National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

**Prenatal Exposure to Cannabis: An Investigation of Postnatal
Consequences in School Age Children**

Colleen Marie Hourihan O'Connell

**Thesis submitted to the Faculty of Graduate and Research in partial fulfillment
of the requirements for the degree of Doctor of Philosophy in Psychology.**

© May 1990

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-58999-X

Thesis Acceptance Form - Doctoral Candidate

The undersigned hereby recommend to
the Faculty of Graduate Studies and Research
acceptance of the thesis,

"Prenatal Exposure to Cannabis: Postnatal Consequences in School Age Children"

submitted by

Colleen Marie Hourihan O'Connell

in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

Chair, Department of Psychology

Thesis Supervisor

External Examiner

Carleton University

Date May, 1990

Acknowledgements

I would like to thank my advisor, Dr. Peter A. Fried, for his guidance during the execution of this study. The expert statistical advice and moral support of Barb Watkinson was invaluable to the analysis of the data and is gratefully acknowledged. My special thanks to Hal O'Connell, not only for his many hours of painstaking work in the typesetting of this thesis, but also for his unfailing support and encouragement throughout my graduate school career.

This study was supported in part by a grant from the National Institute on Drug Abuse to P.A. Fried.

Dedication

This thesis is dedicated to my first teachers, my parents, Francis and Marian Hourihan. By their encouragement and example they taught me the value of not only achievement but of the lessons learned in its pursuit .

Table of Contents

Abstract.....	1
Introduction.....	5
Human Studies.....	13
Possible Mechanisms of Cannabis Effects.....	22
Behavioural Teratology of Cannabis.....	24
Animal Studies.....	25
Human Studies.....	29
Pilot Work.....	33
Rationale.....	35
Method.....	37
Statistical Analysis.....	55
Results.....	58
Multivariate Analyses.....	63
Comparison of prenatal and postnatal covariates.....	77
Path Analysis.....	78
Data from Infant and Preschool Tests.....	83
Discussion.....	94
Directions for Future Research.....	119
Summary.....	124
References.....	131
Appendices A to E	

Table of Contents (cont'd)

Tables:

Table 1: Animal Teratology Studies.....	7-9
Table 2: Human Studies.....	16-18
Table 3: Behavioral Teratology Studies.....	27-28
Table 4: Subjects' Drug Histories.....	41
Table 5: Sample Characteristics.....	59-60
Table 6: Mean Test Scores.....	64-65
Table 7: Discriminant Function Analysis.....	66
Table 8: Two Factor Manova Summary.....	70
Table 9: Two Factor Mancova Summary.....	76
Table 10, Table 11: Correlations between early and present data.....	84, 84a
Table 12 Correlations between early and present data.....	86
Table 13, 14, 15, 16 Correlations between early and present data.....	89-92
Table 17: Comparison of Home Environment Ratings.....	103
Table 18: Correlations between NEO & HEQ.....	127
Table 19: Corelations between NEO & Conners.....	128
Table 20: Correlations between HEQ & Conners....	129
Table 21: Correlations between infant test and NEO.....	130

Figures

Figure 1.....	72-74
Figure 2 Path Analysis.....	80-81

Abstract

In order to assess possible longterm consequences of prenatal cannabis exposure, twenty-eight school age children of cannabis users and twenty-eight children of non-users (matched on maternal cigarette and alcohol use during pregnancy) were examined on a variety of neurobehavioural outcomes. These outcomes included intellectual parameters, visual perceptual skills, attention and memory, language comprehension, academic achievement, visual-motor skills, and parental ratings of behaviour. Demographic information on parental levels of education, income and occupational status were obtained as well as intellectual and personality assessments of the mothers and ratings of home environment. Of thirty-two dependent variables on which the two groups of children were compared, ten reached one-tailed statistical significance in simple bivariate analysis.

Discriminant function analysis revealed that seven outcome variables combined to maximize the difference between the study groups. These outcomes were: two parental behaviour ratings (Conduct Problems and Anxiety); two visual perceptual scores (Visual Discrimination and Visual Sequential Memory); a language comprehension measure (Syntax Quotient); a measure of distractibility (Stroop Interference); and a visual-motor task (Trail Making Test, Part A).

Examination of the demographic, maternal and home environment ratings revealed that seven of these variables were significantly related both to prenatal cannabis exposure and to the discriminating variables and should therefore be considered as potential confounds. These covariates were: maternal age when the child was born; three maternal self-ratings of personality (i.e., Neuroticism, Agreeableness, and Conscientiousness); and three home environment ratings (i.e.,

Aggression-External, Aggression in the Home, and Supervision).

Maternal age when the child was born exhibited a significant factor by covariate interaction with prenatal cannabis exposure and was therefore treated as a separate independent variable. MANOVA results indicated that prenatal cannabis exposure had a significant main effect on the outcome variables but mother's age did not. The interaction term of mother's age with prenatal cannabis exposure did have a significant impact on outcomes. The subsequent MANCOVA (i.e., controlling for the influence of the six remaining covariates) was therefore run with two factors: prenatal cannabis exposure and the interaction term.

After controlling for the influence of mother's age and the six covariates, the effect of prenatal cannabis exposure on the outcomes was no longer statistically significant. In order to better describe the relationships among prenatal cannabis exposure, covariates, and three outcomes which were initially significantly related to prenatal cannabis exposure (Conduct Problems, Visual Discrimination, and Visual Sequential Memory), path analyses were employed.

Path analysis indicated that, for the variable Conduct Problems (on which children of cannabis users were rated higher than children of controls), the negative impact of prenatal cannabis exposure was exacerbated by higher levels of Aggression in the Home. Likewise another home environment scale, Supervision, intervened and compounded the relationship between prenatal exposure to cannabis and lower scores on Visual Discrimination. The lower score on Visual Sequential Memory for the children of cannabis users was related primarily to the interaction between mother's age and prenatal cannabis exposure. This meant that the two study groups differed on this measure but only when the children of mothers

younger than 27 years of age were compared.

For between 31 and 43 subjects in the present study, data from infant and preschool testings were available. Correlations between these early tests and data from the present study revealed some interesting trends. Specifically, children who exhibited marked tremors and startles from birth to one month of age were rated more highly by their parents on Conduct Problems, Hyperactivity Index, and Impulsivity-Hyperactivity. They were also rated highly on Learning Problems and had lower scores on reading comprehension and language comprehension tests.

The results of the present study are discussed in terms of direct and indirect drug effects. The relationships between the results of the present study and data from infant tests, as well as the results of the path analyses, support the notion of a direct effect of cannabis on some outcomes (principally Conduct Problems) assessed in the present study. However, given the finding of differing personality and home environment ratings between users and non-users of cannabis, as well as the findings of altered infant and school age behaviour, it is possible that a "transactional" model may apply. This model states that developmental outcomes are the product of both maternal and child characteristics and the relationship between mother and child characteristics is a reciprocal one. Not only might cannabis-using women have poorer parenting skills because of their particular personality traits (i.e., high on Neuroticism, low on Agreeableness and Conscientiousness) but the heightened "jitteriness" of babies born to cannabis users may be less likely to elicit stimulating interactions from the parents.

Case reports of seven children born to cannabis users are presented for purposes

of illustration of the abovementioned possible direct and indirect effects of prenatal cannabis exposure.

Suggestions for future research derived from a review of the literature and the results of the present study include: more independent assessment of behaviour problems, perhaps by teacher rating; control of the confounding influence of mother's age through matching; more in-depth recording of drug exposure to include postnatal time periods; and assessment of mother-child interactions to more directly evaluate the applicability of the transactional model.

Introduction

Marijuana and hashish (referred to collectively as cannabis after the *Cannabis sativa* plant from which they are derived) have been, and continue to be, popular leisure drugs and the most widely used illegal substances in Canada, although prevalence of use is declining. In 1978, 1980, and 1981 approximately 10% of adult Canadians (i.e., age 15 and above) reported using cannabis in the twelve months prior to the surveys. In 1985 this figure had dropped to six percent (Health and Welfare Canada, 1988). The popularity of cannabis has brought to light many non-beneficial, even harmful effects on general health and behaviour (for detailed review see Addiction Research Foundation, 1981).

Among the systems which may be adversely affected by cannabis is the endocrine system, especially those functions which relate to reproductive physiology (for detailed review see Abel, 1981a). In male animals, exposure to cannabis or its constituents (e.g., delta-9-tetrahydrocannabinol or THC) typically produces decreases in plasma testosterone (Harclerode, Nyquist, Nazar, & Lowe, 1979) and abnormalities in sperm count and sperm morphology (Huang, Nahas, & Hembree, 1979; Zimmerman, Zimmerman, & Raj, 1979). In female animals, cannabinoid compounds cause reduction in reproductive organ weights (Fujimoto, Kostellow, Rosenbaum, Morrill, & Bloch, 1979) and inhibition of ovulation (Smith, Smith, Besch, Smith, & Asch, 1979), largely through effects on hypothalamic hormones. Human studies have not provided such consistent findings. Testosterone levels do seem to be depressed following cannabis or THC ingestion in human males (Barrett, Chiang, & Licko, 1983) and effects on sperm morphology have been noted (Hembree, Nahas, Zeidenberg, & Huang, 1979); these effects appear to be reversible

upon cessation of ingestion. It is not known whether this has an actual impact upon fertility.

Human female cannabis users have not been found to have altered levels of reproductive hormones but have been reported to have shorter menstrual cycles. Given the distinct possibility of other drug use (such as alcohol) being involved in these human reports, the attribution of these effects to cannabis has been questioned (Abel, 1981). It is possible however that cannabis may produce the same hormonal alterations as it does in animals but that the humans who have been studied have developed tolerance to these effects, a phenomenon which has been demonstrated in a long term animal study (Smith, Almirez, Berenberg, & Asch, 1983).

From these studies of hormonal functioning, the question of the impact of cannabis on reproductive outcomes naturally arises. Although the medicinal value of cannabis in facilitating labor has been known for centuries (Abel, 1980), concern for possibly harmful effects of cannabis on the fetus did not emerge until after the thalidomide tragedy of the early 1960's focussed research attention on the prenatal environment. The possibility that cannabis constituents may be teratogenic (i.e., capable of causing fetal malformations) is supported by their lipophilic nature which allows them to be stored in maternal tissues and amniotic fluid (Harbison and Mantilla-Plata, 1972); their long half-life (25 to 36 hours, Wall, Sadler, Brine, Taylor, & Perez-Reyes, 1983); and their ability to cross the placenta, which has been demonstrated in both animal (Bailey, Cunny, Paule, & Slikker, 1987; Idanpaan-Heikkila, Fritchie, Englert, Ho, & McIsaac, 1969) and human studies (Blackard & Tennes, 1984; Greenland, Staisch, Brown, & Gross, 1982).

Table 1: Animal Teratology Studies

Study	Species	Drug	Dose/Route/ Time	Results sig. unless otherwise stated
Persaud & Ellington, 1967	Mouse	Cannabis Resin	16 mg/kg i.p. Days 1-6 or Day 6 only	Complete fetal resorption in animals treated on days 1-6; single dose = high incidence of stunting.
Persaud & Ellington, 1968	Rat	Cannabis Resin	4.2 mg/kg i.p. Days 1-6	High incidence of resorptions and malformations: stunting, syndactyly, phocomelia.
Geber & Schramm, 1969 a,b	Hamster	Crude Marijuana Extract (CME)	25, 50, 100 150, 200, or 300 mg/kg s.c. Days 6-8	Head, spinal, and whole body edema; phocomelia, spina bifida, exencephaly (dose-related)
	Rabbit	CME	130, 250, 500 mg/kg s.c Days 7-10	Increased resorptions, fetal edema, malformations (as above)
Borgen, Davis, & Pace, 1971	Rat	Δ^9 THC	.01, .10, 1.0, 10, 25, 50, 75, 100 mg/kg s.c Days 1-20	Reduced litter size at birth in 100 mg/kg group; high post-natal mortality in >50 mg/kg groups.
Harbison & Mantilla-Plata, 1972	Mouse	Δ^9 THC	200 mg/kg i.p., Days 8 & 9, 10 & 11, or 12 & 13	Significant increase in resorptions if treated on days 8&9; significant reduced fetal weight in all groups.
Mantilla-Plata, Clewe, & Harbison, 1973, 1975	Mouse	Δ^9 THC	50 mg/kg i.p. Days 8-10, 10-11 or 12-14.	50 mg/kg on days 8-10 = increased resorptions; on days 10-11 = reduced fetal weight.
			300 mg/kg i.p. Day 8, 12, 14 or 16	300 mg/kg on day 8 or 16 = increased resorptions; on day 12 or 14 = increased number with cleft palate. Reduced fetal weight.
Haley, Wright, Plank, Keplinger, Braude, & Calandra, 1973	Rabbit	Δ^9 THC or CME (16% THC)	.5, 1.5, 5, 15 mg/kg THC equiv. p.o. Days 6-18	No observable effect
	Rat	Ibid	5, 15, or 50 mg/kg THC equivalent Days 6-15	No observable effect.
Banerjee, Galbreath, & Sofia, 1975	Rat	Δ^9 THC	25, 50, 100 mg/kg p.o. Days 6-15	Reduced fetal weight in 50 mg/kg group. Rudimentary 14th rib noted in treated groups (not significant).
Fleischman, Hayden, Rosencrantz, & Braude, 1975	Mouse	Δ^9 THC	5, 15, 50, 150 mg/kg p.o Days 6-15	Missing sternbrae, extra or rudimentary ribs in treated groups (not significant).

Table 1: Animal Teratology Studies (cont'd)

Study	Species	Drug	Dose/Route/ Time	Results slg. unless otherwise stated
Thomas, 1975	Zebrafish	$\Delta 9$ THC	1-10 ppm. in aquarial media during late blastula (24 to 48 hours)	At > 2 ppm distal trunk anomalies: curved spine, bulbous tipped tail. At > 5 ppm reduced muscle activity, subsequent death.
Wright, Smith, Keplinger, Calandra, & Braude 1976	Rat	$\Delta 9$ THC or CME (16% THC)	.5, 1.5, 5 mg/kg p.o. prepeg. to Day 21 post partum	Reduced pup viability at days 12 and 21 postpartum in 5 mg/kg group (ameliorated by cross-fostering).
	Rabbit	Ibid	5, 15, 50 mg/kg p.o. Days 6-15 .5, 1.5, 5, 15 mg/kg p.o. Days 6-18	No malformations seen. No malformations seen. Reduced fetal weight and viability in 15 mg/kg CME group.
Fried, 1976 c.f.	Rat	Cannabis Smoke	Max. 3.3 mg/day Days 1-19	Reduced birthweight; pups born to & raised by treated dams weighted less at 90 days of age. Treated pups showed delayed eye opening and incisor eruption.
Joneja, 1976	Mouse	$\Delta 9$ THC	10, 20 mg/kg i.v. on Day 7,8, 9,10, or 11	Reduced fetal weight.
			3, 4.5, 6.25, 12.5, 25, 50, 75, 150, 300 mg/kg s.c. as above	Reduced fetal weight, especially in >4.5 mg/kg groups treated on day 10 or 11
			100, 200, 400 mg/kg p.o. as above	Reduced fetal weight. Exencephaly in day 9/400 mg/kg group.
Siegal, Siegal, Krimmer, Doyle, & Barry, 1977	Rat	$\Delta 9$ THC	5, 20 mg/kg p.o. Day 9 - Birth	Increase in fluctuating dental asymmetry. (Pair-feeding used)
Cozens, Clark, Palmer, Hardy, Nahas, & Harvey, 1979	Rabbit	CME (3% THC)	.2, 1 mg/kg (=.6, 3 mg/kg THC) p.o. Days 6-18	Reduced fetal weight, reduced ossification in 1 ml/kg group. Corneal opacities also seen (not significant).
Sofia, Strasbaugh, & Banerjee, 1979	Rabbit	$\Delta 9$ THC	15, 30, or 60 mg/kg s.c. Days 7-19	Reduced fetal weight and viability. Some skeletal anomalies more common in treated group (not significant).

c.f. = cross-fostering

Table 1: Animal Teratology Studies (cont'd)

Study	Species	Drug	Dose/Route/ Time	Results sig. unless otherwise stated
Rosencrantz, 1979	Rat	Cannabis Smoke	.8, 2.6, 3.8 mg/kg THC equiv.	No effect on rats. Significant increase in fetal death in mice.
	Mouse			
	Rat	$\Delta 9$ THC	Days 6-15 12.5, 25, 50 mg/kg p.o.	At higher doses fetal death increased, fetal weight reduced, no malformations seen.
	Mouse	$\Delta 9$ THC	Days 6-7, 6-10, 6-13 or 6-15 150, 300, 600 mg/kg p.o. as above	Dose-related interruption of pregnancy Findings as above.
Fried & Charlebois 1979	Rat	Cannabis Smoke	Max. 3.3 mg THC/Day on Days 1-19	F1 generation were less fertile and had smaller reproductive organs.
		$\Delta 9$ THC	4 mg/kg i.p. 15 times in adulthood prior to mating	F2 generation (offspring of F1 but not prenatally treated) weighed less than controls; eye opening and incisor eruption delayed.
Charlebois & Fried, 1980	Rat	Cannabis Smoke	Max. 16 mg/kg pregestation to Day 19	Poor diet & cannabis exposure increased gestation length, increased stillbirths, decreased birthweight and weight gain, delayed righting reflex, incisor eruption, eye opening and visual placing reflex. Eye opening and placing reflex advanced by rich diet.
Abel, Dintcheff, & Day, 1980 c.f., p.f.	Rat	CME (30% THC)	10, 150 mg/kg p.o. Day 3-Birth	Decreased pup weight at birth & at 21 days of age; increased neonatal mortality in 150 mg/kg group.
Abel, Bush, Dintcheff, & Ernst, 1981 p.f., c.f.	Rat	CME (25% THC)	20, 200 mg/kg p.o. Days 1-7, 8-14, 15-22, or 1-22	Decreased birthweight and increased pup mortality in group given 200 mg/kg on Days 15-22 or 1-22.
Abel, 1984 p.f., c.f.	Rat	$\Delta 9$ THC	5-50 mg/kg p.o. Days 1-5; 50 or 150 mg/kg - Term	Fewer pregnancies carried to term. Decreased birthweight; lower weight at 7 days of age.
Abel & Tan, 1987 p.f.	Mouse	$\Delta 9$ THC	20, 40 mg/kg p.o. Days 6-18	Increased resorption rate, reduced fetal weight.
Hutchings, Morgan, Brake, Shi, & Lasalle, 1987 p.f. c.f.	Rat	$\Delta 9$ THC	15, 50 mg/kg p.o. Days 8-22	Increased resorptions and perinatal death, increased postnatal mortality; slower postnatal growth.
p.f. = pair-feeding c.f. = cross-fostering				

The first scientific investigations into prenatal effects of cannabis found it to be both embryotoxic and teratogenic in two rodent species in that intraperitoneal injections of cannabis resin produced complete fetal resorptions in mice and a high incidence of malformations in rats (Persaud & Ellington, 1967, 1968). Numerous studies followed (see Table 1).

A variety of different species (e.g., mouse, rat, hamster, rabbit, & fish), routes of administration (e.g., oral, subcutaneous, intraperitoneal, intravenous, and inhalation), doses (e.g., from 0.01 to 400 mg/kg) and cannabis preparations (e.g., resin, crude marijuana extract, or pure THC) have been examined. A cursory review of the studies presented in Table 1 suggests that crude marijuana extract (hash oil) or cannabis resin (hashish) is more potent, i.e., is associated with more deleterious outcomes, than is pure THC. This may be due to the presence in those preparations of other cannabinoids, such as cannabidiol and cannabichromene, which have been shown to have toxic effects in adult animals (Rosencrantz, Fleischman, & Grant, 1981).

A major criticism which has been leveled at these animal studies concerns the dosages which have been used. Obvious teratogenic effects have only been seen when the doses were very high, often many times higher than relevant, behaviorally active doses in man. Rosencrantz (1979) has stated that a 50 kilogram human who smokes between one and six cannabis cigarettes (containing 2.6% THC) will ingest between 0.3 and 1.8 milligrams per kilogram of THC. Conversion factors, based on body surface areas, for equivalent animal doses have been calculated to be approximately 3 for monkeys (McGahan, Dublin, & Sassenrath, 1984), 4 for rabbits (Green, Sobel, Fineberg, Wynn, & Bowman, 1981) and 7 and 12 for rats and mice respectively (Nahas, 1979). Oral doses need to be approximately three to six times

greater than inhaled doses to achieve the same behavioural effects. Therefore, the study of Joneja (1976) which found exencephaly in mouse pups following oral administration of 400 mg/kg of THC utilized a dose that was almost four times greater than that which reflected heavy use in humans at that time. The disparity between the animal and human doses may be changing however; the THC content of various forms of cannabis appears to be increasing. An ongoing drug monitoring project has found that samples of marijuana (composed of the leaves, small stems, and seeds of the Cannabis plant) which were collected in 1980 had an average THC concentration of 0.74 percent. By 1982, the THC content in marijuana samples had risen to 3.3 percent. While the THC content in hashish (crude resin collected from dried and finely sifted flowering tops) did not change markedly (i.e., from 2.6 percent in 1980 to 2.4 percent in 1982), an increase was noted for hash oil, a viscous molasses-like product obtained by alcohol extraction of cannabinoids from the flowering tops of the Cannabis plant. In 1980 the average concentration of THC in hash oil samples was 11.5 percent; in 1982 it was 21.6 percent (Schwartz, 1984). Very recent reports have placed the THC content of "street grass" (i.e., marijuana) at 18 percent (Hutchings, 1989).

A more important flaw in many of these studies is the lack of control over the primary, toxic effects of cannabis on the dams. Most of the studies (with the exception of Geber & Schramm, 1969 a,b and Charlebois & Fried, 1980) report that maternal food and water intake was depressed in the treated groups and maternal weight gain was consequently depressed. The impact of maternal undernutrition on the examined outcomes is striking when the studies which utilized pair-feeding procedures are contrasted with those which did not. For example, when pair-feeding procedures are used, low doses (e.g., 20 mg/kg) produce minor physical anomalies such as fluctuating dental asymmetry (Siegel, Siegel, Krimmer, & Doyle,

anomalies such as fluctuating dental asymmetry (Siegel, Siegel, Krimmer, & Doyle, 1977) rather than gross structural malformations (Persaud & Ellington, 1968).

Poor maternal nutrition has been found to interact significantly with exposure to cannabis smoke in adversely affecting survival to term, birthweight, and growth in the neonatal period. Poor nutrition also compounds the delaying effect of cannabis on developmental milestones such as incisor eruption, eye opening, and the righting and visual placing reflexes in rat pups. Enhanced nutrition can counteract the effect of cannabis exposure on eye opening latency and the appearance of the visual placing reflex (Charlebois & Fried, 1980).

