures, especially the significant correlations between cerebellar damage and cognitive measures.

Summary. Neurological studies on the relationship of VS abuse and cognitive functioning clearly indicate that severe VS abuse is related to diffuse CNS damage that includes auditory, visual, tactile, speech and motor functioning as well as attention, memory, and complex cognitions. Correlations between morphological, neurological and neuropsychological measures suggest VS abuse is related to diffuse CNS damage. However none of the studies found a significant relationship between severity of abuse and level of impairment. In addition, none of the studies specifically looked at adolescents or included other variables that are important to understanding the relationship of VS abuse to cognitive impairment.

Neuroradiological and neurological research provide evidence for a relationship of VS abuse and CNS damage as well as neuropsychological correlates, but there has been little or no mention and control of psychological and social variables that may also influence cognitive performance. Thus it would be of help to review the relationship of personality and social factors on cognitive impairment before assessing the neuropsychological research on the relationship of VS abuse and cognitive impairment.

Psychological and Psychosocial Factors Related to Drug Abuse and Cognitive Functioning

The impact of psychological variables such as anxiety, low self-esteem and depression on testing performance have long been acknowledged. How people respond to the demands of the testing situation is influenced by their character and the state they are in at the time of testing. For example, examinees who are depressed may perform poorer on tasks that require concentration/attention, new learning, motor speed, and motivation.

Developmental Delay and Drug Use. Baumrind and Moselle's (1985) model of drug abuse in adolescence includes a psychological and developmental component. They posit that adolescence is a developmental period to "learn how to adaptively endure the suffering inherent in growth." Adolescents may try to "escape from developmental disequilibrium" inherent in this stage by compulsive drug use

that may be associated with identity diffusion or negative identity or an ultra-conservative life-style that reflects the parents' values and may be associated with identity foreclosure. Any of these strategies are seen as an attempt to maintain a sense of equilibrium or identity that hinders rather than facilitates development.

Baumrind and Moselle (1985) suggest that long-term drug abuse can delay psychosocial development by substituting an easily attained euphoria for the sense of well-being that is experienced through interpersonal relationships and stressful and productive interactional activities. Long-term drug use can produce psychosocial dysfunction that includes a sense of alienation and estrangement, self-derogation, egocentrism, escapism, and external locus of control. Implied in this developmental lag is that the younger the onset of drug abuse the greater the psychosocial dysfunction.

Baumrind and Moselle (1985) posit that one possible antecedent to drug abuse is an "amotivational syndrome" that includes: 1) apathetic withdrawal of energy and interest from effortful activity; 2) uncertainty about long-range goals with resultant physical and mental lethargy; 3) loss of creativity; and 4) social withdrawal from demanding social stimuli. Baumrind and Moselle (1985) argue that recreational and experimental drug use is typical among adolescents, and the fall into drug abuse is in part due to difficulty dealing with stressors that are essential elements of identity development

in adolescence and the resultant stasis or regression of development and concomitant psychological problems.

Several studies support this model of drug use. Recreational drug use is related to adequate psychological functioning, while drug abuse is related to problems with social skills, self-esteem, alienation, apathy, and depression. Abstinence is related to delays in social skills learned from interactions with peer groups.

Deykin, Eva, Levy, Janice, and Wells (1987) administered the Diagnostic Interview Schedule to 424 college student volunteers and found that alcohol is a strong marker of depression in females and drug abuse is highly related to depression and other psychiatric diagnoses in both sexes. The psychiatric disorders tended to predate drug use and abuse. Deykin et al. (1987) conclude that these findings suggest an "amotivational syndrome" precedes substance abuse and that drugs are used to self-medicate painful affects.

Shedler and Block's (1990) longitudinal study of adolescents from preschool through 18 years supports Baumrind and Moselle's (1985) theory. Using a Q-sort technique they found that the best adjusted adolescents were those who experimented with drugs. Adolescents who abstained from any drug use were relatively anxious, emotionally constricted, lacking in curiosity, vitality, warmth and interpersonal skills and were socially isolated. Adolescents who were frequent drug users were maladjusted and displayed

interpersonal alienation, emotional distress (including sadness), poor impulse control, and engaged in overtly antisocial behavior.

The frequent users' and abstainers' maladjustment was present prior to the onset of adolescence and drug use. The frequent users at seven years were having trouble with self-esteem, forming genuine peer relationships, being dependable, and appropriately expressing emotions. Both abstainers and frequent users were judged through observation at the age of five years to have received poor maternal parenting relative to the recreational users. The fathers of the frequent users were judged to be similar to those of recreational users. However, the fathers of abstainers were judged to be authoritarian and did not receive or give any pleasure from being around their children.

Thus these findings suggest that personality variables exhibited as early as the age of 7 years and related to parenting styles are related to whether an adolescent abstains from, experiments with or abuses drugs, and how well adjusted he or she is. Adolescents who abstain from or abuse drugs tend to be maladjusted psychologically. However, the groups did not significantly differ on SES or IQ, as measured by the WPPSI, WISC and WAIS.

Shedler and Block's (1990) finding of poor parenting is reflected in Bonnheim and Korman's (1985) findings that Mexican-American VS abusers belonged to families that were

more disorganized and dysfunctional than Controls. The level of acculturation by family members was not related to VS abuse.

Juvenile Delinquency and Cognitive Deficit. Juvenile delinquency is another important phenomenon that appears to have cognitive deficits related to it that are different than those found in non-delinquent groups of similar or higher SES. According to Wolff, Waber, Bauermeister, Cohen and Gerber (1982) delinquents possess more neurological soft signs and neuropsychological deficits than non delinquents of the same or higher SES.

Delinquents were significantly impaired relative to Controls on nearly all language tasks but did not differ on tasks of attention, spatial, perceptual, and motor abilities after adjustment for nonverbal IQ. The three groups (i.e., delinquents, lower middle class and upper middle class) differed significantly on a nonverbal measure of IQ (IPAT Culture Fair Intelligence Tests) and a receptive language estimate of IQ (PPVT). Minor or soft neurological signs predicted 6 out of 7 language measures for delinquents but such correlations did not hold up for Controls. The authors concluded that the significant language impairments found in Delinquents relative to Controls is a characteristic of that group rather than a non-specific correlate of social-environmental factors. The authors suggest that there is an interaction between neurological insults and

environment. The delinquent and lower middle class group had similar minor or soft neurological signs relative to the upper middle class group but 70% of the delinquent group had disorganized or split up families in comparison to 30% of the lower middle class group.

An important point is that delinquents as a group have a lower nonverbal and verbal IQ but few differences in spatial, perceptual, attentional and motor abilities than controls when nonverbal IQ is controlled.

Because all of the subjects in Wolff et al.'s (1982) study were Caucasians and their native language was English it is inappropriate to fully generalize these results to the present study. It is unclear what the effects of ethnicity and native language have on language impairments. However it is reasonable to suggest that the posited interaction of neurological and environmental factors apply across ethnicity and language. Thus it is anticipated that delinquents who belong to ethnic groups other than Caucasian and\or have a first language other than English will also show language impairments.

Influence of SES on Drug Abuse. Wolff et al.'s (1982) finding that SES and delinquency are discriminating variables is congruent with Chadwick, Anderson, Bland and Ramsey's (1989) finding that suggested SES accounted for the performance differences between secondary school adolescents who reported using VS and those who reported no VS use. When

SES was not factored into the results the VS users had significantly lower estimates of vocabulary, verbal intelligence, full scale intelligence and a measure of impulsivity. They concluded that experimental use of VS did not result in neuropsychological impairment.

Psychological Factors and Drug Abuse. Jacobs and Ghodse (1988) compared 20 adolescents who admitted to regular VS abuse with 27 Controls. The VS abusers reported significantly more depressive symptoms, as measured by the General Health Questionnaire-28 and the Great Ormond Street Mood Questionnaire. Subjects were similar in age, situational circumstances, and social class with the exception of VS abusers having slightly more adverse circumstances than the Controls. All but two subjects in the Control group admitted to using at least one drug and preferred cannabis over all other drugs. The VS users tended to be arrested at an earlier age than the Controls (11.6 years vs 13 years, respectively).

Zur and Yule's (1990) comparison of depression in 12 delinquent adolescent VS users and 12 delinquent adolescent non-abusing Controls found that severe VS users were more depressed than moderate VS abusers and non-abusing Controls. Although they also assessed neuropsychological functioning they reported those findings in a separate article and made no connection of the two. See below for the results.

Summary. Taken together the data support the proposition that SES, juvenile delinquency status, family organization and

psychological status are related to cognitive performance on neuropsychological tests. Juvenile delinquents as a group tend to have lower verbal and nonverbal intelligence and more neurological soft signs than subjects from the same or higher SES. The deficits manifest in language skills but do not affect attention and spatial and motor abilities when nonverbal intelligence is controlled for. The type of family environment is also important in that juvenile delinquents tend to have similar soft neurological signs in comparison to the same SES but a greater frequency of disorganized or split up families and language impairments. Family organization also was slightly different for adolescent VS abusers when compared to controls in Korman and Bonnheim's (1985) study. In addition, VS abusers appear to experience more depressive symptoms than Controls. Thus juvenile delinquent VS abusers are expected to have added difficulties (family organization and depression) that compound an already vulnerable situation leaving less environmental support and psychological integrity to help habilitate deficits in addition to the neurotoxic effects of VS abuse. It will be important to keep in mind the social and psychological correlates of cognitive impairment when reviewing neuropsychological studies on the correlates of VS abuse and cognitive impairment.

Neuropsychological Studies

The study of neuropsychological effects of chronic VS abuse has become more sophisticated from the early studies

done in the 1960s. Neuropsychological measures have been developed to provide a better measure of sensitivity to impairment and functionality. Methodology and statistical analyses have also improved. However, despite all these improvements there remains inconclusive data on and no clear model of neuropsychological effects of chronic VS abuse. The data do offer insight into the complexity and difficulty of this type of research and there is some consistency with findings from neurological and neuroradiological studies that can be used to suggest a model of cognitive impairment related to inhalant abuse.

VS abusers with long histories of abuse have displayed impairments in cognitive functioning. Boor & Hurtig (1977) reported on a 25 year old patient with a 10-year history of chronic VS abuse, primarily toluene, who performed a serial sevens task poorly, seemed intellectually dull but did not show any signs of aphasia and his recent memory was intact. He displayed neurological signs and had a CT scan with diffuse cerebellar and cortical atrophy. He began VS abuse around the age of 15 years and was a polydrug user. He then gradually became a full-time VS user for the last five years inhaling on a daily basis with severe abuse, that is almost constant use, in the last six months prior to hospitalization. Although this is a case study, it suggests that long-term VS abuse is related to decreases in overall cognitive performance. However, because other measures and controls were not used it

is difficult to make any conclusions from this study.

Lewis et al.'s (1981) report on two patients who were chronically abusing VS is similar to Boor and Hurtig's (1977) case study in that it reflects the inherent confounds in such research. One patient was 28 years old upon examination and had abused toluene for 14 years on a daily basis. He reported first noticing a slight hand tremor after six years of abuse which worsened after eight years of abuse. His performance on the WAIS placed him in the mildly mentally retarded range of intellectual functioning. He dropped out of school at 14 years and had receptive and expressive aphasias and profound impairment of immediate memory for language. As mentioned above a CT scan revealed systematically enlarged lateral ventricles and prominent cortical sulci, enlargement of the superior cerebellar cistern, quadrigeminal cistern, and brain stem cistern. That is, he suffered from diffuse atrophy of the brain. The authors concluded that he suffered problems in all realms of functioning (social, cognitive and emotional).

The second subject was a 28 year old male who presented upon admission with an acute psychotic episode. He reported sporadic binges of glue sniffing since he was 12 years old with long periods of abstinence. He came from a large family with several siblings having mental retardation or schizophrenia. He had some neurological symptoms but an otherwise intact CNS.

Both of these subjects reported VS abuse. However one

subject reported repeated, chronic abuse that worsened with time and had concomitant neurological involvement. He had no history of mental illness. The other subject had a familial history of schizophrenia, his own diagnosis of schizophrenia and sporadic VS abuse over a long period of time. The data suggest that it is the chronic repeated long-term VS abuse that is very deleterious and other patterns of abuse may be less toxic. But it is impossible to make such a conclusion from these studies alone.