Maternal behaviours may also be altered in the postnatal period by cannabis treatment during gestation. These alterations include inhibition of lactation (Abel, Day, Dintcheff, & Ernst, 1979; Pace, Davis, & Borgen, 1971), suppression of pup retrieval (Abel, 1973), and failure to completely remove and consume placental membranes (Hutchings, Morgan, Brake, Shi, & Lasalle, 1987) in rats and an increase in breaking and resisting contact with infants in monkeys (Golub, Sassenrath, & Chapman, 1981b). These alterations in post-parturition factors, especially lactation, can affect offspring survival. For example, Wright, Smith, Keplinger, Calandra, and Braude (1976) found that a low dose of 5 mg/kg did not alter pup birthweight or litter size but did reduce pup viability at twelve and twenty-one days after birth. Cross-fostering treated pups at birth to non-treated surrogate dams prevented this pup mortality. Even when cross-fostering control procedures have been employed however, significant retardation of postnatal growth has been noted in prenatally treated animals (Abel et al., 1980; Borgen et al., 1973; Fried, 1976; Hutchings et al., 1987).

In summary, the animal literature suggests that cannabis is not classically

teratogenic (i.e., does not produce measurable morphological aberrations) but may well be embryo/fetotoxic and affect postnatal viability and growth rates.

Human Studies

The human literature cannot and does not yield clear cut findings in this field, largely because of ethical and practical concerns of quasi-experimental research. Drugs cannot be administered to gravid women and so exact doses or amounts consumed are not known. Other potentially confounding factors (such as other drug use or maternal behaviour) cannot be controlled by random assignment to groups. Human studies therefore, are based on volunteer samples and self-reports of drug use which are gathered either before (i.e., prospectively) or after (i.e., retrospectively) birth.

In the majority of human studies which have been published, the samples were drawn from hospitals in the core of large urban centers in the United States including Boston (Hingson, Alpert, Day, Dooling, Kayne, Morelock, Oppenheimer, & Zuckerman, 1982; Linn, Schoenbaum, Monson, Rosner, Stubblefield, & Ryan, 1983; Rosett, Weiner, Lee, Zuckerman, Dooling, & Oppenheimer, 1983; Zuckerman, Frank, Hingson, et al., 1989), Pittsburgh (Scher, Richardson, Coble, Day, & Stoffer, 1988), Denver (Tennes, Avitable, Blackard, Boyles, Hassoun, Holmes, & Kreye, 1985), and Los Angeles (Greenland, Staisch, Brown, & Gross, 1982). The subjects recruited at these clinics were typically young, poorly educated, and of limited financial means, all factors which can compound any discernible effects of prenatal drug exposure on postnatal outcomes. Cannabis use appears to be especially closely related to these demographic characteristics (Linn et al., 1983). Even in the one human study which utilized a primarily middle class, low risk sample, "heavy"

cannabis users (i.e., users of five or more "joints" per week) were typically younger and had lower incomes and less education than did non-users (Fried, 1980). As these demographic factors may have as great an impact as cannabis (if not greater) on outcomes such as birthweight (Linn et al., 1983), examination of cannabis effects necessitates control of the influence of the variables of maternal age, education, and income. Given the aforementioned restrictions of quasi-experimental research designs, this control is best achieved with statistical procedures.

The extent of reported cannabis use in pregnancy has varied markedly in these studies. Gibson, Baghurst and Colley (1983) found that only 5.4 percent of their Australian sample admitted to using cannabis at all during pregnancy. In contrast, several North American authors report use in 13-17 percent of their samples (Fried, Watkinson, Grant, & Knights, 1980; Greenland, Richwald, & Honda, 1983; Hingson et al., 1982; Rosett et al., 1983), and more recent reports places it as high as 27 percent (Zuckerman et al., 1989) or 34 percent (Tennes et al., 1985). Likewise "regular use" (generally defined as once per week or more) varies from 0.5 percent (Gibson et al., 1983) to 10 percent (Greenland et al., 1983).

Within the cannabis using population, use tends to decrease as pregnancy proceeds (Fried et al., 1980; Greenland et al., 1982, Tennes & Blackard, 1980; Tennes et al., 1985), although the magnitude of this decrease is least for those who use the drug the most (Fried et al., 1980). The heaviest users are also more likely to re-establish prepregnancy levels of consumption in the year following pregnancy (Fried, Barnes, & Drake, 1985).

Cannabis use has been found to be correlated with cigarette smoking both before and during pregnancy (Fried et al., 1980; Gibson et al., 1983; Linn et al., 1983). The

relationship between cannabis use and alcohol use is much more varied, having been found to be either nonsignificant (Fried et al., 1980; Tennes & Blackard, 1980), weak (Linn et al., 1983) or strong (Tennes et al., 1985). Heavy drinkers are more likely to use cannabis (Hingson et al., 1982; Rosett et al., 1983) and heavy users of cannabis consume more alcohol than other subjects (Fried et al., 1980). Cannabis users are also more likely to use other illicit drugs (e.g., cocaine, LSD, PCP) than are non-users (Gibson et al., 1983; Tennes et al., 1985). The rates of use of these illicit substances however are often too rare to be treated quantitatively in these studies (Tennes & Blackard, 1980).

The studies of cannabis effects on the course and outcome of pregnancy in humans are summarized in Table 2. The majority of the findings do not support a statistically significant impact of cannabis on these measures. Although it would appear to agree with the medicinal folklore of cannabis, the finding of increased incidence of precipitate labor (i.e., less than three hours total) among users (Greenland et al., 1982) was not replicated in a subsequent low-risk sample (Greenland et al., 1983) or when other risk factors (such as smoking) were controlled (Fried, Buckingham, & Von Kulmiz, 1983). Length of gestation has likewise been shortened for some regular users (Fried et al., 1983; Fried, Watkinson, & Willan, 1984; Gibson et al., 1983) but lengthened for others (Tennes et al., 1985). Unlike the animal literature, maternal weight gain during pregnancy has been found to be either unaffected (Fried, 1980), significantly decreased (Fried, 1982; Zuckerman et al., 1989), or significantly increased (Tennes et al., 1985) with cannabis use. Also contrary to animal findings, there is no indication that ingestion of cannabis during pregnancy is associated with difficulties of lactation in humans (Goodine & Fried, 1984; Tennes et al., 1985).

Table 2: Human Studies

Study	Type	N	Findings
Hecht, Beals, Lees, Jolly, Roberts, 1968	Case report	1	Child missing right hand born to cannabis and LSD-using parents.
Carakushansky, Neu, & Gardner, 1969	Case report	1	Child with shortened fingers, absent nails and webbing between fingers and toes born to cannabis and LSD using mother.
Fried, 1980	Prospective	89 (23 Users)	Children born to regular users of cannabis displayed altered response to light, increased tremors. No effect on birthweight, length of labor, or length of gestation.
Tennes & Blackard, 1980	Prospective	278 (? users)	Cannabis use unrelated to birthweight, birthlength, gestation length, or incidence of minor physical anomalies.
Hingson, Alpert, Day, Dooling, Kayne, Morelock, Oppenheimer, & Zuckerman, 1982	Largely Retrospective	1,690 (237 Users)	Children born to cannabis users weighed significantly less at birth and were more likely to have FAS-like features than children of non-users.
Greenland, Staisch, Brown, & Gross, 1982	Prospective (Matched pairs)	71 (35 Users)	Users more frequently had precipitate labor, infants of users exhibited significantly more meconium staining.
Greenland, Richwald, & Honda, 1983	Prospective	313 (41 Users)	Differences between groups on above variables not statistically significant.
Fried, Buckingham, & Von Kulmiz, 1983	Prospective (Matched pairs)	38 (19 Users)	No difference between groups on incidence of precipitate labor, meconium staining, or other risk outcomes. Regular users had a significantly shorter gestation period.
Qazi, Mariano, Beller, Milman, Crombleholme, & Buendia, 1983	Case Report	5	Infants born to cannabis users who denied other drug use; low birthweight, small head size, tremors and some minor physical anomalies noted.
Rosett, Weiner, Lee, Zuckerman, Dooling, & Oppenheimer, 1983	Prospective	469 (80 Users)	Cannabis use did not compound alcohol's effect on birthweight or risk of anomalies.
Linn, Schoenbaum, Monson, Rosner, Stubblefield, & Ryan, 1983	Retrospective	12,424 (1,246 Users)	Initial relationship between cannabis use and low birthweight, shortened gestation, and major malformations was eliminated when demographics and medical history were controlled.
Gibson, Baghurst, & Colley, 1983	Prospective	7,301 (394 Users)	Regular cannabis use was significantly associated with premature birth (ie. <37 weeks gestation).
Fried, Watkinson, & Willan, 1984	Prospective	437 (50 Users)	Cannabis use was significantly negatively related to length of gestation after controlling for confounds.

Table 2: Human Studies (cont'd)

Study	Type	N	Findings
O'Connell & Fried, 1984	Prospective (Matched pairs)	50 (25 Users)	No significant difference between groups on number of minor physical anomalies.
Tennes, Aitable, Blackard, Boyles, Hassoun, Holmes, & Kreye, 1985	Prospective	756 (258 Users)	Cannabis use was significantly negatively related to birthlength; positively related to gestation length; unrelated to incidence of minor physical anomalies.
		129 (92 Users)	Cannabis use was unrelated to growth or behavioural measures at one year of age.
Hatch & Bracken 1986	Prospective	3,857 (367 Users)	Regular cannabis use was associated with an increase risk of low birthweight and/or small for gestational age infants for whites.
Tansley, Fried, & Mount, 1986	Prospective	101 (31 Users)	Visually evoked potentials tended to be more variable for children of users.
Fried & Makin, 1987	Prospective	250 (47 Users)	Cannabis use was significantly associated with increased startles, tremors, irritability, and poorer habituation to light in 4-day old infants.
Fried & O'Connell 1987	Prospective	667 (101 Users)	No Significant negative effects of cannabis on any growth parameters at birth, 12, or 24 months. [N=123 at follow-up (41 Users)]
Fried, Watkinson, Dillon, & Dulberg, 1987	Prospective	254 (32 Users)	Cannabis use significantly associated with increased fine tremors, startles and Moro reflex tremors in 9 and 30-day old infants.
Kline, Stein, & Hutzler, 1987	Prospective	2,815 (275 Users)	Study conducted in two phases. No coherent trend in association with birthweight in Phase I; in Phase II daily use was associated with significant decrease in birthweight.
Fried & Watkinson, 1988	Prospective	217 at 12 months (54 Users) 153 at 24 months (53 Users)	Cannabis use was significantly positively associated with weight at 12 months and height at 24 months and with Primary Cognitive Score at 12 months; significantly negatively related to home environment rating.
Hayes, Dreher, & Nugent, 1988	Prospective	56 (30 Users)	Infants of users had better organized sleep-wake cycles and more autonomic stability than infants of non-users at 1 month of age.
Scher, Richardson, Coble, Day, & Stoffer, 1988	Prospective	55 (26 Users)	Cannabis use predicted increased body movements and decreased quiet sleep in 1-day old infants.
Lester & Dreher, 1989	Prospective	40 (20 Users)	The cries of infants of users were shorter, of higher frequency, contained more dysphonation, and were more suggestive of respiratory tract involvement than were cries of infants of non-users.

Table 2: Human Studies (cont'd)

Study	Type	N	Findings
Zuckerman, Frank, Hingson, Amaro, Levenson, Kayne, Parker, Vinci, Aboagye, Fried, Cabral, Timperi, & Bauchner, 1989	Prospective	1,226 (331 Users)	Cannabis use was associated with a significant decrease in weight and length at birth, after controlling for potential confounds.
Fried & Watkinson, 1990	Prospective	133 (31 Users) at 36 months	Children of users performed worse on a test of quantitative abilities; this did not persist after controlling for confounds.
		130 (29 Users) at 48 months	Children of users performed worse on memory and verbal tests. Lower scores on memory test persisted after controlling for confounds.
Astley & Little, 1990	Prospective Matched Pairs	136 (68 Users)	Cannabis exposure via mother's milk during the first month post partum appeared to be associated with a decrease in motor development at one year of age

Reports of the effects of cannabis use on growth measures at birth are varied. Of the twelve human studies in the literature which examined birthweight, only four found a significant relationship. Hingson et al. (1982) reported that women who used marijuana during pregnancy delivered babies who, on average, weighed 105 grams less than babies of non-users. In this study, marijuana use accounted for only 0.3 percent of the variance in birthweight and these authors noted that the factors of maternal weight prior to pregnancy and weight gain during pregnancy each had nearly three times the impact on this outcome that marijuana use did. Like other researchers (e.g., Linn et al., 1983; Rosett et al., 1983), they also noted that race (i.e., being Black) had a significant negative impact on birthweight independent of marijuana use. This independent impact of race was examined more closely by Hatch and Bracken (1986). They reported that "regular use" of marijuana (i.e., use two to three times per month or more) was associated with an increased risk of delivering a low birthweight or small-for-gestational-age infant, but only for white women. Marijuana use apparently did not add to the already elevated risk of these outcomes for non-whites.

Kline, Stein, and Hutzler (1987) found varying associations between reported marijuana use and birthweight in two consecutive pregnancy cohorts. Their only statistically significant finding was a relationship between daily use of marijuana and a 230 gram decrease in birthweight in the second cohort. The study is flawed in that the authors did not include demographic variables in their analyses nor did they examine the effect of marijuana on birthweight after the effects of both alcohol and cigarettes were controlled. They conclude the presentation of their results by suggesting that the significant finding was due in large part to the use of other drugs such as cocaine.

Finally, Zuckerman et al. (1989) found that infants of marijuana users were both lighter and shorter at birth than infants of non-users, but only if the users had been identified through positive urine assay. Earlier work by this group of researchers had demonstrated that the use of a urine assay in conjunction with a pregnancy interview increased the likelihood of marijuana use being reported (Hingson, Zuckerman, Amaro, Frank, Kayne, Sorenson, Mitchell, Parker, Morelock, & Timperi, 1986). The 1989 study revealed that use of urine assays also enhanced the marijuana/outcome relationship for when self-report was the sole criterion for defining "user" status, the relationship between use and growth measures was not significant. While this research would appear to endorse the use of urine assays as an important adjunct to prenatal research, the limitations of such a technique must be acknowledged. Firstly, it should be noted that, according to the data provided by Zuckerman et al. (1989), 948 subjects tested positive for cannabis. Of this number, 53 (5.5 percent) denied use, which suggests that the use of the assay would be an asset in "catching" dishonest self-reporters. However, 278 subjects reported using cannabis and 46 percent of these (i.e., 129 subjects) tested negative. The problem appears to lie in the nature of the drug itself. Urinary metabolites of THC can be detected up to 72 hours after ingestion of the drug (Wall et al., 1983) and they can be reliably detected in subjects who have been only passively exposed (Law, Mason, Moffat, King, & Marks, 1984). Therefore the urine assay may not give accurate information as to the frequency, pattern, or type of use (i.e., active inhalation versus passive exposure), only that the subject has been exposed at sometime in the past 72 hours. It is possible that the subjects of Zuckerman et al. (1989) who denied use had in fact been passively exposed and those who admitted use but tested negative had used the drug prior to the previous 72 hours. The fact that using the positive urine assay as the criteria for defining use had resulted in a stronger association

between cannabis and reduced birthweight could simply mean that the majority of women who tested positive were heavier and more frequent users of the drug.

Whether cannabis may be considered a classical teratogen in humans remains unanswered. The rather dramatic early case reports (Carakushansky, Neu, & Gardner, 1969; Hecht, Beals, Jolly, & Roberts, 1968) of children with malformed limbs both implicate other drugs as well as cannabis as possible teratogens. The denial of other drug use by the subjects of Qazi (Qazi, Mariano, Beller, Milman, Crombleholme, & Buendia, 1983) whose children exhibited low birthweight, tremors and minor physical anomalies may be considered suspect given the aforementioned correlations among types of drug use. The somewhat startling report of an increased likelihood of Fetal Alcohol Syndrome-like features occurring in children of cannabis users (Hingson et al., 1982) has not been borne out by subsequent studies of either a prospective (O'Connell & Fried, 1984; Rosett et al., 1983) or retrospective design (Linn et al., 1983). The discrepancies among these studies may be due differing diagnostic criteria. Hingson et al. (1982) diagnosed CFAS (i.e., features compatible with fetal alcohol syndrome) if an infant met two of four criteria: 1) small size for gestational age; 2) microcephaly; 3) short palpebral fissures (i.e., small eye slits); and 4) two or more dysmorphic features such as broad low nasal bridge, epicanthic folds, or ear anomalies. Two percent of their 1,384 subjects fit this description. Rosett et al. (1983) however applied a different (and perhaps stricter) set of criteria. Their diagnosis of fetal alcohol effect was in accordance with the full-blown Fetal Alcohol Syndrome in that it required signs in each of three categories: 1) prenatal and postnatal growth retardation; 2) central nervous system involvement; and 3) facial dysmorphology. The criteria used by Linn et al. (1983) did not include facial dysmorphology or central nervous system involvement, but rather considered "minor" and "major" malformations. These three studies did have

in common the finding of no significant relationship between cannabis use and "congenital abnormality" (defined as three or more minor malformations or one major malformation). The O'Connell and Fried study (1984) focussed on minor physical anomalies of the face, hands and feet and found a non-significant relationship between prenatal cannabis exposure and minor anomalies involving the eyes.

Possible Mechanisms of Cannabis Effects on the Fetus

Although to date there has been no conclusive evidence regarding the underlying mechanisms for the various "cannabis effects" reported in the literature, several authors have ventured to speculate. Geber and Schramm (1969b), who were among the earliest investigators of possible cannabis teratogenicity, suggested that the drug's action on the fetus may be largely indirect, that is, due to its sympathomimetic properties. Their hypothesis was that cannabinoids ingested by the mother would stimulate the release of catecholamines from her adrenal medulla, which could then cross the placenta and act directly on the fetus and affect RNA and DNA synthesis, mitotic activity, and cell number and size. Or, alternatively, the catecholamines could imbalance some other maternal parameter that would, in turn, produce the fetal effects.

Similarly "indirect" hypotheses have been presented by other researchers. Borgen et al. (1971) and Siegel et al. (1977) both postulated that the effects seen in their studies could be the result of maternal stress responses to THC ingestion. Borgen et al. (1971) did not find gross teratogenicity in their rat pups but noted increased organ weights in the treated dams. Siegel et al. (1977) reported an increase in fluctuating dental asymmetry in prenatally exposed rat pups. As this

finding has been associated with stressing conditions such as cold and noise, it was cited as evidence that THC is a stressing substance.

In human studies, the theory most often cited to explain cannabis effects on outcomes such as birthweight is that of decreased oxygenation of the blood supply (e.g., Zuckerman et al., 1989). As compared with smoking tobacco, smoking cannabis is associated with a nearly fivefold greater increment in blood carboxyhemoglobin level (Wu, Tashkin, Djahed, & Rose, 1988). Cannabis ingestion may also cause increases in maternal heart rate and blood pressure (Foltin, Fischman, Pedroso, & Pearlson, 1987), both of which could serve to reduce the flow of oxygenated blood to the fetus and thereby impair growth.

The possibility that cannabis could have a more direct effect on the developing fetus is supported by the ability of its constituents to cross the placenta and to be stored in amniotic fluid and in fatty tissues (Bailey et al., 1987; Blackard & Tennes, 1984). While there is no evidence of chromosomal damage resulting from cannabis exposure, cell number could be affected as there is evidence from both in vitro and in vivo studies that mitotic activity may be inhibited (Martin, 1969; Matsuyama & Fu, 1981; Neu, Powers, King & Gardner, 1969).

The detection of cannabinoids in fetal brain tissues (Bailey et al., 1987; Kennedy & Waddell, 1972) led researchers to investigate levels of brain biogenic amines following prenatal exposure. Dalterio, Steger, Mayfield, and Bartke (1984) found that prenatal exposure to the cannabinoids cannabinol (CBN) and cannabidiol (CBD) resulted in decreased levels of norepinephrine and increased levels of serotonin in adult animals. Prenatal CBN exposure also decreased levels of dopamine. Interestingly, THC had no effect on these neurotransmitters in that

study. In other studies, using non-pregnant adult animals, THC has produced changes in biogenic amines very similar to those found by Dalterio et al. (1984) (e.g., Aulakh, Bhattacharya, Hossain, & Pradhan, 1980; Schildkraut & Efron, 1971). While these changes in neurotransmitter levels correlate with changes in behaviour in adult animals (Aulakh et al., 1980), concomittant biochemistry-behavior studies must be done before it is known if prenatal exposure to cannabis results in altered levels of neurotransmitters which, in turn produce postnatal behavioural alterations. However, the lack of definite knowledge about the underlying mechanisms has not interfered with the proliferation of studies examining the relationship between prenatal cannabis exposure and postnatal behaviour.

"Behavioural Teratology" of Cannabis

The term "behavioural teratology" is used to describe the deleterious changes in the behaviour of animals attributed to agents administered during prenatal development (Coyle, Wayner, & Singer, 1976). Behavioural anomalies may reflect the lower end of a spectrum of prenatal effect, with overt morphological aberrations representing the high-dose end. This has proved to be true with regard to alcohol; high doses produce physical malformations and low doses produce more subtle effects such as altered learning ability in the absence of physical malformation (Abel, 1981b). Other substances, such as methyl mercury, produce enduring behavioural deficits but no observable morphological changes (Snyder, 1971). Therefore the absence of cannabis-related malformations does not preclude the possibility that prenatal exposure could result in alterations in normal functional capacity which may be apparent at birth or which may not emerge until later in postnatal development.

Animal Studies

The investigations of possible behavioural teratogenicity of cannabis have been almost as extensive as those concerned with physical malformations. As with the classical teratogenicity studies, there has been a great deal of variation with regard to the species studied, the drug preparation used, and the route and timing of administration, all of which influence the measured outcomes. As well, pair-feeding and cross-fostering procedures have not always been included in the experimental designs. The impact of these inconsistencies may be seen in the variety of outcomes listed in Table 3. For example, performance of treated pups in maze-learning situations may (Gianutsos & Abbatiello, 1972; Kawash, Yeung, & Berg, 1980) or may not (Charlebois & Fried, 1980) be adversely affected. The only common denominator among these experiments was the species studied and no cross-fostering or pair-feeding procedures were implemented. Visual placing reflexes have been found to be delayed following cannabis exposure via both the subcutaneous injection (Borgen, Davis & Pace, 1973) and inhalation routes (Charlebois & Fried, 1980). However, cross-fostering appeared to attenuate the effect of cannabis smoke on this outcome (Fried, 1976). In studies where both cross-fostering and pair-feeding have been carried out (e.g., Abel, 1979, 1984; Brake, Hutchings, Morgan, Lasalle, & Shi, 1984) only very high doses (e.g., 150 mg/kg) have produced behavioural anomalies in the offspring (Abel, 1979).

Another important factor which has varied in this research is the age of the subjects at testing. Borgen et al. (1973) found that cross-fostered pups exposed on days 10 to 12 of gestation to subcutaneously administered doses of 10 mg/kg were hyperactive at nine days of age. However, Uyeno (1973) used a similar drug preparation, route, and timing but much larger doses (i.e., 30, 60, 120 mg/kg) and found no drug effect in 16 day old pups except at the highest dose level, which

produced hypoactivity. This suggests not only that dosage levels may interact with other factors such as age to influence outcomes but that some behavioural effects may be transient, seen only at an early age. Vardaris, Weisz, Fazel, and Rawitch (1976) noted a deficit in shock avoidance learning in prenatally treated pups at 21 days of age which was not present at 90 days of age. Conversely, prenatal exposure may affect some behaviours that only emerge in adulthood (e.g., Dalterio, 1980). It is also possible that the effects of prenatal exposure may be subtle but persistent, requiring sensitive assessment techniques and long term follow up (e.g., Golub, Sassenrath, & Chapman, 1981a, 1982).

Table 3: Behavioural Teratology Studies

Study	Species	Drug	Dose/Route/ Time	Behavioural Measures	Results (stat. sig. diff.)
Gianutsos, & Abbatiello, 1972	Rat	Cannabis Extract	250 mg/kg s.c. Days 8-11	Lashley III Maze	Treated pups made more errors, more trials to criterion, longer time in maze.
Borgen, Davis, & Pace, 1973 c.f.	Rat	$\Delta 9$ THC	10 mg/kg s.c. Days 10-12	Reflex development open field	Treated pups = delayed development of visual placing and cliff avoidance, hyperactivity at 9 days.
Uyeno 1973 c.f.	Rat	$\Delta 9$ THC	30, 60, 120 mg/kg s.c. Days 10-12	Spontaneous activity Y-Maze learning	Highest dose group hyperactive at 16 days.
Fried 1976 c.f.	Rat	Cannabis Smoke	Max. 3.3 mg/day Days 1-19	Reflex development, Activity and EEG response to THC in adulthood	Treated pups hypo-active at 7 days. Treated pups slower to develop tolerance to THC as adults.
Vardaris, Weisz, Fazel, & Rawitch, 1976	Rat	$\Delta 9$ THC	2 mg/kg p.o. Day 3-birth	Open field Push-tube Passive avoidance	At 21 days pups showed deficit in shock avoidance, not at 90 days. At 90 days more aggressive.
Abel 1979 p.f., c.f.	Rat	Cannabis Extract	10, 150 mg/kg p.o. Days 2-21	Rotarod inclined plane; Spontaneous alternation, 2-way shock avoidance	Females in 150 mg group showed deficits on rotarod behaviour.
Charlebois & Fried, 1980	Rat	Cannabis Smoke	Max 16 mg/kg Days 1-19	Reflex development Open field Water maze (at 35 days)	Visual placing reflex delayed; activity at 21 days of age reduced.
Dalterio 1980	Mouse	$\Delta 9$ THC or CBN	50 mg/kg p.o. Day 20-6 days post-partum	Copulatory behaviour in male offspring	Behaviour reduced in adult males.
Kawash, Yeung, & Berg, 1980	Rat	Cannabis Resin	4.2 mg/kg i.p. Days 2-6	Open field Water Maze (at 22 days)	Treated offspring = significantly more trials to criterion in maze.
p.f. = pair-feeding c.f. = cross-fostering					

Table 3: Behavioural Teratology Studies (cont'd)

Study	Species	Drug	Dose/Route/ Time	Behavioural Measures	Results (stat. sig. diff.)
Golub, Sassanrath, & Chapman, 1981a, 1982	Monkey	$\Delta 9$ THC	2.4 mg/kg p.o. 1-2 years pregestation & during pregnancy & lactation	Visual attention	Treated offspring = significantly more attention to stimuli, especially novel stimuli, early in sessions.
Abel 1984 p.f., c.f.	Rat	$\Delta 9$ THC	50 mg/kg p.o. Days 5-21	Shock avoidance Rotarod Spontaneous alternation	No drug effect seen.
Brake, Hutchings, Morgan, Lasalle, & Shi, 1987 p.f., c.f.	Rat	$\Delta 9$ THC	50 mg/kg p.o. Days 8-22	Locomotor activity latency to nipple attachment	No drug effect seen.
p.f. = pair-feeding c.f. = cross-fostering					

The literature regarding the behavioural effects of prenatal exposure in humans is fairly sparse with the majority of published reports coming from the Ottawa Prenatal Prospective study (Fried et al., 1980, refer to Table 2). The first of these, published in 1980, concerned the four day old offspring of twelve regular cannabis users (i.e., consumers of at least two joints per week) who were assessed with the Brazelton Neonatal Behavioral Assessment Scale (Brazelton, 1973). Seven of these infants exhibited altered visual responsiveness in the form of either a lack of response to a light repeatedly directed at the eyes or a failure to habituate to this light. These infants also exhibited heightened tremors and startles. Although other researchers (i.e., Tennes et al., 1985) have not found that variance in Brazelton test scores could be accounted for by prenatal exposure, more detailed analysis of Fried's (1980) findings in a larger sample indicated that, even after controlling for such confounds as gestation length, age at testing, family income, maternal age, caffeine, and other drug use, cannabis showed a highly significant relationship with increased startles, tremors, irritability, and a reduction in habituation to light in four-day old infants (Fried & Makin, 1987). This relationship was less obvious at nine days of age and the altered visual responsiveness had completely dissipated by thirty days of age. An increase in fine tremors and startles however was still obvious at thirty days of age (Fried, Watkinson, Dillon, & Dulberg, 1987). These symptoms resemble those comprising a neonatal abstinence syndrome (i.e., symptoms of drug withdrawal) seen in infants born to opioid-addicted women. Along with hyperactive reflexes and tremors, opioid-addicted babies exhibit abnormal visual processing (i.e., abnormal visually evoked potentials) which is more likely a reflection of poor modulation of arousal than deficits in sensory abilities (Hans, Marcus, Jeremy, & Auerbach, 1984).

A very recent study provides some corroboration for these early findings of the Ottawa Study. Scher, Richardson, Coble, Day and Stoffer (1988) found that prenatal cannabis exposure significantly predicted increased large and small body movements and decreased quiet sleep in newborn infants. The authors interpret this finding as a suggestion that prenatal cannabis use contributes to an overelaboration of the noradrenergic system that is reflected in increased motility and longer active sleep segments in exposed infants at birth.

Interestingly, a study of cannabis use by pregnant women in Jamaica found a very different association between cannabis and Brazelton test scores. In that study, infants of users exhibited better regulation of sleep/wake cycles and fewer tremors and startles than did infants of non-users at one month of age (Hayes, Dreher, & Nugent, 1989). This difference was attributed mainly to differences in care-taking environments for, although socioeconomic status was controlled through matching, cannabis use in Jamaica is associated with economic independence, social support and better access to food and other resources which may result in a more stimulating home environment.

One outcome of the Ottawa study which has been corroborated by work in Jamaica is the incidental finding of cri du chat or high-pitched cry among one-third of the babies born to regular cannabis users. This was never noted among the offspring of non-users. Lester and Dreher (1989) compared the acoustic characteristics of the cries of infants of marijuana users and non-users in Jamaica. In this sample, where both users and non-users were from lower socioeconomic families and were similar with regard to age , parity, and other drug use, the infants of the users were found to have cries that were of shorter duration and

higher frequency, contained more "dysphonation": (i.e., "turbulence" or "noise"), and were suggestive of compromised respiratory tract functioning. This high-pitched cry has also been characterized as a sign of neonatal withdrawal (Hans et al., 1984). It must be noted that, because of the greater frequency of use and higher concentration of cannabinoids in Jamaican cannabis as compared to that typically consumed in North America, the prenatal exposure of the infants could have been as much as 15 to 20 times greater than the exposure of infants in North American studies.

When the children of the Ottawa Study were examined at twelve months of age with the Bayley Scales of Infant Development (Bayley, 1969), no adverse effects of prenatal cannabis exposure were noted. There was, in fact, a positive correlation noted between maternal cannabis use and a subscale which evaluates infant attitudes, interests, and temperament. The relationship persisted after controlling for potential confounds (Fried & Watkinson, 1988). Similarly, Astley and Little (1990) also reported no association between prenatal cannabis exposure and development at one year of age. These researchers reported a significant negative relationship between cannabis exposure via mother's milk and scores on the Psychomotor Development Index (PDI) of the Bayley Scales at twelve months of age. This relationship held only for exposure during the first month postpartum, which accounted for five percent of the variance in test scores. Exposure to alcohol during gestation also accounted for five percent of the variance in test scores; exposure to cocaine during lactation accounted for four percent of the variance. This result awaits corroboration through replication.

In twenty-four month old children, prenatal cannabis exposure was found to be significantly and negatively correlated with scores on a test of language

comprehension. This association did not persist after adjusting for other variables, principally home environment ratings which were positively associated with the language measure and negatively associated with cannabis use (Fried & Watkinson, 1988).

Analysis of data from testing carried out at thirty-six months of age suggest that children of "heavy" users of cannabis (i.e., more than five "joints" per week) performed slightly worse than other children on tests of quantitative abilities. After controlling for potentially confounding variables such as income, mother's age, mother's educational level, prepregnancy weight and weight gain over pregnancy this difference was no longer significant.

At 48 months of age, the children of heavy users could be reliably discriminated from other children on the basis of lower scores on tests of verbal ability and memory. The relationship between prenatal exposure to cannabis and lowered memory score persisted after controlling for the influence of home environment, a measure which was found to be significantly related to both cannabis use and to the outcome measure (Fried & Watkinson, 1990). The emergence of an apparent "cannabis effect" at this age could be due to a type of "maturational effect" wherein the nature of the effects of cannabis exposure is such that development must proceed to a certain level before they can be detected. This would be true if the tests on which the effect is demonstrated were in some way different in terms of complexity from those administered at an earlier age or if the test scores varied a great deal within groups across test ages. However, since the tests administered at 36 and 48 months of age were identical (i.e., the McCarthy Scales of Children's Abilities, McCarthy, 1972) and the group scores were very similar across the test ages (see Fried & Watkinson, 1990), this appears unlikely. A more plausible

explanation might be the lessening impact over time of the particular postnatal confounds used in that study. At both ages, the postnatal confound of home environment was based on the HOME test (Caldwell & Bradley, 1979) which had been administered when the children were 24 months old. It may be that those home environment ratings, while still correlating with outcome scores, no longer provide an adequate assessment of the home environment differences between children of cannabis users and non-users which have an influence on test scores. Bradley and Caldwell (1976) reported that correlations between HOME scores and outcomes such as I.Q. were stronger when the two measures were separated by smaller intervals of time than when separated by several years.

Pilot Work

The children of the Ottawa Prenatal Prospective Study continue to be tested at yearly intervals. Beginning at age five a comprehensive battery of neuropsychological tests is administered in addition to the standardized developmental scales which have been administered since the age of three. These tests include verbal fluency, sound blending, speech discrimination, sentence memory, aphasia screening, vigilance, developmental drawings, visual memory, fine and gross motor skills, tactual abilities and non-verbal reasoning.

In order to highlight those areas of behaviour possibly affected by prenatal cannabis exposure and deserving of further investigation, a discriminant function analysis of the neuropsychological test variables for all children in the Study who had either a five- or six-year test and for whom data were complete ($n=85$) was carried out. The resulting function reliably discriminated the children of regular cannabis users from children of non-users (Wilk's=.54, $p=.0001$). Although none of

the structure coefficients of the contributing variables were larger than 0.3, the magnitude accepted as indicative of significance (Pedhazur, 1982), it is interesting to note which variables did correlate most highly with the discriminant function. They were total finger tapping speed ($r=-.23$), the score on a memory test ($r=.22$), and parental assessment of the presence of learning problems ($r=.20$). A t-test revealed that children of regular users scored significantly lower on finger tapping ($p=.003$) than did children of infrequent users or abstainers.

In summary past and ongoing research suggest that while prenatal cannabis exposure may not be associated with pronounced effects on the course or immediate outcome of pregnancy, it may be associated with subtle but persistent behavioural anomalies in the neonatal period and possibly into early childhood. Further research is needed to determine whether these anomalies may be seen in school age children and whether the early behavioural deviations are predictive of later functional differences.

Rationale

The rationale for the present study was provided by the previously cited findings in both the human and animal literature. While "hard signs" of prenatal exposure are few and are found almost exclusively in the animal literature, "soft signs" or transient behavioural indices do show some consistency across species. In both animals and humans, subtle effects on developmental milestones and behaviours having a visual component have been noted. These include delayed eye opening in rat pups (Fried, 1976; Charlebois & Fried, 1980), visual attentional differences in monkeys (Golub et al., 1981, 1982), and altered visual responsiveness to light in human infants (Fried, 1980, Fried & Makin, 1987). As the animal literature suggests that prenatal exposure may influence behaviour beyond the neonatal stage (e.g., Dalterio, 1980; Fried, 1976; Vardaris et al., 1976) and there is evidence to suggest that transient neurological abnormalities (such as those seen in the infants of cannabis users) can be predictive of functioning in later childhood (Mednick & Michelsen, 1977), a follow-up study of children (especially the subjects of Fried, 1980) prenatally exposed to cannabis would appear warranted. The persistence into childhood of behavioural alterations associated with other commonly ingested "soft drugs" has been demonstrated (e.g., Streissguth, Martin, Barr, Sandman, Kirchner, & Darby, 1984).

The scope of such a follow-up study (in school-aged children) is somewhat broader than that of previously published work (with preschool-aged children), both in terms of the kinds of behaviours assessed and the complexity of the tests instruments used. This is because of the increasing sophistication of a child's abilities as he/she matures. Also, the increasing complexity of a child's behavioural

repertoire is usually accompanied by an enhanced ability to understand complicated instructions, to cooperate, and to respond. One then becomes able to assess higher levels of cognitive functions and integrative abilities. For example, as a child's language abilities mature, one is able to assess not only his/her basic understanding of meanings of words (i.e., simple vocabulary) but also the ability to understand the structure of language (i.e., grammar and syntax). Not only may more behaviours be examined, finer elements of behavioural responses may be analyzed. For example, a child's ability to copy a drawing requires that he/she be able to accurately perceive the stimulus, have the motoric ability to use a pencil, and also be able to integrate the two abilities. Assessment of each of these separate factors may require the administration of many individual tests and that the child be old enough to understand complicated instructions and respond in an appropriate manner. Analysis of components of higher cognitive functions allows for the detection of possibly subtle alterations in behaviour that may be associated with prenatal exposure to cannabis.

The domains of functioning that were assessed in this study were suggested by the earlier published findings and pilot work. Foremost, various aspects of visual-perceptual functioning were tapped to further elucidate the relationship between prenatal exposure and outcomes having a visual component that have been noted by other researchers. Recent work (Fried & Watkinson, 1990) suggests that minor alterations in language development may be associated with prenatal cannabis exposure and so a more comprehensive investigation of this possibility will be carried out. The assessment will also include measures of attention and distractibility as well as parental ratings of child behaviour, all of which are factors which could conceivably vary as a function of prenatal exposure and also, in turn, affect or explain a child's performance on other tests. Because of the importance of

the postnatal environment in predicting developmental test scores (Fried & Watkinson, 1988) a measure of home environment and parental intellectual functioning and personality was undertaken. Many researchers have found that the socioeconomic (SES) status of cannabis users tends to be different from that of non-users (Fried, 1980; Greenland et al., 1982; Linn et al., 1983). As SES could conceivably affect test scores independent of prenatal influences, an up-to-date compilation of the information comprising this variable (parental occupation and income) was undertaken.

Method

Subjects

The subjects of the present study were children, aged six to ten years, born to participants of the Ottawa Prenatal Prospective Study (OPPS).

The OPPS is a collaborative project involving sixteen obstetricians and two hospitals in the Ottawa area which has been ongoing since 1978. Participants in the Study are women who, after being informed of the Study by their doctors or by notices in waiting rooms, volunteered to be interviewed during pregnancy about their lifestyle habits prior to and during pregnancy. The participants were then interviewed once during each trimester remaining in their pregnancies. A female interviewer conducted each interview, usually in the participant's home. The information recorded on the questionnaire included the general health of both the mother- and the father-to-be, including height and weight measurements, and socioeconomic status of the family (i.e., education and income). Age, history of previous pregnancies and exposure to radiation and/or rubella were also asked of

the mother. Information about drinking (broken down into beer, wine, and liquor) in terms of quantities and patterns was recorded and converted to average ounces of absolute alcohol (aa) consumed per day. Nicotine use was established by multiplying the number of cigarettes smoked on a daily average by the nicotine content of the brand smoked. This amount was recorded as average milligrams (mg.) of nicotine consumed per day. Cannabis use was assessed by asking how many "joints" were consumed on average per week. If hashish use was reported, the number of joints was multiplied by five as the THC content of hashish was estimated to be five times that of marijuana. Use of other drugs, both prescribed and non-prescribed, was also recorded.

Nutritional information was gathered by asking each woman to recall all food and drink consumed in the previous 24 hours. This reported intake was then analyzed for nutrient content and compared to the recommended standard intake of various nutrients based on weight and stage of pregnancy (Health and Welfare Canada, 1975).

If a participant entered the Study during the first trimester, the first interview took place during the fourth month. Soft drug usage was determined for the year prior to pregnancy and the first trimester. Subsequent interviews took place during the sixth and ninth months and information about the year prior to pregnancy and the previous trimesters was again recorded. Repeated interviews allowed for the establishment of a rapport between the interviewer and each participant and required that the women recollect drug use for only relatively short periods of time. It also allowed for an estimate of reliability of the self reports. If an inconsistency was reported in terms of drug use from one interview to another with respect to a particular time period (e.g., the year prior to pregnancy), the higher quantity

reported was used for data analysis.

Soft drug use was then categorized for each of the four time periods recorded on the questionnaire: pre-pregnancy, first, second, and third trimesters. Alcohol consumption was divided into four categories: 1) abstinence; 2) light use (consuming less than 0.14 ounces aa/day); 3) moderate use (consuming between 0.14 and 0.85 ounces aa/day); and 4) heavy use (consuming more than 0.85 ounces aa/day). Nicotine use was divided into three categories: 1) abstinence; 2) light use (less than 16 mg./day) and 3) heavy use (at least 16 mg./day). Cannabis use was classified into four categories: 1) no use; 2) light use (less than one joint per week or passive exposure); 3) moderate use (between two and five joints per week); and 4) heavy use (more than five joints per week). In previously published reports from the Ottawa Prenatal Prospective Study (e.g., Fried, 1980), the categories of moderate and heavy use have together been described as "regular use".

After birth, the children of the participants are tested at regular intervals: at four, nine, and thirty days of age; at six, twelve and twenty-four months; and at yearly intervals thereafter.

Since the Study began, approximately 700 women have been interviewed. Of these, approximately 210 have been included in a follow-up cohort. This cohort includes all participants who used cannabis, those who were the heavier social drinkers, and those who smoked cigarettes regularly. As well, approximately 50 women who were non users of cannabis and who abstained or drank little alcohol and who were non-smokers were followed. Since 1978, 100 children have been born to women in the Study who reported any use of cannabis during pregnancy. Of that number, 50 have withdrawn from the Study or have moved away and 20 have not

been followed. The reasons for not being followed include having a dominant language in the home other than English and place of residence being too far from the central Ottawa region to be included in regular testing. The criterion of distance was generally enforced when the participant's soft drug use during pregnancy was minimal. This left 30 children of cannabis users available for participation in the present study. Of these, three were too young to be assessed with the test instruments and three were born to women who reported only very little use of cannabis (i.e., less than one joint per week) and/or passive exposure, leaving 24 subjects born to regular users (i.e., use more than once per week) who had been followed on a regular basis since birth. In addition, the children of four subjects who joined the Ottawa Prenatal Prospective Study in the fall of 1989 in response to an advertisement in the local press were included in the "experimental" or "user" group. Comparisons of these "new recruits" with longtime subjects of the Ottawa Study on all the demographic and background variables in this study are given in Appendix A.

The control group was also comprised of children born to participants in the Ottawa Prenatal Prospective Study. The mothers of these children did not report any cannabis use during pregnancy but did report use of nicotine and alcohol in amounts similar to those reported by the cannabis users. "Other drug use" (alcohol and nicotine) averaged over pregnancy was the criterion on which the "experimental" and "control" groups were matched. The purpose of this matching procedure was to ensure that the distributions of reported "other drug" use were similar in the two groups. The values for these other drug use variables are shown in Table 4. Of the 28 subjects in the control group, two were recent participants in the Ottawa Prenatal Prospective Study, joining in response to advertisements in the local media in the fall and winter of 1989.

Table 4

Experimental ("User") Group				Control Group		
ID	Marcat	Alctot	Nictot	ID	Alctot	Nictot
782	2	.347	2.267	4011	.013	4.000
78	3	.250	2.400	2272	.233	2.133
1011	3	.170	.267	1961	.217	.267
1251	3	.000	7.200	2581	.003	7.500
2211	2	.210	.000	2881	.240	.000
2771	3	.123	35.000	2751	.007	25.000
2871	3	.430	28.833	3891	.367	22.500
2891	3	.190	15.167	5241	.177	15.830
2931	3	.200	10.000	711	.160	10.000
3911	2	.313	7.800	5101	.060	7.830
4331	2	.170	.000	2351	.100	.000
4421	2	.020	.200	2882	.033	.000
5731	3	.760	.000	2111	.570	.000
5732	2	.237	.033	3882	.307	.000
5881	2	.570	2.100	2271	.133	4.000
5882	2	.697	.000	5421	.260	.000
5911	3	1.740	2.500	2491	3.203	11.467
5931	3	.197	.000	1661	.220	.000
6001	2	.433	.000	1031	.423	.000
6051	3	.000	8.667	712	.037	8.000
6052	3	.000	25.000	5721	.023	27.900
6071	2	.300	20.867	1481	.840	28.000
6151	3	.010	.000	3421	.010	.000
6152	3	.017	.000	5361	.003	.000
6451	2	.010	18.700	6491	.040	22.730
6501	3	.277	10.500	1491	.490	11.000
6591	2	.063	12.000	6481	.006	15.300
6631	3	.000	.000	5691	.000	.000
Mean =		.250	7.200		.220	7.900

Marcat 2 = >1 joint/week - 5 joints/week

Marcat 3 = >5 joints/week

Alctot = ounces of absolute alcohol per day, averaged over pregnancy

Nictot = milligrams of nicotine per day, averaged over pregnancy

The two study groups (i.e., "users" and controls) were similar in terms of sex distribution and age range. The children ranged in age from six to ten years of age and all were fluent in English. All of the children had been tested as a regular part of their participation in the OPPS at least once prior to the present study.