Tsushima & Towne (1977) utilized several neuropsychological tests to compare the effects of chronic VS abuse to mild polydrug use. 20 chronic VS abusers with polydrug use (age range of 11 to 24 years), primarily using paint with toluene as the main ingredient and aliphatic hydrocarbons and petroleum distillates as other ingredients, were equated on sex, age and education with 20 mild polydrug users (age range of 9 to 25 years) who did not abuse VS.

Tsushima & Towne found 11 of 13 measures to be significantly different at $p < .05$. Differences on tests that measured primarily psychomotor functioning as well as attention and concentration ranged from strongly significant, $p<.001$, to nonsignificant. VS abusers took significantly longer time to place grooved pegs in a pegboard than Controls with both their dominant and nondominant hands ($p < .01$ and $p<.001$, respectively). VS users completed significantly fewer symbols than Controls ($p < .001$). VS abusers made

significantly fewer taps than Controls ($p < .05$) when using their dominant hand but did not differ when using their nondominant hand. Finally, VS abusers took significantly more time ($p < .05$) to complete a visual-motor sequencing task than Controls but did not differ on a more complicated visual-motor sequencing task.

Performance on a task that primarily requires auditory memory for rhythms and attention and concentration revealed that VS abusers made significantly more errors ($p < .05$) than Controls. On a test of concentration, reaction time, and flexibility (Stroop A, B, & C) VS abusers made significantly fewer correct answers than Controls in all three situations ($p < .01$, $p < .01$, & $p < .001$). On a test that primarily measures visual-spatial memory in addition to attention and concentration and psychomotor functioning VS abusers made significantly more errors than Controls ($p < .01$). Finally on a test of receptive vocabulary (Peabody Picture Vocabulary Test) VS abusers correctly identified significantly fewer pictures than Controls ($p < .001$). The PPVT was used to estimate verbal intelligence and the performance of the two groups suggested that VS abusers had a significantly lower verbal intelligence than Controls ($M = 71.6$ and 93.2, respectively).

The performance on the Trail Making Test Part B is of interest in that VS abusers' mean performance differed greatly from nonVS users' mean performance (M=92.75 sec vs 68.80 sec,

respectively). This suggests that VS abusers have an impairment in visual-conceptual, visual-motor tracking and cognitive flexibility or complex conceptual tracking. However, there was such a huge variability in scores within the VS and Control group (SD=62.08 and 22.25, respectively) that no significant difference was found between groups. On the other hand, variability in performance on part A of the Trail Making Test was more similar between the groups and the means were significantly different (M=35.70 sec and 28.70 sec, respectively).

In addition, VS abusers tapped their dominant hand finger significantly slower ($p < .05$) than Controls but did not differ on their nondominant hand. Upon closer examination, the statistical difference between means for each group was not clinically meaningful (M=51.25 and 55.54, respectively). However, the wider and clinically significant difference between dominant and nondominant hands for both groups suggests some sort of psychomotor impairment for both groups. Thus, both groups appeared impaired in psychomotor functioning and possibly there were other impairments that may be related to factors other than VS abuse. No measures of SES, family organization, or psychological variables were obtained.

Tsushima and Towne (1977) found a strong correlation ($r = .65$, $p < .001$) between number of years used and number of cans consumed on a daily basis. Subjects with a longer duration of use consumed more VS on a daily basis. Subjects

with the longest duration (over 11 years) had the worse performance on all tests with the exception of intelligence but it was not significantly different from the other three groups.

Tsushima and Towne (1977) acknowledged that the detrimental effects seen might be a result of acute intoxication as subjects reported being intoxicated the day prior to testing but were not intoxicated on the day of testing (although they provide no information on how they tested that).

The strong correlation of duration with daily consumption suggests that the poorer performance by subjects with over 11 years of use may be due to greater acute effects because of greater usage prior to testing. The hypothesis that IQ and performance within the VS group should be different across duration if IQ has a selection effect might be misleading in that there are confounds of acute intoxication, and severity abuse. In addition, given the diffuse damage of VS abuse, receptive vocabulary would probably be the most resilient to impairment.

Although Tshushima and Towne (1977) found 11 of 13 significant differences in performance between a group of VS abusers and mild polydrug users with no VS use, it is difficult to meaningfully interpret these findings. No hypotheses were generated a priori and no adjustment for the increase of chance findings were made. The most robust

findings ($p < .001$) were the large differences in estimated Verbal IQ (M= 71.60 and 93.20, respectively), psychomotor functioning (i.e., Grooved Pegboard-nondominant hand and Coding), and cognitive flexibility (Stroop C). If we were to apply a less conservative criterion ($p < .01$) then we would strengthen the above categories of impairment and add a new one - new learning. In the psychomotor category we would add performance of the dominant hand in the Grooved Pegboard test. To cognitive flexibility we would add the Stroop A & B. New learning of visual-spatial images was also significantly poorer for VS abusers. The three remaining measures that were significantly different between groups at the $p < .05$ level include: Finger tapping- nondominant hand, Trail Making Test-Part A and Seashore Rhythm Test.

The results of this study are consistent with the hypothesis that VS abuse is related to diffuse CNS damage that is manifested in decreases in psychomotor speed, attention/concentration and new learning. However, other variables may be involved in these results especially given the inconsistencies in psychomotor tasks and the large difference in VIQ. In addition, the short time from last incident of inhalation confounds the difference between acute and chronic effects of intoxication.

Berry, Heaton & Kirby (1978) studied the effect of chronic VS abuse on cognitive functioning for adolescents by using a battery of neuropsychological tests. The 37 chronic

VS abusers tended to abuse metallic paints and clear paints and varnishes, had abused other substances and ranged in age from 14 to 29 years with a mean age of 18.3 years. The range of VS abuse spanned 1.5 to 7 years (mean = 5.5 years) and frequency averaged 3.7 times per day. The 11 subjects in the Control group ranged in age from 15 to 27 years with a mean age of 17.4 years. They reported no VS abuse and were matched with the VS group on other substances used. Drugs used by subjects in both groups included: heroin, cocaine, hallucinogens, barbiturates, amphetamines, marihuana, and alcohol. Subjects from each group were similar in age, sex, ethnicity, educational level (i.e., 9.7 years and 8.6 years, respectively with only 16% attending school or employed at the time), SES and cultural background. Both groups had several arrests and convictions (5 and 4.9 arrests and 2.3 and 1.4 convictions, respectively) and similar frequency of fathers and mothers abusing alcohol (33% and 27% for fathers and 5% & 9% for mothers, respectively), but differed somewhat on siblings abusing alcohol (64% and 29%, respectively).

Berry et al. (1978) computed 38 t-tests and found VS abusers performed significantly poorer on 12 tests. Four tests were significant at the .01 level (Comprehension, TPT-total time per block, Halstead Impairment Index, Story Memory-trials to criteria) and 8 tests were significant at the .05 level (VIQ [88.16 & 96.82]; FSIQ [89.97 & 97.73], TPT-memory [8.14 & 8.82]; Average Impairment Rating [1.29 &

1.01]; Tactile Form Recognition-sec [17.66 & 15.36]; Grip Strength [79.53 & 96.00kg]; Maze Coordination errors [42 & 28.45]; and Story Memory information/trials [7.89 & 13.50]).

Berry et al. (1978) omitted any subjects with a FSIQ less than 80. 60% of the chronic VS abusers scored in the Dull Normal range (i.e., 80-86) while only one Control subject scored in that range. Subjects' performance on tests of attention/concentration and psychomotor functioning were not significantly different, beyond there being a general one point lower performance for chronic VS abusers than Controls. The large difference in VIQ, with the largest difference in Comprehension suggest some other variables may be influencing the score. Both groups were similar in their poor performance on Information, Arithmetic, and Vocabulary subtests suggesting poor educational and cultural experiences. Perceptual-organization tasks were consistent between groups with the exception of the clinically important difference between PIQ (93.92 & 99.55, respectively).

From the results Berry et al., (1978) concluded that:

> "...inhalant abusers are more deficient than the controls in accumulated knowledge (Verbal I.Q.) and a variety of current adaptive abilities dependent upon brain functions (expanded Halstead-Reitan Battery). Moreover, previous validation research with the neuropsychological test battery employed in this study strongly suggests an organic etiology for many of the deficits shown by the inhalant subjects." (p.130)

Berry et al., (1978) stated what Ron (1986) would later reiterate about the state of research done in this field.

> "Although previous studies provide contrasting conclusions, methodological differences with the present study make them not directly comparable. The previous investigations have studied fewer inhalant abusers with less extensive histories of abuse, have not used very comprehensive or well-validated neuropsychological test procedures, or have not compared inhalant test performance scores with those of an adequate groups of control subjects. We reiterate that there are also several limitations on the conclusions which can be drawn from our own preliminary data. However, the ability deficits noted with our inhalant subjects are of sufficient magnitude to warrant concern and continued research into the possibility that extensive recreational inhalation of these substances may cause irreversible effects on the central nervous system" (p. 130).

Some limitations to the generalizability of Berry et al.'s, (1978) work include poor control of recent abuse, no a priori hypotheses, no correction for findings given the number of tests performed, and no measure of psychological status.

Korman, Matthews, & Lovitt (1981) studied frequency of VS abuse on cognitive functioning. They compared 68 adolescents who were "heavy" chronic VS abusers to 41 adolescents who abused other drugs but not VS. They utilized the WISC-R, Halstead-Reitan, and WRAT-R, to measure cognitive functioning and concluded that the impaired performance on WISC-R (VIQ and PIQ), WRAT-R, Speech Sounds, Visual Suppression, Sensory Perception and Trails Making Test for chronic VS abuse relative to other drug users suggest deficits in a broad array of cognitive skills. There were several limitations to this study that must be carefully considered. Korman et al. (1981) did not report on how they controlled for the possibility of the inhalant abusers being intoxicated at the time of testing or within 24 hours prior to testing. Thus the inhalant

abusers may have been intoxicated during the testing. They did not report their criteria for heavy inhalant use. The subjects were not matched on age, IQ, or education, although an ANOVA was applied to separate out the effect of age on test performance. Korman et al. (1981) did not measure SES, psychological status, or criminal history. Given the large number of statistical analyses performed and low number of subjects a number of tests would be found significant by chance alone and Korman et al. (1981) made no attempt to correct for this. Six of the measures used were redundant (e.g. total Wechsler Performance IQ and Performance Scaled Scores).

In a pilot study, Allison & Jerrom (1984) used a more sophisticated methodology to study the effects of long-term VS abuse on juvenile delinquents. They matched 10 juvenile delinquents who had a long history (i.e, mean of 4.6 years with range of 3 to 8.5 years) of chronic solvent abuse (i.e., glue that contained toluene and acetone) with 10 juvenile delinquents who did not abuse solvents on age, educational level, and reading level. They then compared the two groups' performance on the WISC (Vocabulary and Block Design), Wechsler Memory Scale (WMS), and Paced Auditory Serial Addition Task (PASAT) (attention & concentration) and found that chronic abusers performed significantly lower on Block Design, WMS mental quotient, long term recall of visual reproduction tests, and PASAT. The two groups did not differ

in performance on Vocab, and WMS (information, orientation and long-term recall of logical memory).

Although the subjects were tested well after their admission at the school, Allison and Jerrom (1984) caution against any assumption that the solvent abusers were not intoxicated during testing. Although none reported recent use, without any objective assessment such as a blood sample acute intoxication can not be ruled out. One limitation to their work is a very small sample size. In addition, they did not use measures that are sensitive to a cerebellum syndrome such as Coding, Finger Oscillation, and Grooved Pegboard and that other studies have utilized. Thus it is difficult to compare these results with the common findings of involvement of the cerebellum.

Zur & Yule (1990) looked at the effect of duration and quantity of VS abuse. They compared 12 long-term VS abuse (i.e., had at least one year and 5x/week or two years and 3x/week of abuse) with 12 non VS abusers on measures of symbol digit coding (correlated with Digit Symbol on the WAIS), visual spatial ability (correlated with Block Design on the WAIS), visual perceptual analysis (similar to Picture Completion on the WAIS), and visual recognition memory using the Bexley Maudsler Automated Screening system (BMAPS). They also administered the WISC-R. The chronic abusers performed significantly worse on symbol digit coding and visual perceptual analysis. There were no significant differences in

performance on the WISC but there was a trend for a difference on performance in digit symbol, visual recognition memory and verbal memory. The lower performance for digit symbol is consistent with other findings.