Apparatus

The apparatus for the present study consisted of a number of standardized tests and rating scales which were administered to the children and/or their mothers where appropriate. These tests and scales are described below:

A. Child Assessment

1) Test of Visual Perceptual Skills (Gardner, 1982)

The purpose of this test is to determine a child's strengths and weaknesses in the following areas:

- a) visual discrimination: the ability to match or determine exact characteristics of two forms when one form is among similar forms.
- b) visual memory: the ability to remember for immediate recall (four or five seconds) all of the characteristics of a given form and being able to find this form from an array of similar forms.
- c) visual-spatial relationships: the ability to determine from among five forms of identical configuration, the one single form or part of a single form that is going in a different direction from other forms.
- d) visual-form constancy: the ability to see a form, and being able to find that form, even though the form may be smaller, larger, rotated, and/or hidden.

- e) **visual sequential memory:** the ability to remember for immediate recall (four or five seconds) a series of forms from among four separate forms.
- f) **visual figure-ground:** the ability to perceive a form visually and to find this form hidden in a conglomerated ground of matter.
- g) **visual closure:** the ability to determine, from among four incomplete forms, the one that is the same as the stimulus form (i.e., the completed form).

This test is not timed and does not involve a motor component in responding. The ceiling for each subtest is defined as three failures out of four consecutive responses if the subtest has four choices, or four failures out of five consecutive responses if the subtest has five choices. Preliminary testing of children not in the Study indicated that high-scoring children required about twenty minutes to complete this test. For each of the seven subtests, three types of derived scores are available: scaled scores; percentile ranks; and perceptual ages. For the test as a whole, a Perceptual Quotient may be derived. For this study the scaled scores and the Perceptual Quotient were determined. The reliability (i.e., internal consistency) of the test is fairly high with the reliability coefficients of the Perceptual Quotient ranging from 0.83 to 0.92 across the age groups (four to twelve years) on which the test was normed. The validity of this test has not been extensively investigated but the author cites moderate correlations of TVPS scores with other measures of visual perception and the results of study in which learning disabled students scored significantly worse than did a group of age-, race-, and sex-matched controls as evidence that this test does indeed evaluate visual-perceptual skills.

2) Developmental Test of Visual Motor Integration (Beery, 1982)

This test purports to measure an integration factor over and above visual

perception and motor proficiency. It consists of a sequence of twenty-four geometric forms to be copied with a pencil in a green paper test booklet. It is untimed and yields three derived scores: an age equivalent; a percentile; and a standard score. The standard score was used in this study. Several reliability estimates for this test are provided in the test manual. All are fairly high: the median split-half reliability is 0.79; the median test-retest reliability is 0.81; and the inter-rater reliability is 0.98. The validity of the test is supported by studies which have found that scores on this test are significant predictors of academic achievement (Duffey, Ritter, & Kledner, 1976; Klein, 1978). This test took at most fifteen minutes to administer.

3) Knox Cube Test (Stone & Wright, 1983)

This test has been widely used in neuropsychological batteries as a measure of visual attention and memory. Examination of the construct validity of this test suggests that, while it is primarily a measure of immediate visual-spatial attention, it also has a strong sequencing component (Bornstein, 1983). The test apparatus consists of four one-inch cubes affixed in a row on a strip of wood, with a space of two inches between each block. The examiner taps the cubes in prearranged sequences of increasing length and complexity and the subject must try to imitate the tapping pattern exactly. The number of correct trials up to three consecutive failures provided the raw score which was converted to a Mental Age equivalent and then to a standard score (Knights & Norwood, 1980). No information regarding the reliability of this test is available. This test required at most ten minutes to administer.

4) Trail Making Test (Reitan, 1971)

This is a test of visual conceptual and visuomotor tracking (Lezak, 1983). It requires a degree of alertness in comprehension of stimulus material, interpretation of the symbolic significance of the stimulus material (numbers and letters), visual scanning and, in Part B, the ability to keep in mind a numerical series and an alphabetical series simultaneously (Reitan, 1971). The test has two parts. In Part A, the subject must draw lines to connect sequentially numbered circles on a worksheet. In Part B, the subject must connect circles containing both numbers and letters by alternating between the sequences (i.e., connecting 1 to A to 2 to B, etc.). Errors are pointed out by the examiner allowing the subject to correct them as the test proceeds. Scoring is based on the time required to complete each part of the test as well as a sum of the times for the two parts. These are then converted into a standard score (Knights & Norwood, 1980). The Trail Making Test is considered to be one of the most sensitive tests to the presence of brain damage (Lezak, 1983). Among non-brain damaged subjects it has proven valuable in explaining organizational strategy differences between low and average academic achievers (Kops & Belmont, 1985). Test-retest reliability estimates for children are unavailable, but for adults they are moderately high (i.e., 0.78 for Part A, 0.67 for Part B; Lezak, 1983). This test required a maximum of five minutes to administer.

5) Draw A Man (Harris, 1963)

This test is a standard clinical tool used with school-aged children as a measure of intellectual maturity. The child is simply asked to draw a picture of a man and is under no time constraints. The Goodenough-Harris scoring system was used which awards points for the inclusion of detail, proportion, and co-ordination in the drawing (Harris, 1963). A standard score is then derived. Recent work (Murphy, 1988) suggests that four year old children of cannabis users may differ from others in

terms of the amount and type of detail they include in their drawings. This is the only test used in the present study which required the use of separate norms for boys and girls. This is an untimed test but children spent less than ten minutes in completing this drawing.

6) Test of Language Development-Primary (Newcomer & Hammill, 1982)

The TOLD-P assesses the linguistic features of phonology, syntax, and semantics in both expressive and receptive linguistic systems. For the purpose of the present investigation, the subjects' competence with regard to the syntax of language was assessed with the following three subtests:

- a) **grammatical understanding (gu):** assesses a child's ability to understand the meaning of sentences. No verbalization is required; the child must point to one of three pictures that best represents the stimulus sentence spoken by the examiner.
- b) **sentence imitation (si):** measures aspects of a child's ability to produce correct English sentences. The child must repeat verbatim sentences spoken by the examiner.
- c) **grammatical completion (gc):** assesses a child's ability to recognize, use, and understand common English morphological forms. The examiner reads unfinished sentences and the child supplies the missing morphological form.

The raw scores on each subtest were converted to standard scores and summed to yield a Syntax Quotient ($gu + si + gc$). Test-retest reliability coefficients for the subtests of the TOLD-P (with the effect of age partialled out) have been found to range from 0.86 to 0.98 with the coefficient for the total test being 0.99. The

information regarding the validity of the TOLD-P, derived from correlations of the subtests with many other widely used tests of language development, is likewise impressive, with correlations ranging from 0.69 to 0.80 (Newcomer & Hammill, 1982). The time allowed for the administration of this test was fifteen minutes.

7) Woodcock Reading Mastery Tests-Revised (Woodcock, 1987)

Passage Comprehension Subtest - This test measures the subject's ability to study a short passage and to identify a key word missing from the passage. A blank line represents the missing word. The task is a modified cloze procedure requiring the subject to exercise a variety of comprehension and vocabulary skills. The subtest contains 68 items arranged in order of difficulty. The basal is six consecutive correct answers and the ceiling is six consecutive incorrect answers. Starting points for different estimated reading grade levels are provided. Raw scores were converted into age-normed standard scores. Split-half reliability coefficients for this subtest range from 0.73 to 0.97 across grade levels. Concurrent validity is expressed in terms of correlations between this subtests and other tests purporting to measure the same construct. The correlations between this subtest and the passage comprehension subtest of the Woodcock-Johnson Psychoeducational Battery range from 0.55 for Grade 8 students to 0.71 for Grade One students (Woodcock, 1987). This subtest required ten minutes.

8) The Wide-Range Achievement Test-Revised (Jastak & Wilkinson, 1984)

This is a brief achievement test measuring Reading recognition, Spelling and Arithmetic computation; it is one of the most widely used individual achievement tests (Matuszek, 1985). The Reading subtest consists of three pre-reading parts

(letter identification) and one formal reading section wherein the subject is asked to pronounce as many of 75 printed words as they can to a ceiling of ten consecutive errors. The Spelling subtest consists of three parts: the subject is asked to copy 18 marks presented on the test form; to print or write his/her name; and to print or write 45 words to a ceiling of ten consecutive errors. The Arithmetic subtest has an oral and a written part. The oral questions range from simple counting of stimulus pictures to addition and subtraction problems. The written part consists of 44 computation problems of which the subject is asked to solve as many as possible in a ten minute time limit to a ceiling of ten consecutive errors. For each subtest, an age-normed standard score was derived. Test-retest reliability estimates of these subtests have been found to be in the range of 0.94 to 0.97. Concurrent validity evidence is provided in the test manual, indicating that the Reading subtest score, for example, correlates 0.87 with PIAT grade level scores in Reading Recognition (Jastak & Wilkinson, 1984). Test administration required twenty minutes.

9) Stroop Color and Word Test (Golden, 1978)

This test has been included in many types of psychological research. The test author states that the the test stimuli "involve at a basic level the ability of an individual to sort information from his or her environment and to selectively react to this information" (Golden, 1978, p.2.). The test has three parts. In Part 1, the stimuli consist of the words "RED", "GREEN", and "BLUE" arranged randomly and printed in black ink in five columns of 20 words each. The subject is required to read aloud as many of the words as possible until a 45-second time limit has expired. In Part 2, the stimuli are 100 items all written as "XXXX" printed in either red, green or blue ink and the task is to name aloud the colors of the "XXXX"s as rapidly as possible within the same time frame. In Part 3 the stimuli are the words

from Part 1 printed in the colors of Part 2 so that in no case does the word and the color in which it is printed match (i.e., "RED" is never printed in red ink); the subject must name the color of the ink in which each color name is printed. This requires the suppression of the automatic verbal processing response in favor of the consciously-instructed color naming. An "interference" score can then be derived from the word-naming, color-naming, and color-word scores. This interference score is often used as a measure of cognitive control and distractibility (e.g., Ludwig & Lazarus, 1983) and the validity of this use is supported by the fact that hyperactive children do more poorly on this measure than do normal controls (deHaas, 1986). The test-retest reliability coefficients provided by the author are moderately high (0.73-0.86). Test administration required no more than five minutes.

10) Finger-Tapping Test (Reitan & Davison, 1974)

The finger tapping test is probably the most widely used test of manual dexterity (Lezak, 1983). Considered to be a pure motor test, pilot work indicates that it discriminates between children of cannabis users and children of non users. The apparatus consists of a tapping key with a device for recording the number of taps mounted at the end of a 6-inch by 10-inch board. The tapping lever is perpendicular to the board and the tapping surface is 1 3/4 inches above the board and bent at an angle of 30 degrees from the horizontal. The lever is depressed one-quarter inch to rotate the counter, is spring loaded, and requires a static weight of 400 grams to depress the lever. The subject must keep the wrist on the board and move only the index finger, with the other fingers and thumb motionless. Each hand makes four ten-second trials, alternating between hands with brief rest periods between each trial. The mean of the best three of four ten-second trials were used as the score for each hand. These scores were converted to standard scores based on the norms of

Knights and Moule (1967). This test required three minutes.

11) Wechsler Intelligence Scale for Children - Revised (WISC-R) (Wechsler, 1974)

This is one of the most widely used tests of general intellectual abilities . It comprises eleven subtests. Six of these (Information, Similarities, Vocabulary, Comprehension, Arithmetic, and Digit Span) can be combined to yield a Verbal I.Q. (VIQ), while the remaining five (Picture Completion, Picture Arrangement, Block Design, Object Assembly, and Coding) can be combined to yield a non-verbal or Performance I.Q. (PIQ). In addition to these composite scores, three factor scores may be determined (Kaufman, 1979). They are; Verbal Conceptualization (Information, Similarities, Vocabulary, and Comprehension); Perceptual Organization (Picture Completion, Picture Arrangement, Block Design, and Object Assembly); and Freedom from Distraction (Arithmetic, Digit Span, and Coding).

In order not to make the testing session too long for the children, the WISC-R was administered in a separate testing session lasting no more than one hour. Twenty-five of the subjects of the present study were assessed with this instrument within the last two years and, because of concerns about test sophistication and practice effect, it was not administered anew to those subjects. Instead, the previously gathered scores on this test for those subjects were included in the data of the present study. To control for possible examiner effects, a control variable was created such that those to whom the WISC-R was administered prior to the proposed study were given a score of "2" on this variable while those who received this test for the first time in the present study scored "1". Statistical analysis examined whether a significant association existed between WISC-R scores and the

examiner control variable. No such association was found, and therefore all WISC-R scores were treated as if the same examiner had given all tests.

B. Parental Measures

The following tests and rating scales were given to the mothers of the children being assessed in the present study.

1) Raven's Standard Progressive Matrices (Raven, Court, & Raven, 1983)

This is a highly discriminating, non-verbal and culture-free test of general intelligence (Shipley, 1975). It is a test of a person's capacity "to apprehend meaningless figures presented for his observation, see the relation between them, conceive the nature of the figure completing each system of relations presented, and by so doing, develop a systematic method of reasoning" (Raven et al., 1983, p. 2). The scale consists of 60 items divided into five sets of twelve (sets A-E). Each item is a multiple choice problem; a design or matrix from which a part has been removed. The subject examines the matrix and chooses the correct part for completing it. The themes of the successive subtests are :a) continuous patterns; b) figure analogies; c) progressive alteration of patterns; d) permutations of figures; and e) resolution of figures into constituent parts. The score on this test is the total number of problems solved correctly. The score is then converted to a percentile rank based on norms provided in the manual (Raven et al., 1983). The Standard Progressive Matrices is reported to be a highly reliable test (split-half $r=0.83$ to 0.95 ; test-retest $r=0.83$ to 0.93) which correlates well with other measures of intelligence (see Raven et al., 1983 for a summary of validity studies). This test is untimed and each subject is required to complete all items. Generally 45 minutes is

required for its completion.

2) NEO Five-Factor Inventory (Costa & McCrae, 1989)

This personality inventory was designed to provide a brief, comprehensive measure of five domains of personality: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness. It is a shortened version of the NEO-PI (Costa & McCrae, 1985) and consists of five 12-item scales that measure each of the domains. Each item is a self-referent statement to which the subject responds along a five-point continuum of strongly disagree, disagree, neutral, agree, or strongly agree. Internal consistency coefficients for the five scales range from 0.74 to 0.89. The scales of the NEO-FFI show moderate correlations with the longer NEO-PI (i.e., 0.56 to 0.62) and the NEO-PI scales, in turn, "show a consistent pattern of moderate to strong correlations with corresponding scales from other inventories and with ratings of the same traits made by different observers" (Costa & McCrae, 1985, p. 34). The NEO-FFI requires a sixth grade level of reading comprehension and a maximum of fifteen minutes to complete.

3) Revised Conners Parent Questionnaire

In order to get an up-to-date description of each child's typical behaviour outside the testing session, this 48-item rating scale was given to each child's mother for completion. Each item is scored "not at all", "just a little", "pretty much", or "very much". These ratings are then transformed to scores of 0, 1, 2, or 3 respectively. Six factor scores are derived: Conduct Problems; Learning Problems; Psychosomatic Problems, Impulsivity-Hyperactivity, Anxiety, and Hyperactivity Index (Goyette, Conners, & Ulrich, 1978).

4) Home Environment Questionnaire (Sines, 1983)

The Home Environment Questionnaire (HEQ) was developed to measure Alpha press characteristics of children's environments. The term "press" refers to separable and quantifiable dimensional characteristics of the physical and social environment that have the potential to affect a person in that environment. "Alpha" press are those pressive characteristics of environments that can be assessed objectively, as opposed to the target person's perception of the characteristics of his/her environment or "Beta" press (Sines, 1983).

The HEQ has two forms. The HEQ-2R form is for use with two parent families and has 123 items. The HEQ-1R is for use with one parent families (wherein the mother is the respondent) and it has 91 items. The items are presented in a True/False format. Ten factor scores are derived from this questionnaire: Achievement; Aggression-Home; Aggression-External; Aggression-Total; Supervision, Change; Affiliation; Separation; Sociability; and Socioeconomic Status. This questionnaire required no more than fifteen minutes to complete.

5) Demographic Information

A questionnaire was designed to elicit information about factors which may relate to a child's test performance (see Appendix A). The information regarding parental occupation was converted to "status" (Boyd, 1986) and the higher of the two parents' status scores was used to represent each family's "occupational status". The questionnaire also asked for information about the number of children in the family, the subject's position in the family, the language most commonly spoken at

home, the language of instruction in school, the presence of problems in school, pertinent medical problems and special conditions that may affect test performance. This questionnaire required ten to fifteen minutes of the mothers' time.

The children were tested either at their homes or at Carleton University, whichever setting was most convenient to the parents. Twenty-nine subjects (10 in the "user" group and 19 in the control group) were assessed in their homes; twenty-seven (18 in the "user" group and nine in the control group) were assessed at the University.

The tests were typically administered in the following order:

- 1) Drawaman
- 2) Knox Cube
- 3) Stroop Color and Word Test
- 4) Test of Visual Perceptual Skills
- 5) Passage Comprehension
- 6) Finger Tapping Test
- 7) Trail Making Test
- 8) Beery Visual Motor Integration Test
- 9) TOLD-P Syntax Quotient
- 10) WRAT-R
- 11) WISC-R

When the entire battery was given, the first ten tests could usually be given within one and a half to one and three-quarters hours. The WISC-R was given either after a lunch break or on a separate day.

Statistical Analysis

The independent variables examined in this study consisted of the variable of maternal cannabis use during pregnancy as well as "control" variables (i.e., sample characteristics which are not of primary interest but which may have significant bearing on outcome measures) such as maternal age, education, personality measures, and general intelligence; father's and mother's occupations; family income, language of instruction in school, history of problems in school, language most often spoken at home, the size of the family, the child's position in the family, the child's history of eye or ear infections and presence or absence of special conditions. Maternal cannabis use during pregnancy was the basis on which the study groups were divided. This was represented by the variable MARUSE wherein subjects in the user group were assigned a "1" and subjects in the control group were assigned a "0". The "dependent" variables included all measures taken on the children.

In a study of this nature, with many variables and a relatively small sample size, a primary concern was data reduction. To that end, composite and combined scores were used whenever possible. A Pearson product-moment correlation matrix of dependent variables with MARUSE was generated (see Appendix B). Inspection of the correlations among the independent and dependent variables revealed those variables which had no relation to the variable of interest (i.e., prenatal cannabis exposure) and were therefore dropped from further analyses. Those found to be related to cannabis use at a significance level of 0.10 or less were entered into a discriminant function analysis. Only those variables which meet the requirements for entry into the discriminant function were included in subsequent multivariate analyses.

The "control" variables were considered to be potential confounds and their relationship to MARUSE (i.e, the grouping variable) was examined with ANOVA for continuous variables and Chi square analysis for dichotomous variables. The level of significance accepted in these analyses was $p < 0.10$ in two-tailed tests. Those control variables found to be differentially associated with group membership were then examined for their relationship to the outcome variables through multiple regression analysis. Those potential covariates which produced a significant regression equation when regressed on the group of outcomes derived from discriminant function analysis were considered as covariates in subsequent multivariate analyses.

Multivariate analyses (i.e., MANOVAs) were also run with reduced sets of subjects as a check of the impact of: 1) drug use other than cigarettes and alcohol; and 2) being a "new recruit" on the outcomes which discriminated between groups (as explained below).

The results of the multivariate analysis provided an overall F test as well as univariate F tests for each of the dependent variables. As the initial hypothesis of this research was that prenatal cannabis exposure may have a detrimental effect on behavioural outcomes, the accepted level of significance for these analyses was $p = 0.05$ (one-tailed). For those variables which indicated between group differences, the adjusted means were examined. These adjusted means reflect the values for each dependent variable for each drug group (independent variable) after controlling for the influence of covariates.

Because the children in the Ottawa Prenatal Prospective Study have been

tested at regular intervals since birth, the present study offered a unique opportunity to collate and integrate a great deal of developmental data. Available test scores on infant and preschool tests for the subjects were examined for relationships to the present data through a correlational approach.

Also developed from examination of the early data were a series of case studies. Case studies are characterized as in-depth reports on individuals of interest and do not generally involve statistical analysis. The case studies were developed from all test data based on those children who showed alterations in the earliest behavioural measures (i.e., the Brazelton and the Prechtl exams, see attached Appendix C).

Results

Background Data

The median income category for the present sample assessed at the time of testing was 8, which corresponds to \$40,000.00 to \$49,999.00. This closely approximates the median family income of \$44,461.00 in the Ottawa-Carleton area (Statistics Canada, 1988).

Cannabis users who were "new recruits" (n=4) are compared with those who have been longtime subjects (n=24) in the Ottawa Study in Appendix A. As they did not differ with regard to either demographics or discriminating variables (described below), all cannabis users were considered in the same group (i.e., MARUSE=1). The same was true for the comparison between the children of the "new recruits" (n=2) and the longtime subjects (n=26) in the control group (see Appendix A).

Data from the mothers' scores on the Raven Progressive Matrices, The NEO Five Factor Inventory, The Home Environment Questionnaire, and the Parental Questionnaire yielded 33 "potential confound" variables. The description of the sample with regard to these variables is given in Table 5.

Table 5
Sample Characteristics

Variable	Whole Sample	Users	Controls	p*
Mother's Age at child's birth $\bar{x}$ (SD)	27.5 (4.9)	25.5 (4.5)	29.5 (4.6)	.002
Mother's Educational (a) Level $\bar{x}$, mode	4.1, 4	3.6, 4	4.6, 2	.07
Father's Educational Level $\bar{x}$, mode	4.4, 2	3.7, 2	5.1, 6	.02
Mother's Raven Score $\bar{x}$ %ile (SD)	81.7 (19.7)	79.0 (22.8)	84.0 (16.1)	.35
Mother's NEO Scores				
$\bar{x}$ NEON	50.3 (9.5)	52.5 (8.9)	48.1 (9.7)	.09
$\bar{x}$ NEOE	52.5 (12.3)	50.2 (13.7)	54.8 (10.4)	.16
$\bar{x}$ NEOO	52.9 (9.5)	53.8 (8.8)	51.9 (10.3)	.47
$\bar{x}$ NEOA	55.4 (14.6)	50.8 (14.3)	60.1 (13.6)	.02
$\bar{x}$ NEOC	50.3 (10.9)	45.4 (10.7)	55.3 (8.8)	.00
Highest Occupational Status of Parents. $\bar{x}$ (SD)	56.8 (13.3)	53.4 (14.5)	60.2 (14.5)	.06
Income Level (b) $\bar{x}$, mode	8.2, 11	6.8, 8	9.6, 11	.00
# 2-salary households	37	14	23	.02
# 1-parent households	10	8	2	.08
# children in family $\bar{x}$, mode	2.4, 2	2.4, 3	2.4, 2	1.00
Birth Order $\bar{x}$ (SD)	1.7	1.5 (0.7)	1.9 (0.8)	.06
Sex Ratio M:F	33:23	17:11	16:12	1.00
Language of Home Eng:Eng + other	50:6	24:4	26:2	.67

Table 5
Sample Characteristics (continued)

Variable	Whole Sample	Users	Controls	p*
Language of Instruction Eng/Fre/Bil.	27/26/3	14/13/1	13/13/2	.83
Having problems in school; n (%)	15 (27)	10 (36)	5 (18)	.22
Needed visual correction	3	2	1	1.00
Subject to eye or ear infections	28	5	23	.70
Age in months $\bar{x}$ (SD)	98.07(16.9)	92.61(16.2)	103.54(16.0)	.01
Tester (# given WISC-R in present study)	3	19	12	.17
Home Environment Scales $\bar{x}$ (SD)				
Achievement	46.82 (10.0)	44.82 (9.2)	48.82 (10.5)	.14
Aggression-E	51.73 (10.2)	54.96 (11.4)	48.50 (7.7)	.02
Aggression-H	49.03 (10.8)	52.89 (10.6)	45.18 (9.8)	.01
Aggression-T	50.20 (12.1)	54.75 (12.4)	45.64 (10.2)	.00
Supervision	48.19 (10.4)	45.11 (9.1)	51.29 (10.5)	.02
Change	52.36 (8.4)	54.79 (8.3)	49.93 (7.3)	.03
Affiliation	54.11 (8.6)	52.46(7.5)	55.75 (9.5)	.16
Separation	51.48 (10.3)	51.79(12.2)	51.18 (8.1)	.83
Sociability	53.98 (9.8)	53.39(10.5)	54.57 (9.2)	.66
Social Status	55.28 (11.6)	51.86(13.5)	58.71 (8.3)	.03

(a) Education Level Categories:

- 1=<high school**
- 2=high school graduate**
- 3=trade school**
- 4=community college diploma**
- 5=some university courses**
- 6=university graduate**
- 7=post-graduate training**

***p=2-tailed tests**

(b) Income Level Categories:

- 1=<10,000**
- 2=10,000-14,999**
- 3=15,000-19,999**
- 4=20,000-24,999**
- 5=25,000-29,999**
- 6=30,000-39,999**
- 7=35,000-39,999**
- 8=40,000-45,999**
- 9=50,000-59,999**
- 10=60,000-69,999**
- 11=70,000-above**

In general, the mothers of the children in the experimental or "user" group were younger than their counterparts in the control group when their children were born. They were also less well educated, had lower family incomes and were more likely to be the heads of one-parent households. They did not differ with regard to their scores on the Raven Progressive Matrices but did differ on three scales of the NEO Five Factor Inventory. They rated themselves higher on the Neuroticism scale and lower on Conscientiousness and Agreeableness than did the controls.

Six of the mothers in the user group reported some use of drugs other than cigarettes or alcohol drugs during pregnancy. Four of these women used them only during the first trimester, one during the second trimester and one during the first and second trimesters. For five of the women, the "other drug" was principally cocaine and one woman reported "mushrooms and dexies". The amount of drug used was not reported. In order to determine if this drug use affected the pattern of relationships among the variables in this study, the multivariate analysis (described below) was run with and without the data from the children of these women.

The Home Environment Questionnaire also yielded several differences between the study groups. All three Aggression measures were higher for the user group as was the score for Change. Lower scores were obtained on the Supervision and Social Status scales. The homes of the cannabis users were not different from those of controls with regard to the principal language spoken there. In none of the homes in the present study was a language other than English predominant. The bilingual homes in the user group were comprised of English- and French-speaking parents. Most often, the mother spoke English only. None of the mothers were unilingual in French. In the control group, there were two bilingual homes. In one,

the second language was Polish, in the other it was Italian. In both cases, both sets of parents had been schooled in English and worked in English on a daily basis.

The children in the user group were younger than their control counterparts and slightly more likely to be first born children. They did not differ from the control children with regard to their language of schooling or the incidence of problems in school. The two groups were also much alike with respect to the need for visual correction and history of eye or ear infections. For five children in each group, the mothers had indicated the presence of special conditions which might affect the child's test performance. Four children in the control group and three in the user group were recovering from minor illnesses (typically colds or allergies); one child in the control group had lost a grandparent in the previous month and two children in the user group were adjusting to their mother's remarriage. There were eight sets of siblings in the present study, five in the user group and three in the control group.

The twelve test instruments used in the present study (i.e., eleven tests administered by the investigator and one parental behaviour rating scale) originally yielded 34 variables. Some data points were missing for three of the outcome variables. These were the Stroop Interference score, the TOLD-P Syntax Quotient, and the the second part of the Trail Making Test, Trails B. Eight children (14%) were missing data on the Stroop because of an inability to read; three children (5%) were missing data on the Syntax Quotient because their ages fell above the norms for the test; and 13 children (23%) were missing data on the Trails B because their ages fell below the norms for the test. For the Stroop and the Syntax Quotient, substitution of the mean values of the group was employed as this would allow the subjects to be retained and would not interfere with the distribution of the test

scores (Tabachnick & Fidell, 1983). For the Trails B test (and consequently, the Total Trails score), the large percentage of missing data points necessitated the elimination of those scores from further analyses. Mean scores on the remaining tests for the entire sample as well as the two study groups are given in Table 6.

Multivariate Analyses

Of the remaining 32 variables, 22 were selected for discriminant function analysis because they were correlated with cannabis use at a level of significance less than or equal to 0.10. The variables which were selected for stepwise discriminant function analysis were: all six scores from the Conners Parent Questionnaire; the Full Scale I.Q., the Performance I.Q., Verbal Comprehension Factor and Perceptual Organization Factor of the WISC-R; the Passage Comprehension score; the Syntax Quotient of the TOLD-P; the Beery VMI score; the Trail Making Test (Trails A) score; the Perceptual Quotient of the TVPS as well as five subtest scores from that battery (visual closure, visual discrimination, visual memory, visual sequential memory, and visual spatial relations); and the Reading subtest score from the WRAT-R.

Seven variables stepped into the analysis, yielding a significant discriminant function [χ^2 (4;N=56)=22.17, $p=0.002$; Wilks' lambda=.65] explaining 36 percent of the variance in the outcome variables. The variables making up the discriminant function and their discriminant function coefficients are given in Table 7.

Table 6
Mean Test Scores (SD)

Test	Whole Sample	Users	Controls	p*
Full Scale I.Q.	121.68 (11.8)	119.64 (10.5)	123.71 (12.8)	0.20
Verbal I.Q.	119.00 (13.0)	117.82 (14.3)	120.18 (11.2)	0.50
Performance I.Q.	119.82 (12.8)	117.61 (8.7)	122.04 (15.8)	0.20
Verbal Comprehension	13.28 (1.9)	12.91 (1.9)	13.64 (1.9)	0.17
Perceptual Organization	13.16 (1.9)	12.78 (1.2)	13.54 (2.4)	0.14
Freedom from Distractibility	11.61 (2.0)	11.61 (1.8)	11.61 (2.2)	0.99
Syntax Quotient	108.88 (11.1)	106.54 (10.4)	111.21 (11.5)	0.12
Passage Comprehension	101.07 (15.8)	97.11 (17.5)	105.04 (13.2)	0.06
WRAT-Reading	101.52 (15.0)	98.86 (15.0)	104.18 (14.8)	0.19
WRAT-Spelling	94.34 (15.4)	92.18 (15.0)	96.50 (15.7)	0.30
WRAT-Arithmetic	98.09 (12.2)	98.68 (8.8)	97.50 (15.0)	0.72
Stroop	53.93 (4.6)	52.86 (3.7)	55.00 (5.2)	0.08
Knox Cube	9.29 (6.3)	9.36 (6.7)	9.21 (6.0)	0.93
Visual Discrimination	15.93 (3.1)	15.18 (3.2)	16.68 (2.9)	0.07
Visual Memory	14.09 (3.1)	13.32 (2.8)	14.86 (3.2)	0.06
Visual Spatial Relations	14.34 (3.2)	13.85 (3.4)	14.82 (3.1)	0.27
Visual Form Constancy	13.18 (3.4)	12.89 (3.4)	13.46 (3.5)	0.54
Visual Sequential Memory	13.68 (3.2)	13.03 (2.7)	14.32 (3.6)	0.13
Visual Figure Ground	15.32 (3.9)	14.71 (4.4)	15.93 (3.3)	0.25
Visual Closure	13.66 (4.4)	12.82 (4.2)	14.50 (4.4)	0.15
Perceptual Quotient	131.13 (14.9)	126.89 (13.3)	135.36 (15.3)	0.03
Trails-A	1.11 (0.6)	1.23 (0.7)	0.99 (0.6)	0.18
Draw-A-Man	103.79 (12.9)	102.18 (12.6)	105.40 (13.2)	0.35
Beery VMI	10.08 (3.05)	9.43 (2.71)	10.75 (3.3)	0.11
Finger Tapping Dominant Hand	0.16 (0.9)	0.19 (1.1)	0.12 (0.7)	0.80
Finger Tapping NonDominant Hand	-0.09 (1.6)	-0.05 (2.1)	-0.14 (0.9)	0.83
Conners Parent Questionnaire				
Anxiety	0.18 (0.6)	0.27 (0.7)	0.08 (0.6)	0.26
Conduct Problems	0.06 (1.1)	0.49 (1.3)	-0.37 (0.7)	0.002
Hyperactivity Index	0.08 (1.2)	0.50 (1.3)	-0.34 (0.9)	0.01
Impulsivity-Hyperactivity	0.16 (1.2)	0.51 (1.4)	-0.19 (0.9)	0.03
Learning Problems	0.12 (1.3)	0.44 (1.4)	-0.19 (1.2)	0.07
Psychosomatic	0.13 (0.9)	0.34 (1.1)	-0.09 (0.6)	0.08

Table 6 (continued)

Published norms for tests in present study

Full Scale I.Q.	
Verbal I.Q.	$\bar{x}=100, sd=15$
Performance I.Q.	
Verbal Comprehension	
Perceptual Organization	$\bar{x}=10, sd=3$
Freedom from Distractibility	
Syntax Quotient	
Passage Comprehension	
WRAT Reading	$\bar{x}=100, sd=15$
WRAT Spelling	
WRAT Arithmetic	
Stroop Interference	
	$\bar{x}=50, sd=10$
Knox Cube	
	$\bar{x}=0, sd=1$
Test of Visual Perceptual	
Skills subtests	$\bar{x}=10, sd=3$
Perceptual Quotient	$\bar{x}=100, sd=15$
Trails A	$\bar{x}=0, sd=1$
Draw-A-Man	$\bar{x}=100, sd=15$
Beery VMI	$\bar{x}=10, sd=3$
Finger Tapping	$\bar{x}=0, sd=1$
Conners Parent Questionnaire	$\bar{x}=0, sd=1$

* = 2-tailed tests

Table 7

Discriminant Function Analysis

Variable	Wilks' Lambda	Sig.	Discrim. Func. Coeff.
Conduct Problems	.84	.003	-.62
Visual Sequential Memory	.78	.002	.43
Trails A	.75	.002	-.38
Visual Discrimination	.72	.002	.41
Stroop Interference	.68	.001	.44
Syntax Quotient	.66	.002	.30
Anxiety	.64	.002	-.28

Canonical Discriminant Functions

Eigenvalue .55	Canonical Correlation .60	Wilks' Lambda .64
Chi Square 22.17	d.f. 7	Significance .002

Selection of covariates was a two step process. First, all possible covariates (the 33 "background data" variables) were examined to see if their values differed between the study groups. If this step yielded between group differences significant at $p \leq 0.10$ in two-tailed tests, the covariates were examined for their relationships with the outcome variables contributing to the discriminant function. This was done using multiple regression analyses. One regression was run for each potential covariate. The covariate was the dependent variable and the group of seven outcome variables were the independent variables entered as a block. If the regression yielded a Multiple R significant at $p \leq 0.10$, the covariate was retained for subsequent analyses.

Variables examined using the multiple regression procedure included: six scales of the Home Environment Questionnaire (Aggression-External, Aggression-Home, Total Aggression, Change, Social Status, and Supervision); three scales of the NEO Five Factor Inventory (Agreeableness, Conscientiousness, and Neuroticism); family income; mother's educational level; father's educational level; the highest occupational status rating of the parents; the number of parents in the home; the number of parents working outside the home; the mother's age when the child was born; the birth order of the subject child; and a variable called "Tester" which was an indication of whether the child had been given the WISC-R previous to the present study. The variable representing subject's age was not considered to be a covariate because all of the scores derived for each subject had been converted to standardized scores based on age-referenced norms.

Of these variables nine yielded significant multiple R's when regressed on the discriminating variables. These nine were: Aggression-External (AggresE); Aggression-Home (AggresH); Total Aggression (AggresT); Supervision (Sup); NEO

Agreeableness (NEOA); NEO Conscientiousness (NEOC); NEO Neuroticism (NEON); mother's age when her child was born (MAGEBIRT); and Tester. Two of these variables were dropped from further analyses. The Total Aggression score from the Home Environment Questionnaire is based on the sum of the other two Aggression measures (with which it is highly correlated) and was therefore judged to be redundant. The Tester variable yielded a significant multiple R largely because of its correlation with the Trails A variable. As the Trail Making Test had been administered to all the subjects by the same examiner, this relationship was judged to be misleading and the variable was dropped from further analyses.

Multivariate analyses were begun with a check of the basic assumption of MANCOVA - homogeneity of regression. This means it is assumed that the relationship between covariates and dependent variables is the same in any one group as in any other group. Factor by covariate interaction was assessed using the MANOVA program of SPSSX. The covariates as a group had a significant factor by covariate interaction with the grouping variable MARUSE (Pillais= 0.34264, $p=0.013$), suggesting that the effects of adjusting the dependent variables for the covariates would be different for the cannabis user versus non-user group. In order to determine which of the covariates was responsible for this interaction, the analysis was repeated with the group of covariates successively reduced by one. When the variable MAGEBIRT (i.e., mother's age when the child was born) was not included with the covariates, the factor by covariate interaction was no longer significant. The variable MAGEBIRT, when examined separately, had a significant interaction with MARUSE (Pillais = 0.28688, $p=0.022$). The test for homogeneity of variance-covariance matrices (i.e., Box' M test) was non-significant.

In order to allow MANCOVA to proceed in the face of a violation of a basic

assumption, a blocking strategy was employed (Tabachnick & Fidell, 1983). This involves converting the covariate into another full scale independent variable, the scores of which are cut into two levels. This procedure allows a straightforward interpretation of the independent variable of interest (MARUSE, i.e., cannabis use), with any variation due to the potential covariate removed from the estimate of error variance. The interaction between the factor and covariate also becomes directly testable. MAGEBIRT was dichotomized such that ages 27 and below formed one level of the factor and ages 28 and above formed the second level of the factor. This cutoff provided relatively equal cell sizes with the younger group containing 18 users and 11 controls and the older group containing 10 users and 17 controls. The two-factor MANOVA yielded a significant main effect of MARUSE (Pillais=0.35, $p=0.005$, see Table 8) and a significant effect of the interaction of MARUSE and MAGEBIRT (Pillais=0.29, $p=0.018$). The main effect of MAGEBIRT was not significant (Pillais=0.06, $p=0.87$).

The two-factor MANOVA was run again excluding the data from the children whose mothers had reported use of drugs other than cigarettes and alcohol during pregnancy. The result was not substantially changed. There was significant main effect of MARUSE (Pillais=0.31, $p=0.02$), and a significant effect of the interaction of MARUSE and MAGEBIRT (Pillais=0.27, $p=0.05$). The main effect of MAGEBIRT was again not significant (Pillais=0.04, $p=0.97$).

The MANOVA was run a third time, to exclude the children of new recruits to the Ottawa Study. Again, the result was not substantially changed. The main effect of MARUSE was significant (Pillais=0.34, $p=0.01$); the interaction of MARUSE and MAGEBIRT was significant (Pillais=0.35, $p=0.01$); and the main effect of MAGEBIRT was not significant (Pillais=0.10, $p=0.71$).

Table 8

Two Factor MANOVA Summary

Effect: MARUSE by MAGEBIRT (S=1, M=2 1/2, N=22)

Pillais=0.29 p=0.018

Univariate F tests with (1,52) D.F.

Variable	F	Sig. of F
Conduct Problems	1.46	0.23
Anxiety	0.06	0.80
Visual Sequential Memory	4.36	0.04
Visual Discrimination	1.86	0.18
Stroop Interference	2.66	0.11
Syntax Quotient	4.19	0.05
Trails A	0.32	0.57

Effect: MARUSE (S=1, M=2 1/2, N=22)

Pillais=0.34 p=0.005

Univariate F tests with (1,52) D.F.

Variable	F	Sig. of F
Conduct Problems	7.39	0.01
Anxiety	0.95	0.33
Visual Sequential Memory	3.14	0.08
Visual Discrimination	2.89	0.09
Stroop Interference	2.64	0.11
Syntax Quotient	1.90	0.17
Trails A	1.54	0.22

Box's M=94.68

F with (84,3881) d.f. = 0.81 p=0.89 (approx.)

Chi-Square with 84 d.f. = 70.38 p=0.86 (approx.)

By examining the significance of the F tests for each outcome related to each factor in the MANOVA, it was clear that none of the outcomes were related to MAGEBIRT. The main effect of MARUSE was evident principally with Conduct Problems [$F(1,52)=7.39, p=0.009$], Visual Sequential Memory [$F(1,52)=3.13, p=0.082$ ($p=0.04$ one tailed)], Visual Discrimination [$F(1,52)=2.89, p=0.095$ ($p=0.047$ one tailed)] and Stroop Interference [$F(1,52)=2.64, p=0.110$ ($p=0.055$ one tailed)]. Three outcomes were related to the interaction term of the two factors. They were: Visual Sequential Memory [$F(1,52)=4.36, p=0.042$]; Stroop [$F(1,52)=2.66, p=0.109$ ($p=0.054$ one tailed)]; and Syntax Quotient [$F(1,52)=4.19, p=0.046$].

In order to understand more fully the nature of the impact of the interaction of mother's age and cannabis use on outcomes, the stratified age groups and cannabis groups means on each outcome were plotted. The figures illustrating these relationships are presented on the following pages.

For the measure Conduct Problems, mothers in the user group (i.e., MARUSE=1) consistently gave their children higher scores than did mothers in the control group. Although older users did not rate their children as highly on this measure as did younger users, there was not a significant difference between user age groups. Older and younger mothers in the control group rated their children almost identically.

Main Effect of Cannabis use ($F = 7.39$, $p=0.01$)

Figure 1A.

Main Effect of Cannabis use ($F = 3.14$, $p = .082$)

Effect of Cannabis use x Mother's Age Interaction ($F = 4.36$, $p = .042$)

Figure 1B.

Main Effect of Cannabis use ($F = 2.89$, $p = .095$)

Figure 1C.

Main Effect of Cannabis use ($F = 2.64$, $p = .110$)

Effect of Interaction Cannabis use x Mother's Age ($F = 2.66$, $p = .109$)

Figure 1D.

Effect of Interaction of Cannabis use x Mother's Age ($F = 4.19, p = .05$)

Figure 1E.

The scores for the children of older mothers on the Visual Sequential Memory variable were very similar across MARUSE groups. Within the group of younger mothers however, the children of users scored significantly lower than controls. Within the group of controls, the children of older mothers scored significantly lower than children of younger mothers. On the Visual Discrimination variable, the situation was almost reversed. The children of younger mothers performed equally well across MARUSE groups while children of older mothers differed significantly across groups.

With the Stroop Interference score, both the main effect of MARUSE and the effect of the interaction term approached significance. In this case it was the children of younger mothers who differed significantly across groups.

The Syntax Quotient variable was related only to the interaction term. As illustrated in the figure, children of younger mothers were significantly different on this measure when compared across MARUSE groups. Also, within the group of users (MARUSE =1), children of older mothers tended to score higher than children of younger mothers.

A two-factor MANCOVA was run with the seven outcome variables from the discriminant function analysis and the six remaining covariates from the multiple regression analyses (see Table 9). This MANCOVA revealed that the six covariates were, as a group, significantly related to the outcomes (Pillais=1.09, $p=0.052$). After controlling for these covariates, the interaction of MARUSE and MAGEBIRT was significantly related to the outcomes (Pillais=0.34, $p=0.013$) while MARUSE alone approached significance (Pillais=0.24, $p=0.110$, $p=0.055$ one-tailed).

Table 9
Two Factor MANCOVA Summary

Effect: MAGEBIRT by MARUSE (S=1, M=2 1/2, N=19)

Pillais=0.34 p=0.01

Univariate F tests with (1,46) D.F.

Variable	F	Sig. of F
Conduct Problems	0.28	0.60
Anxiety	0.00	0.99
Visual Sequential Memory	8.69	0.01
Visual Discrimination	0.37	0.55
Stroop Interference	0.88	0.35
Syntax Quotient	4.11	0.05
Trails A	0.44	0.51

Effect: MARUSE (S=1, M=2 1/2, N=19)

Pillais=0.24 p=0.11

Univariate F tests with (1,46) D.F.

Variable	F	Sig. of F
Conduct Problems	2.56	0.12
Anxiety	0.04	0.83
Visual Sequential Memory	1.22	0.28
Visual Discrimination	1.43	0.24
Stroop Interference	2.28	0.14
Syntax Quotient	0.84	0.36
Trails A	3.52	0.07

Adjusted means	MARUSE = 0	MARUSE = 1
Conduct Problems	-0.22	0.27
Anxiety	0.19	0.15
Visual Sequential Memory	14.39	13.41
Visual Discrimination	16.34	15.23
Stroop Interference	55.23	53.14
Syntax Quotient	111.18	108.09
Trails A	0.94	1.31

Comparison of Prenatal and Postnatal Covariates

The covariates in these analyses may be described as either "prenatal" or "postnatal" in terms of when their relationships with both the grouping variable and outcomes may be speculated to occur. Mother's age at birth (i.e., the variable MAGEBIRT) may be said to be "prenatal" as it describes a condition present prior to birth. The other covariates, while arguably describing conditions that may have existed before birth (e.g., the mothers' personality ratings might have been the same at that time as at present), are more likely to have influenced the mother's interaction with her child in the postnatal setting. Therefore, the impact of these prenatal and postnatal covariates on the relationship between cannabis use and the outcomes was compared.

The two-factor MANOVA, in which the effect of MARUSE was evaluated independent of its interaction with MAGEBIRT, a significant effect of cannabis use (see Table 8) was found. The significance of the univariate F tests for the outcome variables in this analysis were as follows:

Conduct Problems	p=0.01
Anxiety	p=0.33
Visual Sequential Memory	p=0.08 (p=0.04 one tailed)
Visual Discrimination	p=0.10 (p=0.05 one tailed)
Stroop Interference	p=0.11
TOLD-P Syntax Quotient	p=0.17
Trail Making Test - A	p=0.22

The subsequent two-factor MANCOVA which included the six "postnatal" covariates from the Home Environment Questionnaire and the NEO Five Factor Inventory yielded a non-significant effect of MARUSE (see Table 9) and also altered the level of significance associated with the univariate F tests thus:

Conduct Problems	p=0.12 (p=0.06 one-tailed)
Anxiety	p=0.83
Visual Sequential Memory	p=0.28
Visual Discrimination	p=0.23
Stroop Interference	p=0.14
TOLD-P Syntax Quotient	p=0.36
Trail Making Test - A	p=0.07

It appears then that the significant impact of cannabis use on the outcomes such as Conduct Problems, Visual Discrimination and Visual Sequential Memory, is mediated largely through its relationship to the home environment and maternal personality measures. To further investigate this mediation by covariates, path analyses were carried out.