Although the subjects were not matched they were similar on years at school, school absences, SES and FSIQ. The groups did differ on age and abuse of other drugs or alcohol. Differences in age and abuse of other substances are problematic in assessing performance differences and possible correlates of differences in performance. In addition, the small sample size and testing at least 24 hours since last intoxication limit interpretation and generalizability of results. Finally, it is difficult to compare these results to other studies because of the limited cross over of neuropsychological measures.

Neuropsychological Research with Nonsignificant Results. There is research of chronic VS abuse that does not support the conclusion that chronic VS abuse results in neuropsychological impairment. Grabski (1961) found in a case study of a 25 year old male with a six year history of VS abuse (mostly toluene) that orientation, memory, and intellectual functioning to be within normal limits despite evidence of a cerebellar disease. The patient had started inhaling toluene at work and degenerated to inhaling pure toluene at home and his mental status deteriorated.

Knox & Nelson's (1966) follow-up of Grabski's patient

after an additional eight years of almost daily VS abuse revealed that the overall WAIS performance was similar to earlier results but that the most recent subtest scores were more erratic than before. The subtests of Block Design and Similarities were well performed while Digit Symbol was impaired due to hand tremor.

Glaser & Massengale (1962) presented a case study of 6 boys who were brought to the hospital and reported solvent abuse (primarily glue). They found the physical exams to be within normal limits. The results from randomly administered psychological testing were nonsignificant.

Massengale, Glaser, Lelieuve, Dodds & Klock (1963) tested 27 adolescents with a history of glue sniffing and found no physical or neurological abnormalities. The intelligence scores of 16 subjects did not differ from those of non glue sniffing subjects. The two groups were similar in age, ethnicity, SES and delinquency background.

Dodds and Santostefano (1964) compared 12 boys who were arrested while intoxicated from sniffing glue to 21 Caucasian boys randomly selected from a public school. The delinquent boys were tested at least 14 hours after their arrest. As a group, they had been sniffing glue from 3 to 42 months with a total number of sessions from 4 to 1200. Their age ranged from 12 to 15.9 and 10 of the boys were Hispanic. The Control group was similar in age. Dodds & Santostefano (1964) found no relationship between the age and performance or

intelligence and performance for either group. They found no differences in performance on the tests administered to both groups (i.e., Level Sharpening Test, Memory Drum Test, Color Block Test, Benton Visual Retention Test, and Incomplete Figures Test). The delinquent boys were given the Ammons Full-Range Picture Vocabulary Test to estimate their intellectual level and the Control group of boys were given the WISC and California Mental Maturities Test.

Summary of Neuropsychological Research. In summary, studies on the cognitive effects of chronic VS abuse by adults and adolescents have been inconclusive. Some studies provide global measures of cognitive functioning with significant results but these measures do not help in addressing posited diffuse damage by VS. Studies with more sensitive and specific measures provide some support for the neurological and neuroradiological findings of diffuse brain atrophy (i.e., psychomotor speed, attention/concentration, and new learning). However, there has been much inconsistency in assessing psychological, social and SES factors as well as abstinence. Independent studies suggest that these are important variables to consider.

In addition, severity of abuse has been equivocal in predicting outcome. Studies that do not support negative effects of VS abuse tend to use very global measures or are poorly designed. Chadwick et al.'s (1989) findings suggest that severity of abuse and SES are important variables to

consider. Thus, future studies should incorporate tests sensitive to diffuse brain damage, social, psychological and SES measures, control for abstinence and assessment of severity of abuse.

It is clear that chronic VS abusers develop diffuse brain damage. Some tests that have been sensitive to differences between groups include: WISC-R (VIQ, Block Design, Digit Span, and Coding), Trail Making Test A (seconds), and Grooved Pegboard. In addition, Bracke-Tolkmitt et al. (1989) found that five patients with cerebellar lesions performed significantly poorer on Spatial Ability (a correlate of PIQ) and the Benton (correct and errors).

Summary

Neuroradiological and neurological measures have shown diffuse CNS insults (that include the cerebral, cerebellum and brainstem areas) with subjects who have severe histories of VS abuse. Neuropsychological measures have also shown diffuse cognitive impairment with severe inhalant abuse but no conclusive evidence has been found. Psychological status, SES, juvenile delinquency, and family organization are all related to drug abuse and/or neuropsychological performance and must be included in any research on the relationship between VS abuse and neuropsychological functioning. Several difficulties in methodology leave the question of how VS abuse is related to neuropsychological functioning unanswered at this time.

One difficulty in the research has been the time of testing. Volatile substances are lipophilic and can take up to several days (72 hours) to be released from the body (Ron, 1986). In this study subjects were tested between 3 to 10 days after they had been incarcerated and had little, if any, exposure to VS. Thus the subjects were not acutely intoxicated when tested unless they had covertly inhaled.

Another concern with the research is the variety, sensitivity and inconsistency of instruments administered to measure the effects of chronic VS abuse. The documented neurological effects of chronic VS abuse include gait ataxia, tremors, nystagmus, loss of hearing, sight and taste, to name a few, which imply global cognitive impairment as well as fine and gross motor, ocular, olfactory and auditory impairment. This study will utilize several of the most common and useful measures of neuropsychological functioning (i.e., WISC-R, Trails A & B, Grooved Peg Board, Benton, and WRAT-R).

Of interest in this study is how much variance in any observed differences in performance between VS abusers and controls is accounted for by psychological, social and drug abuse variables. It is possible that the level of severity of inhalant abuse in this sample is insufficient to primarily account for any cognitive deficits and that psychological and/or social variables may account for a greater proportion of variance in any cognitive deficits observed. A biological,

social and psychological model of drug abuse superimposed on the suggestion that juvenile delinquents suffer from cognitive deficits independent of social status requires that severity of inhalant abuse, psychological status and social status be measured.

Inferred from the diffuse cerebral, cerebellar and brain stem damage associated with inhalant abuse is that inhalant abusers should suffer deficits in psychomotor speed, new learning, and attention/concentration. It is also possible that an overall decline in intellectual performance is related to inhalant abuse, especially with the involvement of the cerebellum, but motivational or psychological factors may also explain overall declines in performance. Aspects of cognitive functioning that are expected to remain intact are long-term memory and language. Long-term memory and language may be poor due to other factors related to the juvenile delinquent population, (e.g., interaction of environment and neuropsychological deficits).

A Model for Cognitive Impairment

Intellectual functioning is related to a number of variables. The biological integrity of the individual, both inherited and developed, cultural exposure and psychological status are intertwined in determining the current level of intellectual functioning.

Baumrind and Moselle's (1985) model of drug abuse includes psychological and developmental components that are

affected or altered by drug abuse. Inferred from their model is that drug abusers tend to halt their development at the level that their drug use becomes abuse. Drug abuse tends to exacerbate the poor psychological health and mental functioning of the abuser by delaying the interpersonal experiences necessary for development. Studies have shown that inhalant abusers tend to display greater psychological distress and have a higher prevalence of chaotic families than other drug abusers. The diffuse neurotoxic effects of inhalant abuse on the CNS imply that the insult to the brain worsens the developmental impairment.

The environmental, psychological and biological deficits that inhalant abusers tend to possess suggest that they will have more diffuse and greater deficits than other drug abusers. Diffuse deficits will be manifest in decreased psychomotor speed, attention/concentration and new learning. Areas resilient to diffuse deficits (long-term information and language) will remain intact. This is expected in addition to the finding that juvenile delinquents who participated in this study tend to have a greater frequency of learning disabilities (language deficits) and a lowered intelligence.

Hypotheses

Given the inconclusive findings related to the long-term effects of chronic volatile substance abuse it is difficult to posit any highly dependable hypotheses. However, several studies offer some insight. Thus the following hypotheses are

posited:

1) Subjects in the VS abuse group will have an overall lower performance on neuropsychological tests (Full Scale IQ, Verbal IQ, and Performance IQ on the WISC-R Split Half) than subjects who do not abuse volatile substances.

2) Subjects in the VS abuse group will have lower scores on neuropsychological tests that are sensitive to global or diffuse brain insult. These areas include: psychomotor speed (as measured by Grooved Peg Board, Trail Making Test A & B, and Coding), new learning (as measured by Block Design, Picture Arrangement, Digits Backwards and Benton) and attention and concentration (as measured by Digits Forward).

3) Intact or long term memory and abilities (i.e., general knowledge and language) are expected to be resilient to diffuse brain injury and thus be the same across groups. It will be measured by Information, Arithmetic, Vocabulary, and Picture Completion subtests on the WISC-R Split Half and the three subtests on the WRAT-R (Reading, Spelling and Arithmetic).

4) All subjects across groups in the study will have lower performances on the neuropsychological tests and greater psychological distress than the norms for the tests.

5) Subjects in the VS group relative to the other group will have a greater frequency of (number of scales positive) and quantity (number of symptoms reported) of psychological distress (as measured by the SCL-90-R or BSI). Subjects in the VS group will also have poorer attributes related to autonomy and identity (i.e., this is to include measures of academic goals, employment, suicidal behavior, outpatient treatment of mental illness and drug abuse, participation in sports, church attendance, and gang membership).

6) Subjects in the VS group relative to the other group will have a greater frequency of family problems (i.e., this is to include measures of family status, family composition, family drug abuse behavior, and sexual abuse).

7) Both groups will display learning disabilities, especially problems with language (as measured by the WRAT-R and WISC-R).

Analysis Plan and Expected Results

An array of statistics will be utilized to test the a priori hypotheses.

To test the first two hypotheses (that VS subjects will have lower IQs and poorer performance on tests sensitive to diffuse brain insult) a mixed design Between and Within Subjects Repeated Measures ANOVA will be done where each subject's performance on the intelligence and neuropsychological measures will be compared to see if the

pattern of performance within each subject and between the two groups is different in any way. From the mixed design Between and Within Subjects Repeated Measures ANOVA a follow up analysis as explained in DeWolfe & Davis (1972) will be done for any interactions found.

A liberal definition of VS group eligibility (i.e., subjects report VS use) will be used to maximize the number of subjects in the VS group, to explore the robustness of the hypothesized differences, and draw conclusions about the population. The dependent measures that will be used include: WISC-R measures (i.e., FSIQ, VIQ, PIQ, Digits backward, Digits forward, Coding, Block Design, Picture Arrangement) Grooved Pegboard, Benton, and Trail Making Test A & B. Together these measures indicate overall intelligence, psychomotor speed, attention/concentration, and new learning.

The criterion for VS group membership will be modified to explore different VS use characteristics (e.g., narrowed to reflect a group that prefers VS to other drugs). This strategy of beginning with the largest sample group possible and then applying different criterion for VS group membership will be employed throughout the analyses suggested in this section. The purpose of such a strategy is to maximize the power of the analyses while simultaneously remaining aware of the complexity and difficulty of studying this population. That is, several

factors may interact and must be considered if more general criteria fail to show significant results.

To evaluate the third hypothesis (that the groups will not differ on tests of long-term memory or language) a Student's t-test will be done using a computed mean from both groups. Several scores from each group will be mathematically combined to create a new mean. The subjects' scores from the WISC-R (Block Design, Picture Arrangement, Coding, Digits forward and backward) and the Benton, Grooved Pegboard, and Trail Making Test A&B will be added together after they are transformed into a standard score and then another set of WISC-R measures (Information, Arithmetic, Vocabulary, and Picture Completion) and WRAT-R measures (Arithmetic, Reading and Spelling) that are sensitive to long-term memory and language functioning will be subtracted to make a new mean for each group. These later measures will also be appropriately transformed. The former measure is expected to be specifically lower for the VS group than Controls and the latter measure is expected to be the same between groups. Separate t-tests of each of the latter measures will be done and follow up analyses from the previous hypothesis testing will be used to help explain the results.