Path Analysis

Path analysis is a regression-based data analytic technique which can be used to estimate and test causal models formulated by a researcher on the basis of knowledge. Correlations among the variables in the model can be used to decompose causal effects, allowing one to distinguish one variable's direct effect upon another from its indirect effect which is mediated by intervening variables. Because a basic assumption of path analysis is that the relationships among the variables in the model is linear, multiplicative or interaction relations are excluded. The path models presented here are recursive, in which each factor is regressed on anterior factors. Path coefficients are calculated to describe the nature of the direct and indirect relationships among the variables. When variables in a model are expressed in standardized form, the path coefficients are standardized regression coefficients obtained in ordinary regression analysis. Whenever a variable is conceived to be dependent upon a single cause, the path coefficient is equal to the

zero order correlation (Kerlinger & Pedhazur, 1973).

For the path analyses described below, each outcome variable and all of the covariates were transformed into z-scores. For each model, the outcome was regressed on the group of covariates as a block and then on the variable MARUSE. This allowed the determination of the direct effect of the covariates on the outcome as well as the direct effect of MARUSE on the outcome, after the covariates had been considered. As the covariates were conceived to depend only on MARUSE, the path coefficients between MARUSE and the covariates are zero-order correlations. To allow the presentation of a more "parsimonious" model (i.e., a clearer picture of the direct and indirect effects of MARUSE and the covariates on the outcomes), only those covariates having a significant Beta weight were retained in the model. The total "indirect" effect of MARUSE on outcomes was calculated in each model by multiplying the path coefficients between MARUSE and the covariates by the path coefficients between the covariates and the outcome.

For the first path analysis, in which Conduct Problems was the outcome (see Figure 2, Path #1), the regression of Conduct Problems on the group of six covariates found that only Aggression in the Home (AggresH) had a significant Beta weight ($\beta=0.51$, $p=0.02$). The regression was rerun, entering AggresH in one step and MARUSE on the following step. The resulting regression equation was significant ($R^2=0.28$, $p=0.0002$). The total indirect effect of MARUSE on Conduct Problems was computed $[(0.36 \times 0.47)=0.17]$ and when this value was added to the "direct" effect of MARUSE on Conduct Problems (0.26), the "total" effect (0.43) closely approximated the zero-order correlation between MARUSE and Conduct Problems ($r=0.39$).

PATH #1

$$R^2 = 0.28$$

$$F = 10.22, p = 0.0002$$

Total Indirect Effect
of MARUSE:
[(0.36 x 0.47)] = 0.17

Total Effect of MARUSE
0.17 + 0.26 = 0.43

r MARUSE, Conduct Problems = 0.39

PATH #2

$$R^2 = 0.16$$

$$F = 5.03, p = 0.01$$

Total Indirect Effect
of MARUSE:
[(-0.30 x 0.38)] = -0.11

Total Effect of MARUSE
-0.11 - 0.14 = -0.25

r MARUSE, Visual Discrimination = -0.24

Figure 2

PATH #3

$$R^2 = 0.11$$

$$F = 1.88, p = 0.14$$

$$r \text{ MARUSE, Visual Sequential Memory} = -0.19$$

PATH #4

$$R^2 = 0.11$$

$$F = 2.21, p = 0.10$$

$$r \text{ MARUSE, TRAILS A} = 0.18$$

Figure 2 (cont'd)

The second path analysis deals with Visual Discrimination as the outcome variable (see Figure 2, Path #2). In the regression of Visual Discrimination on the covariates, only Supervision had a significant Beta weight ($\beta=0.36$, $p=0.03$). The regression was rerun with Supervision entering on the first step and MARUSE entering on the second. The regression equation was significant ($R^2=0.16$, $p=0.01$) The indirect effect of MARUSE on Visual Discrimination was computed [$(-0.30 \times 0.38)=-0.11$] and, when added to the direct effect [$(-0.11) + (-0.14)=-0.25$], the total was found to closely resemble the zero-order correlation between MARUSE and Visual Discrimination ($r=-0.24$).

The third path analysis dealt with Visual Sequential Memory (see Figure 2 Path #3). When this outcome was regressed on all of the covariates however, the resulting regression equation was not significant ($R^2=0.19$, $p=0.15$). Of all the covariates in the equation, only NEOC and AggresE had significant Beta weights . When a second regression was run entering these two variables in a block , followed by MARUSE, the resulting regression equation was again not significant ($R^2=0.11$, $p=.14$). The direct path coefficient between MARUSE and Visual Sequential Memory was equal to the zero-order correlation between the two variables. Therefore, these covariates did not play a major role in mediating the effects of cannabis use on the outcome. It should be remembered here that Visual Sequential Memory was significantly related to the interaction term of MAGEBIRT and MARUSE, which could not be represented in path analysis.

The final path analysis presented was carried out in an attempt to explain the unusual finding that the relationship between MARUSE and the Trails A score became more significant after controlling for the influence of the covariates. When Trails A was regressed on all of the covariates, the resulting regression equation

was not significant ($R^2=0.18$, $p=0.18$). Two of the covariates, NEOC and AggresE had significant Beta weights. A second regression was run and these variables were entered as a block, followed by MARUSE (see Figure 2 Path #4). The resulting regression equation was likewise non-significant ($R^2=0.11$, $p=0.10$). The path coefficient for MARUSE ($\beta=0.26$) was found to be larger than the zero-order correlation coefficient ($r=0.18$). The same was true for the variables AggresE ($\beta=0.24$, $r=0.16$) and NEOC ($\beta=0.21$, $r=0.11$). This situation signals the presence of "suppressor" variables (Tabachnick & Fidell, 1983). Suppressor variables are so named because they suppress some variance in other independent variables that is irrelevant to the prediction of the dependent variable, thus enhancing prediction of the dependent variable. It appears likely that AggresE and NEOC may have been acting as suppressor variables and enhancing the relationship between cannabis use and Trails A.

Data from Infant and Preschool Tests

The early data from the subjects in the present study was examined and compared to the results of the current assessment for the purposes of illustrating trends and consistencies in the data over time. Because of the small sample size and large number of variables, a simple correlational approach was adopted.

In comparing the demographic data collected in the present study and the data available for those subjects whose mothers were interviewed while pregnant, significant correlations were found between income levels at the two time periods ($n=48$, $r=0.52$, $p<.01$) and between mother's educational levels ($n=50$, $r=0.84$, $p<.01$).

Table 10
Correlations between early and present data
Infant Tests & Intellectual Measures

	MARUSE	FSIQ	VERBCOMP	PERCPORG	FREEDIST
Response decrement to light (n=21)	-.001 (p=.49)	.44 (p=.02)	.54 (p=.01)	.23 (p=.16)	.36 (p=.05)
Response decrement to sound (n=20)	-.19 (p=.21)	.21 (p=.19)	-.04 (p=.42)	.12 (p=.30)	.22 (p=.18)
Self--quieting (n=22)	.13 (p=.28)	-.27 (p=.12)	-.23 (p=.15)	-.32 (p=.07)	-.17 (p=.22)
Irritability (n=31)	-.06 (p=.38)	.05 (p=.39)	-.13 (p=.24)	.19 (p=.15)	.02 (p=.47)
Tremors (4 days) (n=31)	.10 (p=.30)	-.17 (p=.18)	-.33 (p=.04)	.23 (p=.10)	-.30 (p=.05)
Startles (4 days) (n=31)	.26 (p=.08)	-.03 (p=.44)	-.10 (p=.29)	.10 (p=.30)	-.10 (p=.29)
Tremors (9 days) (n=35)	.50 (p=.001)	.02 (p=.45)	-.01 (p=.46)	.11 (p=.26)	-.05 (p=.40)
Startles (9 days) (n=35)	.29 (p=.04)	-.01 (p=.48)	.01 (p=.48)	-.09 (p=.29)	.04 (p=.42)
Tremors (30 days) (n=36)	.20 (p=.12)	-.05 (p=.38)	-.01 (p=.48)	.04 (p=.41)	-.14 (p=.20)
Startles (30 days) (n=36)	.40 (p=.01)	.18 (p=.15)	.09 (p=.29)	.02 (p=.47)	.40 (p=.01)
MARUSE		-.17 (p=.10)	-.19 (p=.08)	-.20 (p=.07)	-.002 (p=.50)

Table 11
Correlations between early and present data
Infant tests and present study test scores

	PERCQUOT	PASSCOMP	SYNTAXQT	STROOP	TRAILSA
Response decrement to light (n=21)	.20 (p=.20)	.15 (p=.26)	.21 (p=.20)	.46 (p=.02)	.22 (p=.17)
Response decrement to sound (n=20)	-.15 (p=.27)	-.29 (p=.11)	-.32 (p=.09)	.33 (p=.08)	.03 (p=.45)
Self-quieting (n=22)	-.28 (p=.10)	-.31 (p=.09)	.09 (p=.34)	-.03 (p=.46)	.20 (p=.20)
Irritability (n=31)	.14 (p=.23)	.21 (p=.13)	-.11 (p=.28)	.10 (p=.30)	-.17 (p=.18)
Tremors (4 days) (n=31)	.29 (p=.06)	.22 (p=.12)	-.08 (p=.33)	-.10 (p=.28)	-.20 (p=.15)
Startles (4 days) (n=31)	-.03 (p=.44)	-.10 (p=.30)	-.15 (p=.21)	.12 (p=.25)	.11 (p=.28)
Tremors (9 days) (n=35)	-.09 (p=.40)	-.34 (p=.02)	-.31 (p=.03)	-.10 (p=.28)	.07 (.34)
Startles (9 days) (n=35)	-.14 (p=.20)	-.36 (p=.02)	-.32 (p=.03)	-.03 (p=.44)	.22 (p=.10)
Tremors (30 days) (n=36)	-.03 (p=.42)	-.14 (p=.21)	-.19 (p=.14)	-.05 (p=.38)	-.04 (p=.41)
Startles (30 days) (n=36)	.06 (p=.37)	-.30 (p=.04)	-.04 (p=.41)	-.07 (p=.35)	.23 (p=.09)
MARUSE	-.29 (p=.02)	-.25 (p=.03)	-.21 (p=.06)	-.23 (p=.04)	.18 (p=.09)

Of the subjects in the present study, 31 had been examined at four days of age on the Brazelton Neonatal Behavioural Assessment Scale (Brazelton, 1973) and 35 and 36 had been examined at nine and thirty days of age respectively on the Prechtl neurological examination (Prechtl, 1977). The variables from those tests which have been found to relate to cannabis use (Fried, 1980, Fried & Makin, 1987, Fried et al., 1987) were examined for their relationship to test scores from the present study. The correlations between the infant tests and the intellectual measures are presented in Table 10; the correlations between the infant tests and other test scores, including those which discriminated between the study groups are given in Table 11; and the correlations between the infant tests and the behavioural ratings the parents assigned to the children are given in Table 12. The variables "response decrement to light" and "response decrement to sound" are measures of habituation and are scored such that a score of "9" is given to habituation within one or two exposures to the stimulus and a score of "1" is assigned to continued responding at ten exposures to the stimulus. For the other variables on the infant tests, high scores on "irritability" indicate a more irritable baby, high score on tremors corresponds to a large number of tremors observed, et cetera.

It must be noted here that the sample size for the response decrement to light variable is only 21 (i.e., 10 users and 11 controls). Ten of the subjects in the present sample (six in the user group and four in the control group) did not respond to light directed at the eyes and so are not represented in these correlations. This reduced sample size could account for the discrepancy between these findings and the report of Fried and Makin (1987) wherein cannabis use was significantly and negatively related to the Response Decrement to Light variable. That report was based on a sample size of 250, of which 47 were born to cannabis users.

Table 12

**Correlations between early and present data
Infant tests & later behaviour ratings**

	Anxiety	CondProbs	Hyper. Index	Imp/Hyp	Learn Probs.	Psychsom. Probs.
Response decrement to light (n=21)	.49 (p=.01)	-.10 (p=.33)	-.002 (p=.50)	-.14 (p=.28)	.17 (p=.23)	.16 (p=.26)
Response decrement to sound (n=20)	.15 (p=.27)	.25 (p=.14)	-.03 (p=.45)	-.15 (p=.27)	-.08 (p=.37)	.02 (p=.47)
Self-quieting (n=20)	-.40 (p=.03)	.10 (p=.32)	-.05 (p=.41)	.10 (p=.33)	-.06 (p=.40)	.19 (p=.19)
Irritability (n=31)	.10 (p=.29)	-.08 (p=.32)	-.15 (p=.21)	-.12 (p=.26)	-.15 (p=.21)	.04 (p=.42)
Tremors (4days) (n=31)	.04 (p=.43)	.24 (p=.10)	.32 (p=.04)	.35 (p=.03)	.16 (p=.20)	.26 (p=.08)
Startles (4 days) (n=31)	.08 (p=.34)	.35 (p=.03)	-.05 (p=.40)	-.02 (p=.45)	-.04 (p=.42)	.16 (p=.20)
Tremors (9 days) (n=35)	.19 (p=.14)	.57 (p=.00)	.42 (p=.01)	.37 (p=.02)	.27 (p=.06)	.14 (p=.20)
Startles (9 days) (n=35)	.002 (p=.50)	.33 (p=.03)	.02 (p=.45)	.05 (p=.39)	.05 (p=.38)	-.03 (p=.42)
Tremors (30 days) (n=36)	.15 (p=.20)	-.11 (p=.27)	.13 (p=.22)	.19 (p=.13)	.03 (p=.44)	.22 (p=.10)
Startles (30 days) (n=36)	.13 (p=.23)	.38 (p=.01)	.31 (p=.03)	.18 (p=.15)	.40 (p=.01)	.26 (p=.06)
MARUSE	.15 (p=.13)	.39 (p=.001)	.37 (p=.003)	.29 (p=.02)	.25 (p=.03)	.23 (p=.04)

In the realm of intellectual measures, most significant relationships were noted between the Response Decrement to Light and the Full Scale I.Q. (FSIQ) and between the response decrement to light and two of Kaufman's factors, Verbal Comprehension (VERBCOMP) and Freedom from Distractibility (FREEDIST) suggesting that infants who habituated quickly to light did better on these intellectual measures. Response Decrement to Light as well as the Response Decrement to Sound were positively associated with the Stroop Interference score suggesting that quicker habituation to these stimuli in infancy is associated with a greater ability to screen out distractors in later childhood.

Tremors at four days of age were negatively associated with the Freedom from Distractibility factor, indicating that children who showed marked tremors at four days were more distractible (i.e., did not score as well on the Freedom from Distractibility factor) than children with few or no tremors. Startles at 30 days of age were positively associated with the same factor. Tremors and Startles at nine days of age were each negatively related to the reading comprehension score (i.e., PASSCOMP) and to the Syntax Quotient of the TOLD-P (SYNTAXQT).

With regard to infant test results and later parent ratings of behaviour (Table 12), scores on Anxiety were positively related to the Response Decrement to Light and negatively related to Self-Quieting. Therefore children who were rated higher by their parents on the Anxiety scale had had better habituation to light and poorer self-quieting as infants. Conduct Problems (i.e., CondProbs) was positively related to Tremors at four and nine days of age and to Startles at thirty days of age. The same relationship held for the Hyperactivity Index (i.e., Hyper. Index). Impulsivity-Hyperactivity (Imp/Hyp) was positively related to Tremors at four and nine days of age. Learning Problems were positively related to Tremors at nine days and

Startles at thirty days. Psychosomatic Problems were positively related to Tremors at four days and Startles at thirty days.

Correlations between the preschool data and the present data are presented in Tables 13 to 16. Correlations among intellectual measures are generally all positive and significant, suggesting that they are tapping the same abilities. It is interesting to note that the preschool mental measures do not correlate as well to reading and spelling tests as they do to the WRAT arithmetic test (i.e., WRATARIT). The attentional measures (i.e., Stroop Interference and Knox Cube) do not correlate well with the global intellectual measures.

The preschool language measures (see Table 14) at 24, 36, and 48 months correlate well with the Verbal Comprehension Factor of the WISC-R and with the Syntax Quotient of the TOLD-P. Reading comprehension correlates well only with language comprehension measures. The 60 month test scores generally do not correlate with the scores from the present study.

The preschool perceptual measures (Table 15) show consistent relationships with the composite perceptual measures from the present study. The relationship between the composite memory measures from the preschool tests and the Visual Sequential Memory scores from the present study also correlate positively, although the magnitude of the relationship is not large. The correlation improves with the age at which the McCarthy test is given. The low correlations among the memory measures would appear to be due to the fact that the McCarthy subscale scores are comprised of visual, auditory, and verbal tasks whereas the Visual Sequential Memory taps only part of one of those domains.

2

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1,10a
(ANSI and ISO TEST CHART No. 2)

Table 13
Correlations between early and present data
Intellectual/Achievement/Attentional Measures

	12 month MDI (n=41)	24 month MDI (n=44)	36 month GCI (n=44)	48 month GCI (n=43)	60 month GCI (n=43)
MARUSE	.34 (p=.01)	.08 (p=.31)	-.11 (p=.24)	-.25 (p=.05)	-.24 (p=.06)
FSIQ	.15 (p=.18)	.45 (p=.001)	.43 (p=.002)	.48 (p=.001)	.39 (p=.005)
VIQ	.12 (p=.24)	.42 (p=.002)	.28 (p=.03)	.24 (p=.06)	.34 (p=.01)
PIQ	.14 (p=.19)	.27 (p=.04)	.41 (p=.003)	.54 (p=.00)	.25 (p=.05)
VERBCOMP	.10 (p=.27)	.45 (p=.001)	.36 (p=.008)	.37 (p=.008)	.50 (p=.00)
PERCPORG	.11 (p=.24)	.27 (p=.04)	.41 (p=.003)	.50 (p=.00)	.21 (p=.09)
FREEDIST	.09 (p=.29)	.29 (p=.03)	.29 (p=.03)	.31 (p=.02)	.30 (p=.03)
PERCQUOT	.16 (p=.16)	.15 (p=.17)	.21 (p=.09)	.34 (p=.01)	.32 (p=.02)
PASSCOMP	-.03 (p=.42)	.35 (p=.01)	.25 (p=.05)	.26 (p=.04)	.17 (p=.13)
WRATREAD	.18 (p=.13)	.26 (p=.04)	.06 (p=.35)	.18 (p=.13)	.10 (p=.27)
WRATSPEL	.14 (p=.20)	.28 (p=.03)	.16 (p=.15)	.05 (p=.37)	.06 (p=.36)
WRATARIT	.42 (p=.003)	.39 (p=.004)	.23 (p=.07)	.20 (p=.10)	.31 (p=.02)
SYNTAXQT	.08 (p=.30)	.47 (p=.001)	.24 (p=.06)	.38 (p=.006)	.36 (p=.01)
STROOP	-.09 (p=.29)	-.11 (p=.22)	-.11 (p=.24)	-.10 (p=.27)	-.32 (p=.02)
KNOXSS	.04 (p=.41)	.19 (p=.11)	.27 (p=.04)	.14 (p=.19)	.10 (p=.25)

Table 14
Correlations between preschool data and present study

	Language Measures			
	MARUSE	VERBCOMP	SYNTAXQT	PASSCOMP
Age at 2-word sentences (n=20)	-.37 (p=.06)	.17 (p=.23)	.28 (p=.12)	.04 (p=.43)
24 month Expressive Language(n=43)	.10 (p=.26)	.35 (p=.01)	.35 (p=.01)	.17 (p=.14)
24 month Language Comprehension	-.01 (p=.49)	.38 (p=.01)	.32 (p=.02)	.31 (p=.02)
36 month Expressive Language (n=45)	-.14 (p=.17)	.43 (p=.002)	.50 (p=.00)	.12 (p=.22)
36 month Language Comprehension	-.15 (p=.17)	.40 (p=.003)	.50 (p=.00)	.43 (p=.002)
48 month Expressive Language (n=43)	-.33 (p=.01)	.27 (p=.04)	.32 (p=.02)	.18 (p=.13)
48 month Language Comprehension	-.22 (p=.08)	.40 (p=.004)	.38 (p=.01)	.45 (p=.001)
60 month Expressive Language (n=18)	-.29 (p=.13)	.26 (p=.15)	.31 (p=.11)	-.03 (p=.46)
60 month Language Comprehension	-.09 (p=.36)	.34 (p=.08)	.24 (p=.17)	.20 (p=.21)
MARUSE		-.19 (p=.08)	-.21 (p=.06)	-.25 (p=.03)

VERBCOMP= Verbal Comprehension Factor of WISC-R

SYNTAXQT= Syntax Quotient of TOLD-P

PASSCOMP= Passage Comprehension Subtest of Woodcock Reading Mastery test

24, 36, 48, & 60 month scores from the Reynell Developmental Language Scales

Table 15
Correlations between preschool and present data

Perceptual measures			
	36 month Perceptual Performance (N=44)	48 month Perceptual Performance (N=43)	60 month Perceptual Performance (N=43)
Perceptual Organization	.46 (p=.001)	.56 (p<.01)	.31 (p=.02)
Perceptual Quotient	.36 (p=.01)	.39 (p=.01)	.01 (p=.01)
Visual Discrimination	.27 (p=.04)	.06 (p=.36)	.17 (p=.13)
Visual Sequential Memory	.29 (p=.03)	.19 (p=.11)	.22 (p=.08)
Stroop Interference	-.15 (p=.15)	.004 (p=.49)	-.34 (p=.01)
MARUSE	-.12 (p=.21)	-.09 (p=.28)	-.05 (p=.38)
Memory measures			
	36 month Memory	48 month Memory	60 month Memory
Visual Sequential Memory	-.01 (p=.48)	.21 (p=.09)	.25 (p=.06)
Knox Cube	.001 (p=.50)	.03 (p=.42)	.01 (p=.48)
MARUSE	-.03 (p=.43)	-.36 (p=.01)	-.27 (p=.04)

Table 16
Correlations between preschool and present data

	Motor measures				
	12 month PDI (N=41)	24 month PDI (N=44)	36 month Motor (N=44)	48 month Motor (N=43)	60 month Motor (n=43)
Tapping Dominant Hand	-.09 (p=.27)	-.03 (p=.43)	-.01 (p=.46)	-.11 (p=.24)	-.08 (p=.30)
Tapping Non Dominant Hand	.16 (p=.16)	.06 (p=.34)	.10 (p=.27)	-.03 (p=.40)	-.06 (p=.34)
Trails A	-.04 (p=.41)	-.21 (p=.09)	-.18 (p=.12)	-.06 (p=.36)	-.22 (p=.08)
Visual-Motor Integration	-.04 (p=.41)	-.02 (p=.46)	.36 (p=.01)	.24 (p=.06)	.21 (p=.09)
Draw-A-Man	.06 (p=.36)	.12 (p=.22)	.29 (p=.03)	.00 (p=.49)	.37 (p=.01)
MARUSE	.28 (p=.04)	-.13 (p=.19)	-.03 (p=.43)	-.22 (p=.08)	-.11 (p=.25)

The correlations between preschool motor measures and items from the present study battery having a motoric component are presented in Table 16. The "pure motor" tasks of finger tapping (Lezak, 1983) do not relate to the preschool measures. The correlations are much stronger between the preschool tasks and the drawing tasks. The Trails A task, on which the children of cannabis users performed slightly better than did children of controls (see Table 6), was negatively related to the motor components of the McCarthy test at all ages.