To evaluate the fourth hypothesis (that both groups will show more neuropsychological deficits and psychological distress (SCL-90-R or BSI) than non juvenile

psychological distress (SCL-90-R or BSI) than non juvenile delinquents) the means for both groups on the relevant measures will be compared to appropriate norms using t-tests (one for each group against the norms).

To evaluate the fifth hypothesis (that the VS group will show more psychological distress than the Control group) another mixed design Between and Within Subjects Repeated Measures ANOVA will be done using the clinical scales and indices from the SCL-90-R or BSI. It is predicted that the VS group will have significantly greater scores on the scales for depression, interpersonal sensitivity, anxiety, hostility, and the indices of GSI and PST. It is unclear if subjects will differ on scores for obsessive-compulsive, somatization, psychoticism, paranoid ideation, and phobic anxiety and the index PSDI (magnitude of report of severity of symptoms). Follow up analyses will assess all possible interactions and simple effects. Chi-squares will be used to assess differences between drug groups on categorical questions (i.e., gang membership, employment, participation in sports, highest grade hope to achieve, church attendance, treatment for mental illness or drug abuse (both inpatient and outpatient), and suicide attempt.

To test the sixth hypothesis (that VS abusers will have more family problems than Controls) several Chi-squares will be done using the following variables: family

organization, family status, family drinking behavior, and sexual abuse.

To test the seventh hypothesis (that both groups will have learning disabilities) the difference between the VIQ and PIQ for both drug groups will be compared with the general rule of greater than +/- 15 points suggests a learning disability. Each subject's WRAT-R scores will be subtracted from their Full Scale IQ (FSIQ) score to make another determination of learning disability. The general rule of the WRAT-R scores being -15 points (one standard deviation) below the FSIQ score will be evoked. A t-test on each of the differences between WRAT-R subtest scores and FSIQ for each drug group will be done to see if the differences are statistically significant.

A general index of individual health using the categorical variables relating to psychological functioning will be constructed by assigning a positive value for each variable when negative (e.g., +1 for yes to gang membership) and then summating the scores for each subject. The categorical variables that when combined result in an acceptable level of internal consistency will be selected. A t-test will be done to compare how the drug groups compare on this index. A similar index will be constructed for family problems and drug problems. Then t-tests will be done comparing the two drug groups on these indices. It is expected that the VS group will have more individual and

family problems and a greater drug problem than Controls.

The influence of several potential confounds, namely age of onset of drug use, number of drugs used, severity of drug use, drug use in last 30 days, highest school grade achieved, SES (i.e., parents' occupation), age, and ethnicity will be assessed using chi-square, t-test, correlation or ANOVA when appropriate. It is anticipated that greater use prior to 30 days will be related to lower scores for the VS group relative to Controls.

A comparison using t-tests chi-squares between the drug groups on age of onset of drug use and prevalence of drug use will be done for each of the 14 drug categories. The results will be interpreted.

CHAPTER III

METHOD

Subjects

There are 941 subjects in this sample with 793 male and 148 female. There are 95 (10.1%) Caucasians, 175 (18.7%) African-Americans or Other, and 667 (70.9%) Mexican-Americans. The mean age of the total sample is 14.77 years with 81% 14, 15 or 16 years old and a range of 10 to 18 years. The mean current grade is 8th grade with 51.1% in the 8th or 9th grade and a range of 5th to 12th grade. There are 558 (60.3%) subjects who are enrolled and attending school, 226 (24.6%) are enrolled but not attending school and 138 (15.1%) are not enrolled in school. About half (49.5%) of the sample comes from single parent homes, with 19% reporting both parents at home, 15.9% reporting having a biological and stepparent and 15.3% reporting some other living arrangement. Employment status of mothers include 57.2% unemployed, 25% holding semi-skilled jobs 13.3% with skilled jobs, and 3.7% with professional jobs. The employment status of fathers include 45.1% unemployed, 22.1% with semi-skilled jobs, 23.7% with skilled jobs, and 5.8% with professional jobs. The severity of drug problem (no problem, moderate problem

and severe problem) was about equally distributed across the sample (31.9%, 32.5% & 35.7%). The number of drugs subjects reported taking ranged from 0 to 14 with 40.7% of subjects reporting taking 2 or 3 drugs.

Subjects were detained at a juvenile detention center located in a large city in the Southwest, for more than three days, assessed to have a severe drug problem and have been given the neuropsychological test battery and a semi-structured social history interview. Their information was collected from the archives at the agency doing the project.

Delinquents who were detained at the detention center for less than three days or did not have a severe drug history were not tested due to limitations in time and personnel. Some delinquents who had a severe drug history and stayed at the detention center for more than three days were not tested due to problems in coordinating a time to test around court time and the delinquents release. By virtue of the sample the subjects have two common variables, detainment and severe drug abuse history.

Measurements

Benton Visual Retention Test (Administration A, Form D). Subjects are shown ten geometric designs individually for ten seconds and asked to draw each one once the card is removed from sight. This test was designed to measure perception, visuo-motor functioning and memory. Larabee,

Kane, Schuck, and Francis (1985) report that on a factor analysis it loads primarily on a visual-perceptual-motor factor and secondarily on a memory-concentration-attention factor. It is sensitive to brain damage but has poor predictive ability. The subjects' number of correct designs drawn and number of errors were analyzed.

The Brief Symptom Inventory (BSI). The BSI (Derogatis & Spencer, 1983) is a 53 item self-report symptom inventory that uses a 5-point scale of distress to measure the current psychological symptom status of the individual. It is a shortened version of the Symptoms Checklist-90-Revised. It measures the same nine symptom dimensions and three global indices of distress as the SCL-90-R. The items on this shortened form were those with the highest loading on each dimension. Typically respondents are asked to consider the past week of their life as a frame of reference when answering the questions. Thus the test is a measure of psychological symptom status rather than personality types. Alpha coefficients using Cronbach's coefficient alpha ranged from .71 for the Psychoticism scale to .85 for the Depression scale. Test-retest stability for a two-week interval found correlation coefficients ranging from .69 for the Somatization scale to .91 for the Phobic Anxiety scale.

The Lafayette Grooved PegBoard Test. Subjects are provided a board with a 5 X 5 matrix of grooved holes and

25 slotted pegs to be placed in them. The grooves are randomly positioned. Subjects are asked to place the slotted pegs in the grooved holes as quickly as possible using only one hand. This is a sensitive test of visual-motor coordination and manipulative dexterity that requires more complex visual-motor coordination than other pegboards because of the need to align the slots on the peg with the grooves in the board (Lafayette, 1989). The dominant hand is used first and the nondominant second. Time to complete the test and number of errors (drops) for both dominant and nondominant hands were analyzed. This test is sensitive to lateralized brain damage and normative data have been collected by Knights & Norwood (1980).

Semi-structured Interview. A semi-structured interview that covers drug history, family history, social history, educational history, and other social information.

Symptoms Check List-90 -Revised (SCL-90-R). The SCL-90-R (Derogatis, 1976) is a 90 item self-report symptom inventory that uses a 5-point scale of distress to measure the current psychological symptom status of the individual. There are 9 primary symptom dimensions and 3 global indices of distress. The nine clinical scales include: 1. Somatization, 2. Obsessive-compulsive; 3. Interpersonal Sensitivity; 4. Depression; 5. Anxiety; 6. Hostility; 7. Phobic Anxiety; 8. Paranoid Ideation; 9. Psychoticism. The three general indices include: 1. Global Severity Index

(GSI); 2. Positive Symptom Distress Index (PSDI); and 3. Positive Symptom Total (PST). The GSI represents the current level of psychological distress the subject is experiencing and combines the number of symptoms and level of distress. The PSDI represents the response style of the subject in reporting symptoms (i.e., repressive or sensitive) and the average level of distress. The PST represents the number of symptoms the subject reports as having to any degree. The SCL-90-R may be utilized with adolescents down to 13 years of age and was used with younger subjects if they were assessed to be able to read and comprehend it. The alpha coefficients ranged from .77 for the Psychoticism scale to .90 for the Depression scale. Test-retest stability for a one-week interval found correlation coefficients ranging from .787 for the Hostility scale to .90 for the Phobic Anxiety scale. T-scores for the nine clinical scales and the three indices were analyzed.

Trail Making Test A & B. This is a test of attention, mental flexibility, motor function and speed for visual search (Spreen and Strauss, 1991). Subjects are given a piece of paper with randomly placed numbers or numbers and letters (A & B respectively). They are told to connect the numbers or numbers and letters sequentially and given a practice test. Subjects are then corrected if necessary, and then instructed to work as quickly as they can on the

test form. Form A is a randomly placed set of numerals and B is a randomly placed set of numerals and letters. It is sensitive to general brain impairment but is more sensitive to anterior frontal lesions (Grant & Adams, 1986) There are two forms one for children aged 9-14 years and one for adults aged 15 and older. The children's version consists of 15 circles and the adult's version consists of 25 circles. Time to complete each test for both dominant and nondominant hands was analyzed.

Wechsler Intelligence Scale for Children-Revised Split-half (WISC-R Split-half). The WISC-R Split Half (Hobby, 1989) was constructed to reduce testing time. It uses the same standard administration procedures discussed in the WISC-R Manual (Wechsler, 1974). Odd numbered items are administered on all the shortened subtests with the exception of Block Design. Thus the number of items administered are one half that given on the WISC-R. The test of temporal stability between the split half form and the split half and long form found no significant IQ scale stability differences with the exception of the Information and Object Assembly test-retest comparisons between the short and long forms (Hobby, 1989). However, Hobby (1989) concludes that the Information test-retest correlation coefficient is higher than most of the long form test-retest correlation coefficients and that the inclusion of Object Assembly in the computation of IQ does not have a

detrimental effect on the stability of IQ. The comparison of the subtest and IQ means between the short and long form found close similarities (Hobby, 1989). The variability of the short form scores from long form scores "...is equal to or less than this normal variability (Hobby, 1989)." The Standard Scores for all subtests except Mazes, Picture Completion, Similarities, Object Assembly, and Digit Span were analyzed separately. The raw scores for Digits Forward and Backward were analyzed.

Wide Range Achievement Test-Revised (WRAT-R). The WRAT-R (Jastak & Wilkinson, 1984) is a test of "codes" needed to learn the basic skills of reading, spelling and arithmetic. The test is broken down into three subtests: reading, spelling, and arithmetic. The Reading subtest consists of the subjects pronouncing a set of words. The Spelling subtest consists of writing out the correct spelling of words presented orally by the examiner. The Arithmetic subtest consists of math problems that begin with simple addition and subtraction and end with geometry problems. Subjects are given 10 minutes to complete the Arithmetic subtest. Raw scores are translated into standard scores, percentiles and grade equivalents. Standard scores for the three subtests (Reading, Spelling, & Arithmetic) were analyzed.

Procedure

Data on subjects were drawn from the archives on an

intervention project carried out at a juvenile detention center in a large Southwest city . Subjects who were detained at a juvenile detention center for at least three days are interviewed by a social worker and if assessed to have a severe drug problem, by the social worker and treatment team, were administered a battery of neuropsychological tests. Examiners were not blind to level and kind of drug use.

Subjects were assigned to one of two groups: polydrug use without VS abuse (Controls) and polydrug use that includes inhalant abuse (VS group).

Psychomotor speed was assessed with elements of the WISC-R (Coding), Trails Making Test and Grooved Pegboard. Lezak (1983) suggests that Digit Symbol is more likely to be depressed than any other WAIS score even if damage is minimal. Findings for the WAIS are generally considered true for the WISC-R. The Grooved Pegboard test is considered to be a good test of psychomotor agility.

New learning was assessed by subtests of the WISC-R (Block Design, Picture Arrangement, and Digit Span-Backwards) and the Benton Visual Retention Test (Administration A, Form D). According to Lezak (1983) Block Design tends to be lower when any kind of brain insult is present and Picture Arrangement appears to be sensitive to diffuse brain damage. Digits Backwards relies more on memory and visual-scanning rather than just

attention, is very vulnerable to diffuse brain damage related to dementing diseases and is generally sensitive to brain damage (Lezak, 1983). The 10 second presentation and then removal of designs in the Benton requires retention of the design in memory long enough to reproduce it without any visual aid. Psychomotor speed and attention/ concentration are important elements of these tests as well.