Case Reports

The case reports on seven children of users in the present study are presented in Appendix C. All of these children showed some behavioural alteration on infant testing. A fairly common theme among these reports is the notation by the testers

of some difficulty in eliciting either verbal responses from shy children or cooperation from highly active children. Both of these situations could have adversely affected how children scored on the developmental tests. Another trend noted among these children was the presence of tremors during moments of tension during the testing session. This was true for subjects 783, 2211 and 2771. Two of these children were rated by their mothers as above average on Impulsivity-Hyperactivity, the third was slightly above average on Learning Problems and Anxiety. All of their mothers rated themselves as quite low on Conscientiousness.

Discussion

The basic hypothesis of this study, which was derived from a review of both animal and human investigations, was that prenatal cannabis exposure could have a deleterious impact on postnatal outcomes. Because other research (both human and animal) had suggested that the type of behaviours possibly affected varied from simple activity level (Uyeno, 1973) to subtle forms of visual behaviour (Golub et al., 1981a) to language comprehension (Fried & Watkinson, 1988), a fairly comprehensive assessment of the neurobehavioural development of children of cannabis users was undertaken. Aside from global intellectual parameters, finer elements of visual perception, attention, language comprehension and visual-motor skills were assessed. Complementing these objective measures were the parental ratings of typical behaviour of the children along the dimensions of anxiety, conduct problems, impulsivity, hyperactivity, learning problems and psychosomatic concerns. Although the age range of the subjects (i.e., six to ten years) may be viewed as developmentally quite broad, care was taken to ensure that all scores derived from the assessment were based on age-referenced norms.

At several stages of the data analysis, consistencies with previous research were noted. The results of the present study will therefore be discussed first in terms of general trends in the data as related to previous work and then in terms of specific findings.

Congruent with the basic hypothesis of deleterious impact, children of cannabis users performed worse than children of non-users on the majority of the 32 variables on which they were compared (see Table 6). This poorer performance reached one-tailed statistical significance on ten outcomes in simple bivariate

comparisons; this proportion of significant findings is somewhat higher than would be expected due to chance alone. The outcomes on which the two groups differed spanned several behavioural domains: Passage Comprehension (i.e., reading comprehension); Stroop Interference (i.e., a measure of distractibility); Visual Discrimination; Visual Memory; Perceptual Quotient (i.e., a composite visual perceptual score); and five scales on which the mothers rated their children. These parental ratings indicated that the children of cannabis users were rated higher than controls on Conduct Problems, Hyperactivity Index, Impulsivity-Hyperactivity, Learning Problems and Psychosomatic Problems.

In order to determine which of the variety of outcomes would combine to maximize the difference between the groups, a discriminant function analysis was carried out. Seven of the outcome variables combined to form a significant discriminant function. A variety of behavioural domains was again represented. Two parental ratings of behaviour (Conduct Problems and Anxiety), two visual perceptual scores (Visual Discrimination and Visual Sequential Memory), a measure of distractibility (Stroop Interference), a measure of language comprehension (Syntax Quotient), and a visual-motor task (Trail Making, Part A) combined to account for 36 percent in the between group variance. On one of the discriminating variables (Trail Making, Part A), the children of cannabis users performed slightly better than did the controls.

At this stage of the analysis, several consistencies with previous research may be noted. For example, language comprehension (Syntax Quotient) was lower for the children of cannabis users relative to controls in the present study. Language comprehension has also been found to be lower for 24 month old children of cannabis users in a previous study (Fried & Watkinson, 1988). The finding of a

lowered Visual Sequential Memory score for the children in the “user” group also paralleled a finding from the Ottawa Study. Children of cannabis users have scored more poorly on the Memory Scale of the McCarthy Scales of Children’s Abilities (McCarthy, 1972) at 48 months of age (Fried & Watkinson, 1990). In that same report it was noted that at the age of 36 months, children of cannabis users performed better than children of non-users on the Motor Scale of the McCarthy test. In the present study, one test having a definite motoric component (Trail Making, Part A) figured into the discriminant function and on this measure, the children of the cannabis users performed better than the controls,

The remaining discriminating variables - Conduct Problems, Anxiety, Visual Discrimination, and Stroop Interference - have not been specifically examined in previous research. However, the animal literature may offer some counterparts. Higher scores on the Conduct Problems scale of the Conners Parent Questionnaire means that a mother endorsed some or all of the following items as being descriptive of her child’s behaviour: sassy to grown-ups, carries a chip on his shoulder, destructive, denies mistakes or blames others, quarrelsome, pouts and sulks, steals, disobedient or obeys but resentfully, bullies others, mood changes quickly or drastically, doesn’t like or doesn’t follow rules and restrictions, and basically an unhappy child. Many of these items have an aggressive connotation. Vardaris et al. (1976) found that prenatally treated rat pups were more aggressive at 90 days of age than were non-treated controls.

While effects on visual discrimination have not previously been reported, visual elements figure in many of the animal study results (see Table 3). For example, Borgen et al. (1973) and Charlebois and Fried (1980) found that visually mediated reflexes (i.e., cliff avoidance and visual placing) were slower to develop in prenatally

treated rat pups.

Although the results of the present study appear in many ways to be similar to the results of previous work, three concerns about the present sample which had not surfaced in previous studies had to be addressed. In order to maximize the number of children of cannabis users in the sample (i.e., in order to reduce the risk of Type II error or failing to reject the null hypothesis because of small sample size), children of users of "hard" drugs (i.e., drugs other than cigarettes and alcohol - usually cocaine, $n=6$), children of "new recruits" whose pregnancy drug history was collected retrospectively ($n=6$), and siblings ($n=8$ sets) were included. Care was taken to ensure that these possible "contaminants" did not have a marked impact on the outcomes measured in this study. In the former two instances this was done by comparing the results of the initial MANOVAs run with and without the "contaminant" group in question (i.e., hard drug users or new recruits). No difference in the relationship of prenatal cannabis use to outcomes was noted.

With regard to the use of siblings in the same sample, Streissguth (1986) has stated that the use of multiple offspring violates the assumption of independence upon which statistical tests are based. However, in the present study, each child had a unique prenatal drug history (see Table 4) and set of test scores (see Appendix E). Also, despite having redundancies with regard to mother's I.Q. (which was not a covariate) and mother's personality ratings (which were covariates), there was some variation in home environment ratings within sibling pairs (see Appendix D). Because of these facts and the increased sample size (and therefore increased power) the use of siblings afforded, they were retained in the sample.

Since the purpose of the study was to determine if prenatal cannabis exposure

had an effect on postnatal outcomes, care had to be taken that factors whose influence could confound that of cannabis would be controlled. In order to do this, all demographic data (mother's age, mother's and father's education, highest occupational status of the parents, family income, family size, number of parents in the home, the language of the home), additional data on the children (birth order, presence of problems in school, history of eye or ear infections, language of instruction in school, presence of special conditions at the time of testing, need for visual correction), and measures completed by the mothers (Raven Progressive Matrices, NEO Five Factor Inventory, and the Home Environment Questionnaire) were examined for relationship to prenatal cannabis exposure and to the variables forming the discriminant function. Seven variables were related to both cannabis use and to the outcomes and were retained in subsequent analyses. These were maternal age when the child was born, three home environment scales (Aggression-External, Aggression in the Home, and Supervision), and three scales from the NEO Five Factor Inventory (Neuroticism, Agreeableness, and Conscientiousness). These covariates were retained as possible confounds because it was felt that they could either exacerbate or ameliorate a direct cannabis effect.

These covariates could be described as either "prenatal" or "postnatal" depending on the time period during which they could interact with cannabis exposure to affect outcomes. Maternal age when the child was born would be considered a prenatal covariate because it "occurred" at the same time as the cannabis exposure. Other drug use during pregnancy would also be a prenatal covariate and potential confound, however in the present study this was controlled through matching subjects on maternal cigarette and alcohol use. Maternal personality (self) ratings could be considered either prenatal or postnatal covariates. Because it can be argued that personality characteristics may not alter greatly over

time, it is possible that the ratings would have been exactly the same had they been obtained during pregnancy. However, since it is not clear how maternal personality could have had an influence on a child in utero and so confound cannabis effects and since the ratings were obtained postnatally, they were considered to be postnatal covariates. Home environment ratings constitute postnatal covariates because they are assessed postnatally and the method of assessment used here placed evaluation of the home in the context of interactions with the child. Each of the ten scales that make up the Home Environment Questionnaire (Sines, 1983) contains items which deal specifically with the child involved in the present study.

Whether these potentially confounding covariates were prenatal or postnatal was actually immaterial to their inclusion in the present study. The fact that some of the covariates considered here were postnatal influences serves merely to underscore that the analytic approach used in the present study is a conservative one, which assigns shared variance to potentially confounding variables rather than to prenatal cannabis exposure. Some researchers (e.g., Sampson, Streissguth, Barr, & Bookstein, 1986) suggest that the influence of postnatal covariates should not be controlled because the covariates themselves may be affected by the use of the drug in question. These authors endorse a causal chain rationale in determining what variables ought to be considered as potentially confounding factors and suggest that only other prenatal influences can truly confound the effect of prenatal drug exposure. Postnatal covariates, in their view, could well be the result of interactions with an "affected" infant and therefore represent another consequence of prenatal drug exposure.

The adoption of the more conservative approach of inclusion of postnatal covariates allows a more comprehensive picture of the relationship between

prenatal cannabis exposure and neurobehavioural outcomes in school aged children to be presented. Both indirect effects (i.e., those mediated through mother's personality and/or home environment) and the direct effects (i.e., the association remaining after the influence of covariates is accounted for) of maternal drug use may be evaluated.

The data analysis therefore proceeded with MANCOVA and path analyses. The MANCOVA allowed the determination of the change in magnitude of the relationship between prenatal cannabis use and outcomes after the influence of covariates was taken into account. The path analyses provided further description of the way in which the covariates interacted with cannabis use to affect outcomes.

Comparing the results of the two-factor MANOVA (see Table 8) with the results of the two-factor MANCOVA (see Table 9), it is apparent that the initially significant relationships between cannabis exposure and higher scores on Conduct Problems and lower scores on Visual Discrimination and Visual Sequential Memory were mediated by the covariates. Before moving specifically to these findings, it should be noted that the importance of postnatal covariates in mediating cannabis effects has also been found in previous research.

Home environment had been found to be an important postnatal confound in previous studies involving children of younger ages. Controlling for the influence of home environment lessened the impact of prenatal cannabis exposure on language comprehension scores in twenty-four month old children (Fried & Watkinson, 1988). In thirty-six month old children, controlling for the influence of home environment rendered the relationship between heavy maternal use of the drug and lowered scores on a test of quantitative abilities non-significant. With forty-eight month old

children, controlling for home environment reduced the significance of the relationship between prenatal exposure and lowered scores on a test of verbal ability but did not change the relationship between prenatal exposure and lowered scores on a memory test (Fried & Watkinson, 1990).

In the present study, a new measure of home environment was used. This new home environment measure - the Home Environment Questionnaire or HEQ (Sines, 1983) differs somewhat from the HOME test (Caldwell & Bradley, 1979) which was used in the earlier work. The HOME was designed to assess the stimulation potential of the early developmental environment in order to identify those children living in environments placing them at risk for developmental delay. There are two forms of the HOME; one covering the age span from birth to three years and a second covering the span from three to six years. The form appropriate for the younger age group has been used in the Ottawa Study. Based on in-home observation and inquiry, its six subscales can be summed to yield an overall score which is expressed in stanine form. Because of its purpose and scoring, the test has limits when used in middle-class samples where scores are likely to vary little and may have a "ceiling effect" (Zimmerman, 1981).

The HEQ on the other hand was not designed to detect particular types of environments but rather to measure specific characteristics of the home environment in normal (i.e., non-clinical) populations. It is more comprehensive than the HOME in that it assesses the home, neighborhood, and school environments. According to the author (Sines, 1983) it is appropriate for assessing the environments of children up to fifteen years of age. Because it is completed by the mother of each child, it may be less objective but may provide a more representative picture of day-to-day living in the home environment than does the

HOME which is based on one visit by an external rater. The correlations between the two instruments are presented in Table 17 . Two of the scales of the HEQ Change and Separation - have little or no relation to the HOME, suggesting that they are tapping other dimensions.

Many of the correlations among the subscales are significant, suggesting that the two scales do measure similar aspects of the home environment. Emotional and Verbal Responsivity of the Mother, Avoidance of Restriction and Punishment, and Maternal Involvement with the Child of the HOME test are all negatively related to the measures of aggression on the Home Environment Questionnaire. However the magnitude of the correlations is not great enough to suggest extensive overlap.

As mentioned above, three of the seven variables forming the discrimination function were significantly related to prenatal cannabis exposure in the two-factor MANOVA but were no longer significantly related after the influence of covariates was controlled. These three were: Conduct Problems; Visual Discrimination; and Visual Sequential Memory. Path analyses permitted a more detailed examination of how the covariates interacted with cannabis to affect these three outcomes.

Table 17

**Correlations between early data and present study
Comparison of Home Environment Ratings**

N=43

	H10	H11	H12	H13	H14	H15	H16
Achievement p=	.00 (.50)	.19 (.11)	.24 (.06)	.31 (.02)	.11 (.24)	.16 (.15)	.21 (.09)
Aggression-External p=	-.25 (.05)	-.26 (.04)	-.26 (.05)	-.13 (.21)	-.25 (.06)	-.25 (.05)	-.39 (.004)
Aggression-Home p=	-.23 (.07)	-.24 (.06)	-.24 (.06)	-.11 (.24)	-.22 (.08)	-.29 (.03)	-.40 (.004)
Aggression-Total p=	-.27 (.04)	-.27 (.04)	-.27 (.04)	-.12 (.21)	-.25 (.05)	-.31 (.02)	-.44 (.002)
Supervision p=	.41 (.003)	.21 (.08)	.12 (.21)	.22 (.08)	.43 (.002)	.40 (.004)	.43 (.002)
Change p=	-.04 (.40)	.10 (.27)	-.16 (.16)	-.10 (.26)	-.004 (.49)	.08 (.32)	-.01 (.48)
Affiliation p=	.24 (.06)	.13 (.21)	.21 (.09)	.22 (.08)	.24 (.06)	.46 (.001)	.41 (.003)
Separation p=	-.06 (.36)	-.08 (.31)	-.13 (.21)	-.04 (.39)	-.14 (.19)	-.23 (.07)	-.16 (.15)
Sociability p=	.35 (.01)	.13 (.20)	.19 (.11)	.09 (.29)	.34 (.01)	.13 (.20)	.24 (.06)
Social Status p=	.32 (.02)	.41 (.003)	.19 (.11)	.14 (.20)	.43 (.002)	.47 (.001)	.43 (.002)
MARUSE p=	-.21 (.08)	.002 (.49)	-.26 (.05)	-.27 (.04)	-.12 (.22)	-.11 (.25)	-.25 (.06)

H10=Emotional & Verbal Responsivity of Mother

H11=Avoidance of Restriction & Punishment

H12=Organization of Physical Environment

H13=Provision of Appropriate Play Materials

H14=Maternal Involvement with Child

H15=Opportunity for Variety in Daily Routine

H16=Total HOME Score

Conduct Problems

The maternal rating of Conduct Problems was the most significant outcome in the two-factor MANOVA ($p=0.005$, one tailed) and remained close to significance after controlling for the influence of the covariates ($p=0.06$, one tailed). Path analyses revealed that the relationship between cannabis use and Conduct Problems was explained largely through the Home Environment Questionnaire measure Aggression in the Home (see Figure 2, Path #1).

Cannabis use (represented by MARUSE) was significantly and positively related to both Conduct Problems ($r=0.39$) and Aggression in the Home ($r=0.36$). These zero-order correlations indicate that the “drug accountable variance” (Fried & Watkinson, 1988) in Conduct Problems could be as high as fifteen percent (i.e., 0.39×0.39). After accounting for the influence of Aggression in the Home, the drug accountable variance dropped to roughly seven percent (i.e., 0.26×0.26). Although this appears to be a very small proportion of variance accounted for by cannabis use, it is actually slightly higher than proportions typically reported in the Ottawa Study. Fried and Makin (1987) for example, examined the relationship between neonatal behaviours and prenatal exposure to alcohol, nicotine, and cannabis and determined that the unique variance in outcomes attributable to each drug ranged from 1.5 to five percent. The unique variance in 24 month language comprehension scores accounted for by cannabis was negligible (Fried & Watkinson, 1988). It would therefore appear that the higher ratings of Conduct Problems in children of cannabis users may be a consequence of both a direct influence of prenatal exposure and an indirect effect of higher levels of aggression in the home.

The relationship between Aggression in the Home and socially undesirable behaviours has been found elsewhere. Sines (1983) reported significant positive correlations between children's aggression, inhibition, activity level, and sleep disturbance and the Aggression in the Home measure for both boys and girls. Likewise he reported a significant negative relationship between this home environment measure and prosocial behaviours.

Because the ratings of mother's personality, the ratings of the home environment, and ratings of behaviour all come from the same source - the mother - there may be some dependence among the measures (see Tables 18 to 21). While Aggression in the Home correlates with Conduct Problems ($r=0.47$, $p<.001$), it also correlates with NEO Neuroticism ($r=0.70$, $p<.001$), NEO Agreeableness ($r=-0.57$, $p<.001$) and the NEO Conscientiousness score ($r=-0.29$, $p=.01$). According to these correlations, a woman who rates herself highly on the Neuroticism scale by agreeing with statements such as "I often feel tense and jittery", "I often get angry at the way people treat me", and "I often feel inferior to others" is more likely to endorse as true items from the HEQ Aggression in the Home scale such as "I am often depressed", "My feelings are easily hurt", and "I'm easily upset" which refer to "aggressive and rejecting behaviours toward the target child by persons in the home" (Sines, 1983 p. 10). She is also more likely to see her child as one who is "destructive", "sassy to grown ups", "quarrelsome", and who "denies mistakes or blames others" - items from the Conners Parent Questionnaire. Of concern therefore is the possibility that, unlike the rest of the outcomes in the present study, the parental ratings of behaviour (specifically Conduct Problems) may not be objective and may be due more to the mother's perceptions than to alterations in the child's actual behaviour. If this were indeed the case, the relationship between higher score on Conduct Problems and cannabis use would be explained totally by

some peculiarity of cannabis users' ways of perceiving and interacting with their children and not by any effect of cannabis exposure on the children.

One solution to this dilemma would be to have more independent assessment of these variables. Independent assessment of mother's personality would be difficult as the majority of personality scales require that the individual being rated or someone very close to that person complete them. Use of projective techniques would be time-consuming and therefore costly. However independent assessment of the home and the child's behaviour are feasible. As mentioned above, the HOME may be viewed as a more objective (though perhaps less comprehensive) assessment of the environment. The total HOME score for the subjects in the present study (for whom this data was available, $n=43$) correlates with Conduct Problems ($r=-0.37$, $p=.01$). That the more objective assessment of home environment also relates to Conduct Problems suggests that the behaviour rating may not simply be the result of a mother's personality influencing her rating of the home environment and her perception of her child.

A more independent assessment of a child's typical behaviour could be obtained from a source such as a classroom teacher. Teacher ratings were not obtainable in the present study as most of the data was collected during the summer. Examination of the infant data however, may provide a relatively independent assessment of a child's behaviour. As shown in Table 12, some infant behavioural anomalies which have been found to be associated with cannabis use (Fried, 1980, Fried & Makin, 1987) correlate significantly with Conduct Problems and with the other scales of the Conners Parent Questionnaire. Children who exhibited more startles at four, nine, and thirty days of age and more tremors at four and nine days of age were more likely to be rated highly on Conduct Problems. These findings

suggest an underlying cannabis effect (i.e., an altered behaviour assessed by an independent examiner) which corresponds to mother's rating of the child.

However, future studies would do well to include independent assessments of the child's behaviour. A finding discrepant with that of the mother would suggest that the altered behaviour rating is largely due to the mother's perceptions. If an independent rating did not disagree with that provided by the mother, it could still be possible that the behaviour problems could be the result of an altered mother-child relationship possibly due to the effect of cannabis on the child (i.e., more startles and tremors) interacting with the mother's personality. Parenting skills of women who rate themselves highly on Neuroticism and low on Agreeableness and Conscientiousness may not be adequate for dealing with jittery, irritable infants. The "goodness of fit" (Thomas & Chess, 1977) between the child's temperamental endowments and the quality of care offered by his cannabis using mother may not be optimal. The reciprocal impact of child characteristics on eliciting parental involvement and parental involvement in stimulating child responses is referred to as the "transactional model" of development (Sameroff & Chandler, 1975). It has been used to explain both the negative outcomes for babies born to methadone-maintained women (Johnson, Diano & Rosen, 1984) as well as to explain the lack of negative impact of ganja use on infants in Jamaica (Hayes et al., 1988). In the latter instance, the more stimulating environment provided for their children by the ganja users is believed to contribute to better organized sleep/wake cycles in the children and the quieter children are more likely to elicit stimulating interactions from the adults. In the present relatively low-risk, middle-class sample of cannabis-using subjects, the product of a non-optimal parent-child interaction is not likely to be as severe as the neurobehavioural delays seen in children born to methadone-maintained mothers (Johnson et al., 1984). Rather, it is likely to be fairly subtle,

and may emerge only as a higher score on parental ratings of behaviour problems. Further research on mother-child interactions is needed to properly answer this question.

A further possibility exists to explain the higher rate of Conduct Problems in children of cannabis users. These women rate themselves lower than the control mothers on Agreeableness by agreeing with statements such as “I often get into arguments with my family and co-workers”, “Some people think I’m selfish and egotistical”, “If I don’t like people, I let them know it”, and “If necessary, I am willing to manipulate people to get what I want”. They may unwittingly be modelling socially undesirable behaviour which, when exhibited by their children, is labelled as “quarrelsome”, “pouts and sulks”, and “bullies others” on the Conners Parent Questionnaire.