Attention/concentration was assessed by a subtest on the WISC-R (Digit Span). Digit Span was broken down into its two components (forward and backward). Digits Forward, as compared to Digits Backward, is more representative of the efficiency of attention, is relatively stable and less vulnerable to diffuse or right hemisphere damage (Lezak, 1983). Arithmetic was added to this component as suggested by Kaufman's factor III (1979) but Coding was omitted and placed in the other group.

An assessment of academic achievement was made using the Wide Range Achievement Test-Revised to determine if there were learning disabilities. Learning disabilities were implied from any significant differences between VIQ and PIQ within each group.

Psychological status was evaluated using the SCL-90-R or BSI and interview measures that include: gang membership, goal for school achievement, participation in school sports, church attendance, employment, treatment for

drug use or mental illness both inpatient and outpatient, and suicidal behavior.

The family organization and health was derived from interview questions that include: family status, family composition, family drug use behavior, and sexual abuse.

The clinical semi-structured interview was used to assess parental employment, who is living at home, and pattern of drug use for family. Information was gathered on each subject's: level of education, age, ethnicity, types of drugs abused, favorite and next favorite drug abused, age of onset of use, type of drug use in last 30 days, administration of drug and educational goals.

CHAPTER IV

RESULTS

Comparison of Drug Groups (VS and Control)

In the VS poly drug abuse group (VS group) there are 268 (28.5%) subjects and 647 subjects (69.8%) in the polydrug abuse group (Control). The other 26 of 941 subjects were excluded from the sample because they reported only cigarrette use. The number of subjects for each analysis varied depending on the completeness of data for each subject. The degrees of freedom reported for *t*-tests are computed from separate variance because of the frequently wildly discrepant number of subjects for many analyses. The VS group in comparison to Controls had a significantly higher frequency of severe drug use (67.3% & 25.1%, respectively) and lower frequency of no drug use (6% & 36.1%, respectively) than Controls Chi^2 (2, *N* = 840) = 153.7, *p*<.001. The VS group in comparison to Controls report a significantly greater amount of drugs used (*M*= 5.4 & 2.9, respectively) *F*(1, 845) = 414.46, *p*<.001. The mean for duration of VS use was 1.65 years, median was 1 year with a range from 0 to 11 years. Seven subjects reported use of 6 or more years. The mean duration of polydrug use was .735 years, median was 1 year with a range of 0 to 7 years. The VS group in comparison to the Controls

had a significantly greater frequency of parents who drank daily (28.1% & 14.3%, respectively) and a significantly smaller frequency of parents who drank little if any (16.5% & 35.2%, respectively) Chi^2 (2, $\underline{N}$ = 747) = 37.14, $\underline{p}$<.001. Fewer VS users were enrolled and attending school than Controls (48.9% and 64%, respectively), Chi^2 (2, $\underline{N}$ = 832) = 18.71, $\underline{p}$<.001. However, there were a similar amount of subjects not enrolled in school for both groups. More VS users than Controls were enrolled in school but did not attend. Almost twice as many Controls than VS users reported attending church (43.1% and 24.1%, respectively) Chi^2 (1, $\underline{N}$ = 837) = 27.53, $\underline{p}$<.001. Nearly four times as many VS users than Controls reported a drug overdose (12.2% and 3.7%, respectively) Chi^2 (1, $\underline{N}$ = 809) = 21.57, $\underline{p}$<.001. The drug groups did not differ on age, gang involvement, participation in sports, enrollment in alternative school, employment, composition of home (which parents are at home) and parents employment. There were three subjects who reported only VS use and only one of them had complete IQ, neuropsychological and psychological data. That one subject reported duration of use of approximately one year.

Comparisons Between Ethnic Groups

There were significantly fewer Caucasians than Others in the VS group (8.6% & 91.3%, respectively) and Control group (10.2% & 89.7%, respectively) Chi^2 (2, $\underline{N}$ = 843) = 58.39, $\underline{p}$<.001. A One-way ANOVA found that Caucasians scored

significantly higher than Others on VIQ $\underline{F}$ (1, 376) = 39.91, $\underline{p}$<.001 and PIQ $\underline{F}$ (1, 379) = 25.35, $\underline{p}$<.001 (See Table 2).

The ethnic groups did not statistically differ on psychological scores (i.e., the SCL-90-R or BSI) but did display significant differences on WISC-R subtests, a neuropsychological test (i.e., Trail Making Test A (sec)) and two indices (drug problem and drug treatment). See Table 2. Caucasians reported receiving significantly more treatment than Others for mental health problems (37.2% & 6.9%, respectively) Chi^2 (1, $\underline{N}$ = 865) = 79.20, $\underline{p}$<.001, drug problems in outpatient modality (22.9% & 8%, respectively) Chi^2 (1, $\underline{N}$ = 850) = 19.60, $\underline{p}$<.001, drug problems in inpatient setting (16.5% & 4.7%, respectively), Chi^2 (1,$\underline{N}$ = 852) = 19.21, $\underline{p}$<.001, and significantly more suicide attempts (25.6% & 13.2%, respectively) Chi^2 (1,$\underline{N}$ = 865) = 9.57, $\underline{p}$<.01. The groups did not statistically differ on rated drug problems and sum of drug use within 30 days of incarceration.

Comparison of Drug Groups on IQ Measures

The test of the hypothesis that subjects in the VS group will have an overall lower performance on an intelligence test (i.e., VIQ and PIQ) than those in the Control group was done by using a mixed model Between and Within Repeated Measures ANOVA. The significant difference of ethnic groups (Caucasian and Other) in performance on IQ measures suggested that ethnicity be included as an independent variable in the design.

Table 2.

One-Way ANOVA Between Ethnic Groups on IQ and Neuropsychological Scores. Mean Scores Reported.

	GROUPS		
WISC-R	Anglo	Other	p
VIQ	91.51	80.30	<.001
PIQ	108.14	97.49	<.001
Pict Arrang	11.3	10.33	<.05
Block Design	10.98	9.34	<.001
Coding	10.56	9.62	<.05
DFrwrd	8.46	7.02	<.001
DBkwrd	6.08	5.24	<.001
Neuropsychological			
TMT A(sec)	12.82	11.96	<.05
Indices			
Drugprob	13.37	11.38	<.05
Drugtreat	.38	.12	<.001

A Drug Group (2) by Ethnicity (2) mixed design Between and Within Repeated Measures ANOVA with VIQ and PIQ used as repeated measures found no significant main effect for drug group but a significant effect for Ethnicity F (1, 351)= 44.87, $p<.001$. The interaction between drug group and ethnicity was nonsignificant. The within measure using IQs as the dependent variables was significant F (1,351) = 267.77, $p<.001$. Within-by-drug group, within-by-ethnicity and a within-by-drug group-by-ethnicity effects were all nonsignificant. The significant within-subjects effect consisted of PIQ being greater than VIQ. No further analyses were computed given these results. The findings do not support the hypothesis that VS users have a lower VIQ and/or PIQ than Controls. See Table 3 for means.

Comparison of Drug Groups on Neuropsychological Measures

The test of the hypothesis that subjects in the VS group, in comparison to Controls, have an overall lower performance on neuropsychological tests that are sensitive to global or diffuse brain insult (i.e., Grooved Pegboard, Trail Making Test A & B, Benton, and WISC-R subtests: Block Design, Picture Arrangement, Digit Span, and Coding) was done by using a mixed design Between and Within Repeated Measures ANOVA.

All scores were converted to a T-score (i.e., mean=50, sd=10). A mean of 10 and sd of 3 was used to convert the WISC-R subtest scores. A mean and sd was calculated from the total sample for the other measures that were without a

Table 3.

Means of Drug Users on VIQ and PIQ

	Caucasians		Other	
	VS	Control	VS	Control
VIQ	91.63	91.88	78.78	81.18
PIQ	111.13	107.04	96.64	98.61

standard mean and sd (i.e., Benton, Grooved Pegboard, Trail Making Test, and raw scores for Digits Forward and Digits Backward). The significant difference between ethnic groups and difference in performance between ethnicity suggested that ethnicity be included as an independent variable in the design.

A Drug Group (2) by Ethnicity (2) mixed design Between and Within Repeated Measures ANOVA with 14 neuropsychological measures used as repeated measures found no significant main effect for drug group but a significant main effect for Ethnicity F (1,330) = 6.09, $p<.05$. The interaction between drug group and ethnicity was nonsignificant. The within subject measure using the 14 neuropsychological scores as the dependent variables was significant F (13,4290) = 2.84, $p<.001$. Significant interactions include: within-by-drug group F (13, 4290) = 1.91, $p<.05$; within-by-ethnicity F (13, 4290) = 4.41, $p<.001$; and within-by-drug group-by-ethnicity F (13, 4290) = 2.27, $p<.01$.

The three way interaction was analyzed by computing two sets of 14 individual t-tests for drug group, one set for Caucasian and one set for Other. Each subject's individual T-score on each dependent variable was subtracted from his T-score performance mean across all dependent variables (i.e., subject's grand mean) to get a deviation score. The sum of that computation, deviation score, was included in each t-test. This form of pattern analysis allows for the

exploration of individual group differences while taking into consideration the individual's overall grand mean of performance. This protects against confusing group mean difference from pattern (interaction) difference (see DeWolfe & Davis, 1972).

Comparison of Drug Groups on Neuropsychological Measures Within Caucasian Group

For the Caucasian group 12 of the tests were nonsignificant and 2 were significant. VS polydrug users made more errors than Controls on the Grooved Pegboard test using the dominant hand t (22.07) = .83, $p<.05$. The VS group did significantly better than Controls on Block Design t (36.99) = 2.43, $p<.05$. See Table 4 below.

Comparison of Drug Groups on Neuropsychological Measures Within Other Group

For the Other group nine of the tests were nonsignificant and five were significant. The VS groups took significantly less time than Controls to complete the Grooved Pegboard test using the dominant hand t (305.65) = 1.06, $p<.05$ and the nondominant hand t (334.6) = 2.54, $p<.05$. The VS group took significantly less time to complete Trail Making Test A t (265.28) =1.99, $p<.05$ and B t (295.07) = 2.43, $p<.05$. Finally the VS group recalled significantly shorter serial strings forwards than the Control group t(303.51) = -4.04, $p<.001$) See Table 4 for the means and sd between groups. With the exception of the VS group performing worse on Digits Forward these findings do not support the hypothesis that VS users

Table 4.

Neuropsychological Scores Between Drug Groups for Caucasian and Other Groups. Significant Results Only.

	VS		Control	
TESTS	mean	sd	mean	sd
		Causian		
Grooved Pegboard				
dom/hand(err)	-10.16	14.29	-.9	9.37
WISC-R				
Block Design	4.95	6	-.09	7.44
		Other		
Grooved Pegboard				
dom/hand(sec)	1.26	7.92	-.60	9.03
nondom(sec)	1.59	7.29	-.68	9.59
Trail Making Test				
A(sec)	.88	9.42	-1.07	8.47
B(sec)	1.28	8.15	-.89	8.48
WISC-R				
DFRWRD	-2.61	8.5	1.23	9.29

have deficits in attention/concentration, psychomotor speed, and new learning relative to Controls. In fact, some differences are in the opposite direction than what was predicted.

Comparison Between Groups on Abilities Resilient to VS Abuse

A t-test between drug groups was computed to test the hypothesis that the VS group and Control group would be similar on tests sensitive to language functioning and long-term memory. The tests that measure general knowledge and language abilities (i.e., Vocabulary, Information, Arithmetic, Picture Completion, and all WRAT-R subtests) were summed and subtracted from the 14 neuropsychological tests that were posited to be lower for VS abusers relative to Controls. The VS group had a significantly higher score than Controls on the difference between the two measures (M = 430.54 & 414.05) t (218.75) = 2.83, $p<.01$.

Follow-up analyses were computed on the sum of the seven scores and seven separate t-tests on each of the neuropsychological tests posited to be intact for VS users. The VS group performed significantly poorer than Controls on the sum of seven tests (M = 270.01 & 283.73, respectively) t (236.19) = -2.5, $p<.05$. The VS group performed significantly poorer than controls on five of the seven tests including: Information t (231.53) = -1.97 $p<.05$; Vocabulary t (230.26) = -2.7 $p<.01$; Reading t (305.95) = -2.42 $p<.05$; Spelling t (314.81) = -2.25, $p<.05$; and Arithmetic t (313.18) = -4.6 $p<$.

001. These results do not support the hypotheses that the VS group would have similar performance on measures resilient to diffuse brain damage. See Table 5 for means and standard deviations.

Comparison of Psychological Status Between Drug Groups

The hypothesis that the VS group would report more psychological distress (i.e., elevated scores on scales for depression, interpersonal sensitivity, anxiety, hostility, and general indices GSI and PSI) than controls was tested using a mixed model Between and Within Subject Repeated Measures ANOVA. The nine clinical scale scores and three indices from the SCL-90-R or BSI were the 12 dependent variables used as repeated measures. There was a significant main effect for drug goup F (1,282) = 4.47, $p<.05$ and a significant within-subjects effect $F(11, 3102) = 15.14$, $p<.001$. The interactions wre nonsignificant.

Follow-up Analyses for Psychological Differences Between Drug Groups

A follow-up analysis between drug group using a t-test for each of the 12 psychological variables found 4 variables nonsignificant and 8 significant. The VS group scored significantly higher than Controls on the following clinical scales and indices: Obsessive-compulsiveness $t(265.59) = 2.88$, $p<.01$; Interpersonal-sensitivity $t(249.49) = 2.09$, $p<.05$; Depression $t(241.19) = 2.24$, $p<.05$; Hostility $t(260.75) = 2.79$, $p<.01$; Psychotism $t(248.94) = 3.09$, $p<.01$; GSI $t(257.05) = 2.31$, $p<.05$; PSDI $t;(251.09) = 2.02$, $p<.05$; PST

Table 5.

Significant Scores for Drug Groups on Measures Resilient to Diffuse Brain Insult.

TESTS	GROUPS VS mean	sd	Controls mean	sd
WISC-R				
Information	37.89	9.31	39.89	8.67
Vocabulary	35.36	8.57	37.87	7.89
WRAT-R				
Reading	37.52	12.92	40.61	12.04
Spelling	35.49	10.82	37.95	10.56
Arithmetic	31.09	10.33	35.85	9.89

$t(230.22) = 1.99$, $p<.05$. See Table 6 below for means and standard deviations.

These findings lend support to the hypothesis that depression, interpersonal sensitivity, hostility and the indices GSI and PSDI would be more elevated for VS users than Controls. However the hypothesis did not predict anxiety to be nonsignificant nor the obsessive-compulsiveness, psychotism, and PST to be different.

Comparison of Drug Use Index Between Drug Groups and Relationship to Other Measures

To assess the relationship of drug use behavior with test performance, self-report of psychological health, family behavior, and interpersonal behavior, a drug use index was constructed that displayed an acceptable level of internal consistency between variables. The drug use variables considered for the index included: number of drugs used, level of drug problem, sum of level of drug use in the last 30 days for each of the possible 13 drugs, duration of polydrug use, duration of VS use, hospitalization for drug use, outpatient treatment for drug use, and overdose on drugs. After several reliability computations an index that consisted of four items (i.e., severity of drug problem, number of drugs used, duration of polydrug use, and sum of level of drug use in the last 30 days for each of the 13 drugs) with a standardized item alpha of .7046 was selected.

A t-test using the drug problem index as the dependent variable found that the VS group had a significantly higher

Table 6.

Means and Standard Deviations Between Drug Groups for Significant t-tests on SCL-90-R or BSI.

	GROUPS			
SCALE	VS mean	sd	Controls mean	sd
OC	51.08	10.17	47.69	11
IS	47.86	10.16	45.47	10.2
DEPRESSION	52.79	10.6	50.15	10.25
HOSTILITY	52.47	10.72	49.04	11.35
PSYCHOTISM	53.39	9.03	50.25	9.05
GSI	50.5	10.17	47.79	10.66
PSDI	55.12	11.08	52.57	11.29
PST	47	10.16	45.77	9.36

level of problems than Controls (M = 17.87 & 10.35) t (400.57) = 12.17, $p<.001$. This result is consistent with the prediction that VS users will have a greater drug problem index score than Controls. When the drug problem index was correlated with the 36 dependent variables in the VS group 4 of 36 correlations were significant at the $p<.01$ level. When the drug problem index was correlated with the 36 dependent variables in the Control group 1 of the 36 correlations was significant at the $p<.01$ level. See Table 7 below. For VS users an increase in drug problem is positively correlated with verbal ability and anxiety. However, no such relationship exists for Controls.

Comparison of Social Problem Index Between Drug Groups and Relationship to Other Measures

To assess the relationship of interpersonal/social behaviors and mental health with test performance, self-report of psychological health and drug use an index of social problems was constructed that displayed an acceptable level of internal consistency. The social variables considered for the index included: involvement in gangs, employment, participation in sports, church attendance, hospitalization for mental illness, suicide attempt, hospitalization for drug use, outpatient care for drug use, language spoken at home, drug overdose, sexual abuse victim, alternate school status, school status, highest grade hope to achieve, and ethnicity. After several reliability computations an index that consisted of two items

Table 7.

Correlations of Drug Problem Index, Drug Treatment Index, Psychological Scores, Neuropsychological Scores, and IQ Scores. All Correlations Are Significant at the $p < .01$ Level.

	Drug Group VS Control			
Variables	Drugprob	Drugtreat	Drugprob	Drugtreat
Numberdrug		.2807		.3102
Drugsum				.1629
Drugsevere				.1885
Durapoly		.2455		.1356
Drugtreat	.2299		.2642	
WISC-R				
VIQ	.2848	.2360		
PIQ		.2740		
Pict Arrang		.2423		
BlockDesign		.2814		
Vocabulary	.2939			
Information	.2353			
SCL-90-R or BSI				
Anxiety	.2511			
Hostility			.1859	

(i.e., hospitalization for drug use, and outpatient care for drug use) with a standardized item alpha = .6006 was selected.

The amount of drug treatment reported by each group was significantly different with VS abusers reporting more treatment than Controls ($\underline{M}$ = .35 & .09, respectively) $\underline{t}(126.75) = 5.02$, $\underline{p}<.001$. This result is consistent with the hypothesis that VS users have more personal problems. When the drug treatment index was correlated with the 36 dependent variables in the VS group 7 of 36 correlations were significant at the $\underline{p}<.01$ level. When the drug treatment index was correlated with the 36 dependent variables in the Control group 5 of the 36 correlations were significant at the $\underline{p}<.01$ level. As the frequency of treatment for drug use increases verbal and nonverbal IQ and severity of drug problem increases for VS users. However, frequency of drug treatment is only positively correlated with drug severity for Controls. See Table 7 for summary of correlations of drug treatment with psychological, neuropsychological, IQ and drug problems.

Follow-up Analyses of Drug Use Variables

The individual drug use variables (number of drugs, drug use in last 30 days, duration of drug use for Controls, duration of VS use, and severity of drug problem) were correlated with the neuropsychological, IQ and psychological scores separately for the VS and Control groups. For the VS group the number of drugs was significantly correlated with VIQ ($r=.3065$, $\underline{p}<.01$), Vocabulary ($r=.2501$, $\underline{p}<.01$),

Information (r=.2623, p<.01) depressive complaints (r=.2884, p<.01), anxiety complaints (r=.2914, p<.01), and PST (r=.2681, p<.01). Duration of VS use was significantly correlated with anxiety complaints (r=.2827,p<.01), depression (r=.2527, p<.01), somatic complaints (r=.2411, p<.01), PST (r=.2971, p<.01), and GSI (r=.2451, p<.01). VS use in the 30 days prior to incarceration was significantly correlated with only Coding (r = -.3856, p<.01). For the Control group the number of drugs was correlated with Hostility (r=.2033, p<.01). No other measures were significantly correlated with the dependent variables for Controls. The reduction in performance on Coding as the report of frequency in recent VS use increases is consistent with the suggestion that VS use decreases psychomotor speed.

Follow-up Analyses of Social Problem Variables

Several of the social variables that were not selected for the index but were significantly different between drug groups (i.e., church attendance and suicide attempt) in addition to outpatient treatment and inpatient treatment for drug use were analyzed individually on the 24 dependent variables (i.e., IQ, neuropsychological and psychological scores) using t-tests. Church attendance did not have any statistical differences. Outpatient drug treatment, inpatient drug treatment, and reported suicide attempt all had significant results. See Table 8 for these results.

Table 8.

Several t-tests for Drug Treatment and Suicide Variables. Only t-tests with p<.01 reported.

VARIABLE	df	t value	MEAN YES	MEAN NO
INPATIENT DRUG				
Anxiety	31.55	-3.06	53.04	47.74
OUTPATIENT DRUG				
Block Design	62.45	-3.29	10.64	9.42
TMT B(SEC)	82.40	2.62	56.27	65.83
Depression	51.88	-2.92	55.47	50.21
Anxiety	53.10	-2.79	52.51	47.53
Hostility	56.82	-3.19	54.56	49.17
PST	52.02	-3.33	51.16	45.57
SUICIDE				
Pict Arrange	80.38	-2.92	11.47	10.13
Somaticism	75.69	-5.15	52.95	45.65
Obsess/compul	83.80	-4.36	53.74	47.52
Interper sens	79.36	-4.55	51.80	45.23
Depression	79.79	-5.32	57.38	49.72
Anxiety	77.04	-4.42	54.02	47.12
Hostility	73.94	-3.98	55.83	48.87
Paranoid idea	79.02	-4.59	54.14	47.23
Psychotism	75.76	-3.47	55.24	50.49
GSI	78.24	-5.76	55.53	47.16
PSDI	85.78	-3.81	58.09	52.43
PST	75.31	-5.57	52.77	45.05

The VS group reported a significantly greater frequency of treatment for inpatient drug use Chi^2 (1,N =798) = 30.19 p<.001, outpatient drug treatment Chi^2 (1, N =792) =57.8, p<.001, and suicide attempts Chi^2 (1,N = 802)=16.89, p<.001 than the Control group. The drug groups did not differ on report of inpatient treatment for mental illness. These results are supportive of the hypothesis that VS users have more personal problems and depression than Controls.

Comparison of Family Problems Between Groups and Relationship with Other Measures

To assess the relationship of family status and behavior with test performance, self-report of psychological health, drug use and interpersonal behavior a family problem index was explored that had an acceptable level of internal consistency between variables. The family variables considered for the index included: which parents were living at home, language spoken at home, victim of sexual abuse, number of family members who drink, ethnicity, occupation of father, and occupation of mother. After several reliability computations the highest standardized item alpha obtained was .1357 with five items. This was an unacceptable score and thus no index of family problems was constructed.

Chi-squares were computed for each of the family variables between drug groups. T-tests were computed for each family variable on the dependent variables when appropriate. Number of family members who drank or did drugs, report of sexual abuse, parents occupation and

composition of parental unit did not differ between groups. However, severity of a family member's drinking behavior differed significantly Chi^2 (1, N = 747) = 20.58, p<.001. The VS group had a higher percentage of severe drinkers in their family than Controls (28.1% & 14.3%, respectively). The VS group had significantly fewer subjects who came from English only speaking homes than Controls (42.9% % 63.3%, respectively) Chi^2 (1, N = 736) = 27.9, p<.001. Language spoken at home was significantly different on several measures. Subjects from English speaking families in comparison to bilingual or Spanish only speaking homes had a significantly lower score on the drug problem index t(713.2)=-3.31, p<.001, higher VIQ t (312.45)=4.4, p<.001, higher Vocabulary t(269.92)=2.68,p<.01, higher Information t (286.72) = 5.05, p<.001, higher PIQ t (315.68) = 3.24, p<.001, higher Block Design t(303.52)=2.05, p<.05, greater Digits Forward t (374.92) = 3.47, p<.001, and a quicker time on the Grooved Pegboard nondominant hand t (376.39) = 2.20, p<.05. See Table 9 for means. These results are consistent with the suggestion that subjects with more family issues (e.g., acculturation) do poorer on intelligence tests and the VS group has a greater frequency of bilinqual or Spanish speaking families than Controls.

Comparisons to Norms

Two groups of 8 t-tests on neuropsychological measures (Benton, Grooved Pegboard-seconds and errors, Trail Making

Table 9.

Means for English and Bilingual or Spanish Only Speaking Homes. Results Greater than $p<.01$ are Reported.

	MEANS	
	English	Spanish
Drug Problem	11	13.03
VIQ	83.54	78.05
PIQ	99.92	95.31
Vocabulary	6.31	5.55
Information	7.32	5.87
Digits Forward	7.51	6.66

Test A&B-seconds and errors), two groups of t-tests on 12 psychological measures (SCL-90-R or BSI) and t-tests on the two intelligence scores (WISC-R) were computed to test the hypotheses that both groups differ from the norms on the tests administered. As predicted both VS abusers and Controls were significantly different from the norms on all neuropsychological scores and the VIQ score with the exception of PIQ and the Benton. See Table 10.

These results support the hypothesis that the juvenile delinquent group would score significantly lower than the norms on neuropsychological tests. Exceptions to this hypothesis include the nonsignificant difference of PIQ and Benton from the norm for both groups. In addition, the small differences between the norms and each group suggest that these differences may not be clinically discriminating. The VS group had greater scores than the SCL-90-R or BSI norms on scales of depression, psychoticism, hostility and PSDI. The scale that measures interpersonal sensitivity and the PST index were significantly lower than the norm. The Control group overall had lower scores on the SCL-90-R or BSI relative to norms. Although the VS users had significantly greater scores than the norms the differences are not clinically discriminating. Thus the results do not support the hypothesis that both groups will have higher scores than the norms with the exception of PSDI.

A cluster of pathonomic indicators was compared between

Table 10.

Mean Difference of Drug Groups from Norms for Neuropsychological, Psychological and IQ Scores.

	Drug Groups VS		Controls	
TESTS	Mean	p	Mean	p
Grooved Pegboard				
Domhand(sec)	-4.4	<.001	-6.42	<.001
Domhand(error)	-.26	<.001	-.24	<.001
NonHand(sec)	-3.52	<.001	-5.40	<.001
NonHand(error)	-.43	<.001	-.39	<.001
Trail Making Test				
A(sec)	-9.74	<.001	-11.67	<.001
A(error)	-.24	<.001	-.20	<.001
B(sec)	-33.31	<.001	-40.21	<.001
B(error)	-.64	<.001	-.68	<.001
Benton correct	-.11	ns	-.12	ns
WISC-R				
PIQ	-1.66	ns	-.49	ns
VIQ	-19.73	<.001	-17.66	<.001
SCL-90-R				
Somaticism	-1.63	ns	-3.5	<.001
Obsess/compul	1.08	ns	-2.3	<.01
Interper sen	-2.14	<.05	-4.53	<.001
Paranoid idea	-.44	ns	-1.99	<.01
Phobic anxiety	-.37	ns	-1.53	<.05
Anxiety	-1.16	ns	-1.77	<.05
Depression	2.79	<.01	.15	ns
Psychotism	3.49	<.001	.25	ns
Hostility	2.47	<.05	-.96	ns
GSI	.50	ns	-2.21	<.01
PST	-2.0	<.05	-4.23	<.001
PSDI	5.12	<.01	2.57	<.001

the two groups to see if one group had a greater amount of deficits than the other. The groups were not significantly different.

Learning Disabilities

To assess the hypothesis that juvenile delinquents have learning disabilities, several t-tests were computed comparing FSIQ with the three WRAT-R subtests (i.e., Reading, Spelling & Arithmetic) on both of the drug groups separately. All t-tests for both groups were significant. See Table 11.

Although all t-tests comparing each subject's FSIQ with each WRAT-R subtest score were statistically significant only the WRAT-R Arithmetic subtest for the VS polydrug abuse group was clinically suggestive of a learning disability (i.e., the difference was -16.5 or 1.5 points greater than the criterion of 15 points). Both drug groups had a difference between their VIQ and PIQ greater than the criterion of 15 points. Performance scores were significantly greater than verbal scores for both groups.

Thus, the VS group has strong evidence for a learning disability in Arithmetic and verbal ability and the Control group has some evidence of a learning disability in verbal ability. These findings support the hypothesis that both groups have learning disabilities, but the VS group has an added learning disability in math.

Table 11.

Comparison of FSIQ with the Three WRAT-R Subtests Using t-tests and VIQ-PIQ. All t-tests Were Significant at the p< .001 Level or Better.

WRAT-R	VS mean	Control mean
Reading	-5.57	-3.66
Spelling	-9.42	-8.16
Arithmetic	-16.5	-10.56
VIQ-PIQ	-18.66	-17.25

Possible Groupings of Drug Use Between Drug Groups

To evaluate whether or not there are any groupings of drugs associated with the use of VS in contrast to the Control group, several chi-squares were run for drug group by each of the 13 individual drug categories. The results are listed in Table 12.

There were 12 out of 13 significant chi-squares for number of drugs used between VS abusers and Controls. The tests are extremely sensitive due to the large sample size. Nine of the 13 drugs appear to have an important difference between the groups. VS users tend to have a higher frequency of use than Controls for the following drugs: cigarettes, alcohol, marijuana, crack, cocaine, speed, stimulants, heroin, LSD. The largest and most notable differences between groups appear to be for cocaine and LSD. Both are at the 50/50 mark for VS users but very infrequent for Controls. The drugs that appear to have little difference in frequency between the two groups include: PCP, ice, tranquilizers, and other.

Exploration of Comparisons between Groups Using Other Criterion

A more restrictive criteria of selecting only subjects who reported inhalants as either their favorite or next favorite drug of choice in the sample of inhalant users had mixed results. In assessing differences between groups on IQ, neuropsychological and psychological scores the results were nonsignificant or so similar to the first comparisons

Table 12.

Chi-Squares Between Drug Group on Each of the 13 Individual Drugs. Age is in Years. Mean Age of Onset of VS Use Was 12.897 Years.

Drug	VS abuse N (%)	Control N (%)	p
Cigarettes			
yes	217(81.9)	388(58.2)	<.001
age	12.08	12.6	<.05
Alcohol			
yes	251(93.7)	549(82.2)	<.001
age	12.3	12.95	<.001
Tranquilizers			
yes	20(8.2)	16(2.5)	<.001
age	13.72	14.58	ns
Marijuana			
yes	249(92.9)	428(64.2)	<.001
age	11.97	12.98	<.001
Heroin			
yes	38(15.3)	13(2.0)	<.001
age	13.74	14.17	ns
LSD			
yes	123(49.2)	111(17.0)	<.001
age	13.31	13.84	<.05
PCP			
yes	10(4.1)	6(.9)	<.01
age	13.1	14.0	ns
Cocaine			
yes	131(49.1)	120(18.0)	<.001
age	13.61	14.29	<.001
Crack			
yes	47(17.6)	25(3.7)	<.001
age	13.32	14.14	ns
Speed			
Yes	66(24.7)	38(5.7)	<.001
age	13.32	12.68	ns
Stimulants			
yes	15(6.1)	3(.5)	<.001
age	13.15	12.67	
ICE			
yes	5(2.0)	1(.2)	<.01
age	14.0	15.0	no variance
Other			
yes	13(4.9)	17(2.5)	ns
age	13.71	13.6	ns

that they did not add any new information. In addition, the number of subjects in the Caucasian VS group was very low (four) thus limiting the extent of analyses.

A breakdown of the sample into four groups on duration of use (VS use for at least four years, VS use for less than four years, polydrug use for at least four years without VS use, and poly drug use for less than four years without VS use) found polydrug use for less than four years without VS use to have a significantly better score on the drug problem index F (3,843) = 88.57, $p<.001$ than the other three groups (M = 9.26, 15.05, 15.35 & 16.29 for polydrug use less than four years, polydrug use greater than or equal to four years, VS use greater than or equal to four years and VS use less than four years, respectively). The polydrug group with less than four years of use was also significantly better than the two VS use groups on Digits Forward F (3,417)=4.87,<.01 (M = 7.52, 6.21 & 6.69, respectively). No other significant results were found for the neuropsychological, psychological and intelligence scores.

Using a breakdown of the sample into four groups based on reported VS abuse in 30 days prior to incarceration (little to none, some, every other day, every day) a One-way Anova on the psychological, neuropsychological and IQ scores found two significant results. The four groups were significantly different on Coding F (3,47)=3.42, $p<.05$ (M = 10.62, 10.14, 8.91, & 7.8, respectively), and Digits Forward

F (3,50)=5.75, p<.01 (M = 6.57, 8, 5.09, & 5.45, respectively). The subjects with more use had lower scores than subjects with less use. This is consistent with the finding that VS abuse may linger in the CNS and be related to acute psychomotor and attention deficits.

CHAPTER V

DISCUSSION

The majority of subjects in this study are Mexican-American males between the ages of 14-16 years, who are in the 8th or 9th grade, and come from low SES single parent homes. Juveniles who report polydrug use that includes VS use make up almost a third of the sample. VS users as a group tend to report using two more drugs (including VS) than non VS users, more than twice as long a duration of drug use or twice as early an initiation in drug use, having a greater frequency of family members with more severe alcohol use, and tend to be rated more frequently as having a severe drug problem than non VS users. Three subjects reported VS use only but only one of these subjects had complete data on neuropsychological, psychological and intelligence measures.

As discussed by Kaufman (1979, 1990) the significant difference in VIQ and PIQ scores between ethnic groups (primarily Caucasians relative to other groups) may be related to cultural values and experiences, language spoken at home and SES. More will be said about this below.

Differences in IQ Measures

The hypothesis that IQ would differ between drug groups was not supported. This hypothesis was the result of Leiner

et al.'s (1989) theory of the functioning of the cerebellum, Bracke-Tolkmitt et al.'s (1989) findings that patients with lesions to their cerebellum score significantly lower on IQ scores than controls and the neuroradiological evidence of diffuse brain atrophy. There are a number of explanations for this result.

The duration of VS abuse may not have been long enough and/or the quantity of VS abused may not have been great enough to result in a pervasive and ominous decrease in intelligence. Subjects with a longer duration of abuse and/or greater quantity of VS abused may exhibit the predicted significant differences in IQ.

A related explanation is that the measures used are not sensitive enough to pick up any significant differences between these two groups, especially if being a delinquent and primarily Mexican-American population already lowers both drug groups' performance. In other words there might be a floor effect related to the delinquency and ethnicity.

In addition, the fact that both drug groups are primarily polydrug users may confound any expected differences between pure VS drug users and controls. That is, Bracke-Tolkmitt et al.'s (1989) study was of patients with lesions to the cerebellum and neuroradiological studies looked at subjects who were abusing solely or primarily toluene and for a long duration. Thus the use of polydrugs may somehow buffer any deleterious effects of VS abuse.

Future studies may try to tease out these confounds by comparing a sample of VS users with a wide range of duration and quantity of VS abuse with a range of nonVS using drug users and nondrug users. The exploratory finding that polydrug subjects with less than four years of abuse do better than all VS users on Digits Forward adds some support to this suggestion of further research. However, given the number of analyses done one significant finding may be spurious.

Differences in Neuropsychological Measures

The hypothesis that the VS use group, relative to Controls, would show deficits in attention/concentration, new learning, and psychomotor speed (i.e., diffuse deficits) was weakly supported if supported at all. The follow up analyses of the three-way interaction revealed that the Caucasian group had one significant difference between drug groups in the predicted direction. VS users made more errors on a psychomotor task (Grooved Pegboard Test) than Controls. However, other measures within the cluster of psychomotor ability were not significant and one test of new learning and psychomotor speed came out in the opposite direction than predicted. VS users did better on Block Design than Controls. However, this difference could be interpreted as not clinically meaningful in that the two groups differed by less than a 1/2 of a standard deviation which translates into about 1.5 points, which is less than the expected test-retest differences for that subtest. In addition, the difference is

in the opposite direction of what was predicted, which is significant in itself.

The results for the Other ethnic group were equally mixed and offered weak support if any of the hypothesis. VS users performed significantly poorer than Controls on a test of new learning/attention (Digits Backward). However, the difference is 1/4th of the standard deviation which translates into about 1/4th of one correct serial string. Other scores in this cluster did not come out significant. In addition, the VS users performed better on psychomotor speed tasks (Grooved Pegboard and Trail Making Test) but the difference was a very small percentage of the standard deviation and is not clinically discriminating between the groups.

Taken together these results provide little to no support of the hypothesis that VS users have poorer performance in attention/concentration, new learning and psychomotor speed. The few differences found are too small to discriminate between groups and may be more a result of the size of the sample and power of the statistical tests to find a statistical difference. In addition, the impairment found was not by any means overwhelming or consistent. The difference in pattern between drug groups on significant results may be a reflection of chance findings given the large number of analyses run or suggest some potential differences between groups with more homogeneous drug groups and greater range of drug use.

The relatively short duration and quantity of VS use may be related to the few subtle yet detectable differences. A sample with a longer duration and greater quantity of VS use may reveal larger differences between groups. In addition, as discussed above polydrug use may be a confound, washing out any differences that pure VS users may exhibit relative to other drug users.

Prediction of Intact Abilities

The hypothesis that VS use would not result in impairment to long-term memory and language abilities was not supported. VS users performed consistently lower on tests sensitive to long-term memory and language. However, the differences on each test between the two groups were relatively small and could be considered clinically nondiscriminating. Three of the five subtests for both groups were more than one standard deviation below the norm suggesting that both groups experience some sort of deficit in these areas. Two of the three subtests were one standard deviation below the norm for the Controls but more than one standard deviation below the norm for VS users.

The overall lower performance by VS users might be related to VS use in that VS users pay less attention in class or do less work in class or some other type of behavioral reason. The lower performance may also be related to other factors of drug abuse, e.g., family instability. It is unclear if the poorer performance is related to cerebral

deficits but a more conservative explanation would not imply VS use caused cerebral deficits that resulted in these differences. The family environment and/or psychological health of the VS user, as well as the overall larger number of drug use might also play a part in these lower scorers.

Learning Disabilities

The hypothesis that both drug groups would display evidence of learning disabilities was supported by the large VIQ-PIQ split. In addition the significantly poor Arithmetic performance of the VS users suggests a learning disability in that area for them but not for Controls.

Kaufman (1979) notes that significant differences between VIQ and PIQ may be related to differences in crystallized and fluid ability, respectively, rather than verbal and nonverbal reasoning. That is, children may not be encouraged to learn the facts taught in school and instead rely on raw intelligence and develop dynamic problem-solving skills or everyday learning skills Thus this sample of delinquents may be more students of their environment rather than school and if they were helped to focus on school facts they might improve their performance on verbal reasoning. In fact, the average PIQ of this sample may be a better estimate of potential intellectual ability and, if accentuated, could help remediate the poor verbal reasoning skills.

Furthermore, the difference in VIQs between groups is more significant than the general VIQ-PIQ difference. That

is, the non Caucasian mean VIQ is not only lower than the Caucasians VIQ but it is also more than one standard deviation lower than the average VIQ while the Caucasians VIQ is less than a standard deviation below the norm. On the other hand the PIQ for non Caucasians is close to the average PIQ but still lower than Caucasians. Ethnicity appears to play a big role in verbal reasoning or crystalized ability in this population. Further studies are needed to answer the question if VS use results in a vulnerability to a math disability. Motivation or environmental exposure to math may be related to these differences.

Differences in Psychological Status

There were several psychological differences found between the two drug groups that were predicted and several differences that were not predicted. The VS users reported a higher level of symptoms than Controls on interpersonal sensitivity, depression, hostility and the summative indices of general level of symptoms over all scales and PST as predicted. Contrary to the hypothesis the two drug groups did not differ on anxiety. However, number of drugs was significantly correlated with anxiety for the VS group and not the Control group. In addition to what was predicted, the VS users reported a higher level of symptoms than Controls on obsessive-compulsiveness, psychotism, and PSDI. The amount of difference between the two groups varied depending on the scale. The more sizable differences (at least three points)

were on obsessive-compulsiveness, hostility, and psychotism. The differences between each of the scales were not greater than one standard deviation.

The constellation of results suggests that VS users tend to report a higher frequency of symptoms than Controls around obsessive-compulsiveness, hostility, psychotism, depression, and the three indices (GSI, PSI, and PSDI). The results suggest a coping style (obsessive-compulsiveness and related rigidity) and major symptoms (hostility, depression, interpersonal sensitivity) that VS users experience relative to Controls. With an increase in duration and quantity of use the scores may be further elevated and discriminating. The absence of anxiety as significantly different between the two groups may be related to the premise that adolescents take drugs to relieve anxiety and thus polydrug users share a common experience or do not differ on this at all. The delinquent lifestyle may have acclimated them to stressful events and they do not commonly or are unable to identify anxious feelings. Certainly, more research into this question of the relationship of personality variables to choice of drug is important and will be discussed further below.

Drug Use Index

The drug use index consisted of four factors: severity of drug problem, number of drugs used, maximum duration of poly drug use, and the sum of level of drug use in the 30 days prior to incarceration. Together these factors describe the

severity of drug use for each individual. That is, the more drugs an individual does, the longer the duration and greater the recent use is, and the greater the rated severity of abuse the higher the number on the drug problem index. The VS group had a significantly higher drug problem index than Controls suggesting more involvement overall with drugs.

Correlations of the drug problem index with dependent variables suggest that VS users have better verbal ability and experience more psychological distress (anxiety and PSI) as their level of drug use increases while Controls experience more hostility as their drug problem becomes worse. The number of drugs an individual uses is related to somatic, depressive, and anxiety complaints as well as PSI and GSI. These results suggest that VS use is more related to psychological factors than polydrug use without VS. These results are tenuous and need to be replicated.

Comparison to Norms

As expected juvenile delinquents with drug problems did significantly worse on all neuropsychological tests and VIQ with the exception of PIQ and the Benton. With the exception of the VIQ and Trail Making Test B (seconds) the differences from the norms for both groups suggest a trend but are not clinically discriminating.

The expected differences from the SCL-90-R or BSI was not evident for VS users with the exception of PSDI and occurred in the opposite direction predicted for the Controls with the

exception of PSDI. The measures used may not be sensitive enough to detect differences within this group. On the other hand, delinquent youth or low SES subjects may tend to constrict their affect more and report less symptoms and either different norms or a different measure may be more useful.

Drug Groupings

The data suggest that VS users begin to use several drugs, excluding VS, at an earlier age than controls. VS users seem to start using cigarettes, alcohol and marijuana sooner than Controls. In fact they tend to begin these other drugs prior to their initiation into VS use. In addition, VS users as a group tend to report a greater prevalence of drugs used than Controls. Puberty appears to be an important threshold into the world of drug use and prevention might be targeted on the grades directly preceding 6th grade (4th and 5th). VS users show a greater preference primarily for LSD and Cocaine (50/50) and secondarily for crack, speed and heroin than Controls. In fact Controls tend to focus their use on primarily alcohol with cigarettes and marijuana also very popular and some minor cocaine and LSD involvement.

Multimodal Model of the Effects of Drug Use on Cognition

The results suggest, as did Wolff et al. (1982), that juvenile delinquents experience lowered performance on VIQ and an overall lowered performance on neuropsychological tests. The majority of subjects are Mexican-American and come from

either bilingual or primarily Spanish speaking households and low SES single parent homes. Many of them are exposed to moderate to severe alcohol and/or drug abuse by their parents. Thus many subjects have several stressors even before considering drug use (i.e., single parent home, low SES, bilingual household or English as a second language, delinquency, and parental drug or alcohol problem). In addition they have a lower verbal or crystallized ability but an average nonverbal or fluid cognitive ability.

The use of drugs may be a response to these stressors or exacerbated by these stressors. There are significant differences between VS polydrug users and Controls. The VS users tend to begin drug use at an earlier age and take, on the average, two more drugs than Controls. In terms of youngest age reported initiation of VS use the VS group has the youngest age of any drug category, as young as five years old. They have a significantly greater tendency to use cocaine and LSD than Controls and tend to exhibit an obsessive-compulsive, rigid coping style with hostility, interpersonal sensitivity, psychoticism, and depression as primary symptoms in contrast to Controls who tend to suppress their feelings. VS users also have a greater chance to have a learning disability in arithmetic than Controls.

VS abusers receive significantly more treatment for their drug problems and report a greater frequency of suicide attempts than Controls. Interestingly, the degree of drug

problem for VS users is positively correlated with some IQ or neuropsychological measures and suggests that as the increase in VS polydrug severity increases so does the intelligence of the users. That is VS using juveniles may have a tendency to be brighter which may be suppressed or lowered by drug use.

Although these results are germane to the population of juvenile delinquents the sample was inadequate to focus on the effect of duration and quantity of VS abuse. The median length of use was one year and the amount of VS inhaled was not measured. As mentioned above, subjects who abuse VS for an extended period of time, such as through their adolescence and into early adulthood may exhibit severe deficits relative to Controls and VS users with less use. It is possible that there is an additive effect of VS use, as suggested by animal studies, and that each year of VS use is detrimental but severe deficits are not revealed until a later point in time.

The lack of discriminatory ability of many social and family variables is instructive. It appears that gang involvement, employment, church attendance, and sports participation do not discriminate the two groups. However, other measures of psychological health and family dynamics not included in this study may prove useful. The SCL-90-R and BSI may prove too general to assess differences between groups. What factors are related to the use of VS remains unclear but there does appear to be a difference between VS users and Controls in overall involvement with substance abuse that

future research should attempt to explain.

These results suggest longitudinal research such as Shedler and Block's (1990) is essential in beginning to tease out what factors are related to what outcomes. In addition, replication of these results is essential in determining their generalizability and the import of ethnicity, SES, and psychological variables on cognitive performance and drug use. A multimodal model of drug use and cognitive functioning seems important to consider and somewhat supported by these results. Early intervention that focuses on learning disabilities, family values, self-esteem and learning styles seems essential to preventing problems secondary to drug use, especially the diffuse damage related to VS use.

Summary

A juvenile delinquent population was studied to evaluate the relationship between VS use and intelligence, neuropsychological performance, psychological health, drug problems, and family problems. As expected the juvenile delinquent sample as a whole displayed significant deficits in verbal intelligence relative to nonverbal intelligence. One possible explanation for this was the large proportion of Mexican-Americans and prevalence of low SES in the sample. In addition, verbal intelligence was below one standard deviation from the norm for VS users. This might be related to the juvenile population, in that they are already vulnerable to some deficit in verbal reasoning and the environment they come

from exacerbates the vulnerability.

Neuropsychological differences between juvenile delinquents who report VS use in addition to other drug use and those who deny VS use are mixed and do not support the hypothesis that VS use is related to deficits in attention/ concentration, new learning, and psychomotor speed.

Psychological health and treatment and family problems differ between the two groups. VS users tend to receive more drug treatment and report more psychological distress as well as report more frequently family members with severe substance abuse.

Future research might focus more on the issue of duration and quantity of abuse as well as psychological and external problems. It is possible that VS users with more intense use (longer period of time with a high quantity of exposure) suffer extremely debilitating effects as suggested by the studies using radiography and reporting very long term abuse (more than 6 years) and high quantity of use (daily with at least a 10 oz can per day). Many of the subjects in those studies reported VS were the drug of choice and in many cases the only drug, spending the whole day maintaining intoxication.

It is essential to state that this study in no way suggests that VS use is safe or not harmful. The short-term risks of VS use include death and this study is unable to assess the long-term or additive effects of VS use. For

example, it is unclear what variables are related to increased VS use and succession of use before severe deficits are evident.

In addition, the juvenile delinquent population may have a greater degree of risk and already suffer from some neurological deficits and thus be more sensitive to VS use. It is not appropriate to generalize these findings to other populations.

This study does suggest that juvenile delinquents are in need of much educational, psychological, and social intervention to develop their cognitive abilities, communication abilities, and environment. If they are, as a group, already vulnerable to disabilities then enriching their environment may prove beneficial and cost-effective. It also suggests that delinquency may be related in some way to verbal reasoning deficits and poor environments. Further research is needed to answer important questions related to duration and quantity of VS abuse and the impact of impoverished conditions on children's areas of functioning in psychological, neuropsychological and intelligence. In addition more research is needed on why some children start VS and other drug use at a very young age.

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