Visual Discrimination

The visual components related to prenatal cannabis exposure, the Visual Discrimination and Visual Sequential Memory subtests of the Test of Visual Perceptual Skills (TVPS), were each related to prenatal cannabis exposure before controlling for the influence of covariates. The relationships were no longer significant after controlling for the covariates’ influence. Although not depicted in Table 11, the correlations between these visual subtests and the infant behaviours (i.e., Response Decrement to Light, Response Decrement to Sound, Self-Quieting, Irritability, and Tremors and Startles at 4, 9 and 30 days) were similar in magnitude and direction as the correlations between the total Perceptual Quotient of the TVPS (i.e., PERCQUOT) and the infant behaviours.

For Visual Discrimination, the effect of cannabis was principally mediated through a lower score on the Supervision scale of the Home Environment Questionnaire (see Figure 2, Path #2). The items on the scale connote parental supervision and management of the child's time and activities. It includes items such as "I like to plan my children's activities", "I do not allow ____ to watch certain TV shows", "A certain time is set aside for ____ to do homework", and "We have very high standards for everyone in our family". It correlates negatively with Neuroticism ($r=-0.33$, $p=.01$) and positively with Extraversion ($r=0.41$, $p=.001$), Agreeableness ($r=0.36$, $p=.003$), and Conscientiousness ($r=0.51$, $p<.001$). It also correlates positively with the total HOME score ($r=0.43$, $p=.002$). According to these correlations, mothers who are more involved in their children's activities tend to be more agreeable and conscientious and have children who do better on the Visual Discrimination task. They are also less likely to be cannabis users. It would appear that the negative relationship between prenatal cannabis exposure and Visual Discrimination ($r=-0.24$) was due to its relatively small direct effect ($B=-0.14$) being exacerbated by the negative relationship between the cannabis-using status of the mothers and their rating of Supervision in the home ($r=-0.30$). In this case the drug accountable variance dropped from roughly six percent when no covariates were considered to two percent after accounting for Supervision in the home.

Because the Visual Discrimination task is an objective measure and was administered by an investigator blind to each child's drug exposure history, concern about bias in evaluation is not relevant here. The possible explanations for the way in which parental supervision (or lack of it) could exacerbate a cannabis effect are not obvious. It may be that children whose parents conscientiously supervise homework in fact, get more "practice" at tasks which resemble the Visual Discrimination task. The Visual Discrimination task requires subjects to find the

figure which exactly matches a stimulus figures from an array of several closely similar figures and one identical figure. If a child gets more practice at printing or writing, or copying maps from books for example, he or she may develop relatively advanced visual discrimination skills over those children whose parents do not make as much of an effort to supervise their children's activities. Perhaps, in a more general sense, parents who are more involved in their children's activities, interact with them on a more adult level and thereby stimulate development of particular skills, one of which may be visual discrimination ability.

The animal literature on prenatal cannabis exposure yields an example which, in a sense, parallels this connection between maternal behaviours and offspring performance on a visual test. Golub et al. (1981b) reported that rhesus monkeys who had been treated with THC throughout pregnancy and lactation engaged in more negative behaviours such as breaking and resisting contact with their infants than did untreated monkeys. These offspring subsequently showed alterations in visual behaviour typified by a failure to limit responding to novel stimuli (Golub et al., 1981a). These researchers have not however investigated the relationship between maternal behaviour and infant test performance. An obvious difference between these two findings is that, in the animal literature, alterations in maternal behaviour are considered to be a result of exposure to the drug. In human studies, no such assumptions can be made. In fact, it would appear that behavioural alterations in cannabis users precede the onset of cannabis use (Halikas, Weller, Morse, & Hoffman, 1983).

Visual Sequential Memory

Visual Sequential Memory was significantly related to the interaction between

cannabis use and mother's age when the child was born. This meant that while children of users did not do as well on this measure as did the children of controls, the difference was principally seen when the younger mothers (i.e., whose age was less than or equal to 27 years) were compared. Also, within the control group, children of the younger mothers did significantly better than the children of the older mothers. Children of older and younger mothers in the user group did not differ on this measure. Aside from this, the covariates did not explain a significant proportion of the variance in this outcome (see Figure 2, Path #3). This highlights another important way in which maternal characteristics can influence the relationship between cannabis use and outcomes. Mother's age has often been found to differ between users and controls (e.g., Hingson et al., 1982, Linn et al., 1983, Tennes et al., 1985) and is therefore controlled statistically. This appears to be the first report where it interacted with cannabis use in this fashion. It is not clear why the children of older non-users should be different from children of younger non-users on this measure. Future studies could circumvent this interaction by matching the subjects on mother's age at the outset.

This measure did highlight an element of consistency with the early data as it was positively correlated with the Memory component of the McCarthy Scales at 48 ($r=0.21$, $p=.09$), and 60 months ($r=0.25$, $p=.06$). The correlations were positive but fairly low (see Table 15), possibly due to the fact that the McCarthy scales are composed of verbal, auditory, and visual elements, while Visual Sequential Memory taps only one type of visual element. The tests also differ with regard to how memory is accessed. The memory elements of the McCarthy test all require the subject to recall stimuli presented by the examiner (e.g., individual sentences, a brief story, pictures, or a sequence of notes played on a xylophone). The Visual Sequential Memory task requires recognition of previously seen stimuli rather than

recall. The child is asked to look at a stimulus figure for a fixed length of time (the examiner allows five seconds and then turns the page) and then is asked to find the stimulus figure on the next page where there are several similar figures and one identical figure. The stimulus figures are strings of symbols which gradually increase in length from two to nine symbols. The fact that children of cannabis users perform more poorly on both recall and recognition tasks suggests that there may be a generalized memory "deficit" (i.e., possibly affecting both storage and retrieval of information) associated with prenatal exposure. The term "deficit" is used cautiously as memory scores in the Ottawa Study do not typically fall below published means.

Conduct Problems and Visual Sequential Memory entered the discriminant function analysis on the first and second steps respectively. Together they accounted for twenty-two percent of the between-group variance. Although these two measures are not significantly correlated with each other ($r = 0.10$, $p = 0.23$) they are each separately related to measures of distractibility. In the present sample, high scores on parental ratings of Conduct Problems were associated with lower scores on the Stroop Color and Word Test ($r = -0.22$, $p = 0.05$), suggesting a poorer ability to screen out distractors. High scores on Visual Sequential Memory were associated with high scores on the Freedom from Distractibility factor of the WISC-R ($r = 0.21$, $p = 0.06$). These relationships suggest that alterations in an underlying attentional mechanism may form the basis for at least some of the between-group differences seen in the present study. Future studies should include tasks sensitive to attentional alterations.

The simple correlational approach adopted for the examination of the relationships among prenatal cannabis exposure, infant and preschool data, and the present data did not allow an in-depth analysis of the contribution of other influences such as maternal alcohol or cigarette use or socioeconomic status. However several interesting trends were noted.

The significant relationship between several of the infant test scores and the present data correspond to evidence that mental development is continuous rather than discontinuous from infancy through childhood. Response decrement to light and to sound represent a measure of attention that has been identified as a potential index of mental development in infancy (Bornstein & Sigman, 1986). Greater decrement of attention or faster habituation is generally interpreted as a more efficient style of information processing. The response decrement to light was significantly and positively related to the Full Scale I.Q., the Verbal Comprehension Factor, the Freedom from Distractibility Factor and the Stroop Interference score, which is also a measure of distractibility. Children who exhibited a faster habituation to light at four days of age had higher Full Scale I.Q.'s and higher scores on the Verbal Comprehension Factor. They also had higher scores on the Freedom from Distractibility Factor and on Stroop Interference, meaning they were less distractible than children who had exhibited poor habituation to light.

The magnitude of the correlation of the response decrement to light and the Full Scale I.Q. ($r=0.44$) is congruent with Bornstein and Sigman's (1986) claim that attention measures account for between eight and 59 percent of the variance in childhood intelligence. Here the percentage of variance in Full Scale I.Q. accounted

for by the response decrement to light was nineteen percent.

The response decrement to sound was also related to the Stroop Interference score ($r=0.33$, $p=0.08$) indicating that quicker habituation to sound in infancy was related to a better ability to screen out distractors in later childhood. The fact that the response decrements to both light and sound were related positively to the same outcome (i.e., Stroop Interference) underscores Bornstein and Sigman's (1986) contention that the decrement of attention phenomenon is modality independent and probably centrally controlled.

The correlations between the early infant tests and the data from the present study also suggest that precursors to later behavioural and scholastic problems may be detected in infancy. There was found a connection between heightened tremors, startles, poorer self-quieting in infancy and poorer scores on reading comprehension and language comprehension tests. Given this relationship, it was perhaps not surprising to also find that these same tremors and startles were related to a higher rating on the Learning Problems scale of the Conners Parent Questionnaire.

Tremors and startles were also related to higher scores on Conduct Problems, Impulsivity/Hyperactivity and the Hyperactivity Index. Infants who were poorer at self-quieting were rated higher on Anxiety in later childhood. A common element among these relationships is that both the infant test scores and the present data with which they correlate are related to prenatal cannabis exposure. The tremors and startles seen in infancy may have been a manifestation of a withdrawal syndrome or perhaps an indication of overelaboration of the noradrenergic system (Scher et al., 1988). That they appear to predict later test performance suggests that there could be a direct and persistent effect of prenatal cannabis exposure

characterized by greater arousal (activity). It has been speculated that acute administration of cannabinoids in adults disrupts inhibitory input to the reticular activating system, resulting in impaired ability to focus attention and habituate to novel stimuli (Miller & Branconnier, 1983). It is possible that cannabis constituents may have a similar, perhaps permanent, effect on children as a result of prenatal exposure. This lack of inhibition of arousal could be manifested by heightened startles in response to random environmental stimuli and poorer self-quieting in infancy or as increase in behaviours labelled as "hyperactive" in childhood. Congruent with this hypothesis are the reports in the animal literature of prenatally exposed offspring displaying hyperactivity (Borgen et al., 1973, Uyeno, 1973) and aggressiveness (Vardaris et al., 1976).

It is possible that the present findings could be a product of the interaction of inadequate parenting on the part of cannabis using women with the withdrawal symptoms of the infants. They may also be a product of ongoing interactions between mother's personality and an increased activity level in the child. These interactions would constitute indirect, but nonetheless real, effects of prenatal cannabis exposure. This intriguing set of "transactional" (Sameroff & Chandler, 1975) relationships awaits further study.

Comparison of data from preschool assessments with data from the present study (Tables 13 to 16) indicates that there is consistency in these children's performances across time. Within the present sample, correlations between preschool cognitive measures and present intellectual measures were positive and significant from the age of twenty-four months onward. This was true also for the motor, perceptual, and memory measures. An exception was the language measures (Table 14) where scores derived from testing at sixty months of age did

not correlate with present data as well as the scores from thirty-six or forty-eight month testing did. This may be due in large part to the very small sample size ($n=18$) from the sixty month testing.

The simple correlations between prenatal cannabis exposure and preschool measures became stronger (i.e., more negative) as the children became older. This was especially true for the intellectual measures (i.e., MDI's and GCI's). In the published reports dealing with the preschool data from the Ottawa Study, there has been a trend toward an increasing difference in scores on intellectual measures between children of the heavy users of cannabis (i.e., users of more than five joints per week) and children of non-users. At twelve months of age the mean Mental Development Index score for the children of heavy users was 112.1 versus 107.7 for the children of non-users. At twenty-four months, the scores were 115.9 for the heavy users' children and 116.5 for the non-users' children (Fried & Watkinson, 1988). At thirty-six months of age, the mean General Cognitive Index for the children of heavy users was 111.0 versus 115.8 for the children of non-users. This represents a difference of roughly one-third of a standard deviation. At forty-eight months, the mean GCI for the children of heavy users was 116.5; the mean GCI for the children of non-users was 124.8, a difference of approximately one-half of a standard deviation (Fried & Watkinson, 1990). While these comparisons do not take into account intervening variables (i.e., covariates), they suggest that this apparently widening gap between children of heavy cannabis users and children of non-users merits further attention.

The McCarthy Memory scores at 48 and 60 months of age were significantly and negatively related to prenatal cannabis exposure for the subjects of the present study. This indicates that the lower memory score seen in children of cannabis

users at 48 months of age is stable even when a fairly small sample (i.e., $n=43$, 23 children of users of more than one joint per week) is considered. The consistency over time and the stability of the relationship between prenatal cannabis exposure and memory scores suggests that further investigation of memory functioning in prenatally exposed children may be a worthwhile area for future research.

Case Reports

The case reports (Appendix C) illustrate the abovementioned trends in the data and provide anecdotal support for both direct and indirect effects of prenatal exposure to cannabis.

Although all the children in the present study performed at or well above the published norm means on the majority of tests they were given and were uniformly cooperative during the testing, the earlier test results for some of the children, especially those who were born to cannabis users and showed heightened tremors and startles in infancy, were somewhat more varied. For several of the children described in the case reports shyness (e.g., subjects 1011 and 2771) lack of cooperation (e.g., subjects 783 and 1251) likely affected many early test scores, especially expressive language. Some congruence between mothers' present ratings of hyperactivity and the early testers' description of behaviour were noted for subjects 1251 and 2891. In both cases, the children were very active and restless during the 36 month testing, although subject 2891 was described as "attentive" and subject 1251 as "uncooperative". How mother's personality and/or parenting skills can contribute to outcomes was illustrated in the case of subject 1251. His mother rated herself (in the present study) as being quite low on Conscientiousness.

It was noted on the child's file from the thirty-six month testing that she did not believe in discipline and therefore did not intervene when her child's behaviour (i.e., running away from the testing table) interfered with a proper assessment of his capabilities. The child's overactivity and the mother's personality combined to have adverse effects on neurobehavioural outcomes. This combination could affect not only developmental test scores (by lack of cooperation) but lack of proper discipline in a very active child could lead him to develop a tendency to be "sassy to grown-ups", or "destructive" or "disobedient" which would produce a high score on the Conduct Problems scale of the Conners Parent Questionnaire.

By the present testing, behavioural alterations (i.e., shyness, lack of cooperation or restlessness) did not affect test scores for any of the children.

Possibly direct and persistent effects of prenatal exposure to cannabis were illustrated by subjects 783, 2211 and 2771, who had exhibited heightened tremors and/or startles at four and nine days of age. They were also noted to exhibit tremors during testing at either twelve or twenty-four months of age. These tremors apparently did not have an adverse effect on the children's ability to perform the tasks. They were noted on the files because their occurrence in the entire Ottawa Study sample was extremely rare.

Directions for Future Research

Several of the findings in the present study suggest possible avenues for future research. Firstly, given that behaviour problems appear to be associated with cannabis use, researchers seeking to replicate this finding would do well to include an independent assessment of behaviour. There appear to be infant correlates for

later ratings of behaviour problems and evidence that independent testers would describe the behaviour of the children in much the same way that the mothers do. An independent assessment of behaviour would help to tease apart the relationships among maternal characteristics, home environment, and behaviour found in the present study.

Secondly, as maternal age was found to have a significant interactive relationship with cannabis use and so affect outcomes, future researchers would be advised to take steps to control for the influence of this factor. Matching mothers in the user and control groups on this variable is one possible solution. If the sample is large enough, the sample could be stratified and analyses run separately for children of younger mothers versus children of older mothers.

Thirdly, given that the impact of prenatal cannabis exposure on school-aged children appears to be mediated through maternal and home environmental variables, the possibility of altered mother-child interaction exists. Future research should perhaps focus on assessing this possibility more directly. This would be a massive undertaking, requiring the detailed recording of interactions over a long period of time (Lytton, 1982). Because cannabis appears to exert its most direct effect on behaviour in the neonatal stage (Fried, 1980, Lester & Dreher, 1989, Scher et al., 1988), this would be the best time to begin the observations. Combining assessments of mothers personality with objective evaluation of the infant's behaviour (e.g., tremors, pitch of cry, sleep/wake cycles) could illuminate the direction or pattern of relationships these variables may have with later outcome measures. These evaluations could continue to take place over time, perhaps coincident with each child's regular developmental testing with an independent observer recording mother-child interactions during and between test sessions.

Such a combined study would provide information on objectively determined measures of neurobehavioural development as well as the type of processes which may influence them.

It must be recognized that, while recording mother-child interactions would a major step forward in examining the relationship between prenatal drug exposure and postnatal behaviour, the approach described above has its weaknesses. As a child develops, his or her interactions expand beyond those involving the mother. In a family system, father's influence, as well as the marital relation, must also be considered. Not only may relations between the spouses influence the child via their parenting behaviour, but the child will also influence the state of the marriage. Furthermore, sibling effects also play a role in most families and these should be analyzed as part of the family system. The state-of-the-art analysis in this area is not advanced enough to allow the examination of the interaction of all of these systems over time. It is possible to study the interactions of the complex family system at one point in time of the transactional effects for one type of parent-child dyad over time (Lytton, 1982).

Also, investigations of transactional effects should include developmental measures other than strict cognitive tasks or overt behavioural ratings. As the higher scores on Anxiety for the children of cannabis users in the present study indicate, a child's affect or emotional disposition may be an important factor to consider.

A basic issue in prenatal cannabis research which should be further clarified in future studies is the measurement of drug intake. Because cannabis is still an illegal substance, there is no simple means of standardizing the amount consumed

as there is with cigarette consumption, for example. Perhaps because of this, most human studies categorize their subjects with regard to frequency of use (e.g., number of times per week or month) rather than amount (i.e., number of joints). The precision of these estimates has ranged from the simplest of categorization of use during pregnancy versus no use during pregnancy (Rosett et al., 1983) to the more complex system of Scher et al. (1988) which had five categories (i.e., abstainers, less than one joint per month, one to three joints per month, one to six joints per week, and one or more joints per day). Adding to this diversity of measurement is the recent finding that cannabis exposure via breastfeeding may have an impact on developmental outcomes (Astley & Little, 1990). This suggests that postnatal exposure should also be studied and in some way quantified. Postnatal exposure could occur not only through breastfeeding, but through a child's passive exposure to his parents' cannabis smoking, or through a child's ingestion of cannabis tea. This latter method of exposure is more common among children of "ganja" users in Jamaica where ganja tea is considered to be beneficial both to general health and to academic performance (Dreher, 1984).

Postnatal exposure was not assessed in the present study, largely for practical reasons. The examiner had to remain blind to maternal drug history throughout the testing of both the child and the mother. Including questions about the child's exposure to second-hand cannabis smoke on the parental questionnaire (which was often filled out in the presence of the examiner so that parental queries could be addressed) could have compromised the "blind" status of the examiner. Questions about a child's passive exposure to cannabis have never been a part of the Ottawa Study protocol and therefore the information was not available in the infant or preschool data files. Asking the mothers in the present study to estimate a child's history of exposure would have required recall over six to ten years and would have

been unlikely to elicit any information beyond a simple yes/no to the question of whether the child had been exposed. Further quantitative and qualitative information would require knowledge of the size and potency of the cannabis joints involved, the size of the room where the cannabis was consumed, the length of time the child was exposed, and the number of occasions on which the exposure occurred. Future studies which plan detailed follow-up of subjects should consider including follow-up interviews on maternal drug taking and possible postnatal exposure of the child, conducted by an interviewer not involved with neurobehavioural testing, and timed to coincide with the developmental testing of the child. This would help to reduce the possibility of recall bias and obtain a more accurate estimate of postnatal exposure.

Assessment of patterns of drug use beyond pregnancy has value outside of determining a child's postnatal drug exposure. Given the relationship among maternal drug habits, home environment, and personality characteristics, it is possible that closer examination of postnatal habits may highlight further maternal and environmental factors which distinguish women who continue to use the drug from women who cease to use it after their children are born. Astley and Little (1990) reported that women who used cannabis during lactation were slightly more likely to be cocaine users. It is possible that women who continue to use cannabis after their children are born may differ from women who do not in terms of other lifestyle characteristics which may, in turn, influence developmental outcomes of their children.

Finally, with regard to the types of behaviours which might be most relevant to a future study, the results of the present investigation, although not statistically significant, may be viewed as supporting an impact of cannabis on memory functioning. In the present study, scores for the children of cannabis users were

lower than those of control children on both Visual Memory and Visual Sequential Memory tasks. The Visual Sequential Memory score contributed to the discriminant function which maximized the differences between the study groups.

Other reports in the literature also suggest that memory may be worthy of closer examination with regard to possible cannabis effects. Impaired memory functioning may underlie some of the behavioural effects attributed to prenatal cannabis exposure in the animal literature. Gianutsos and Abbatiello (1972) and Kawash et al. (1980) reported that prenatally treated rat pups were slower to learn a maze; Vardaris et al. (1976) found deficits in shock avoidance learning in prenatally treated rats. These studies were flawed in that pair-feeding and cross-fostering were not included so that it is impossible to attribute the results to a direct effect of the drug or to secondary effects on maternal health and behaviour. However, they also have not been replicated so it is not possible to determine if the results would have been substantially changed with the introduction of these controls.

Relatively lower memory scores persisted for preschool children of cannabis users after controlling for potential confounds in the Ottawa Study (Fried & Watkinson, 1990). While the memory effect may have persisted because the postnatal confound of home environment rating was inappropriate (having been assessed two years prior to the developmental testing), it is possible that it may represent a very real effect of the drug. Comparison of the type of memory tasks on which the children in the present study have been evaluated with those they were given as preschoolers, suggests that lower memory scores may be seen in both recall and recognition tasks and may be evident in both visual and auditory modalities.

A verifiable impact of prenatal exposure on postnatal memory functioning would

highlight a correspondence between adult and fetal effects because memory impairment is the single most consistently reported psychological deficit produced by cannabinoids (Miller & Branconnier, 1983).

It is important to remember for all future research that, although direction of cannabis effects may be specified a priori and one-tailed test may therefore be justified, the exclusive use of one-tailed tests may suggest bias on the part of the examiner. Care must be taken results, even those which are contrary to expectations (eg. test on which the children of cannabis users perform better than children of non-users) be given equal weight and emphasis.

Summary

The present study found indications of prenatal cannabis effect on postnatal functions principally in two areas: behaviour problems and visual perceptual abilities. It is important to remember that for all of the tests administered in the present study, both study groups performed at or well above the published norm means. Many prenatal drug studies have difficulty in that "differences between groups in specific cognitive characteristics must be identified against a background of somewhat generally depressed functioning" (Strauss & Allred, 1986, p.370). The opposite situation would seem to present itself here. The background level of functioning of the subjects in the present study would appear to be quite high. Although several univariate comparisons suggest that the children of cannabis users did more poorly on several types of tests (see Table 10), the lowered score for the group never fell below "normal" or into the "clinical range".

While the results of the present study do not support a marked direct effect of

prenatal cannabis exposure on neurobehavioural development in school-aged children, these results must be viewed in light of the sample characteristics. The subjects of the present study were chiefly representative of a low-risk, middle-class population. It is possible that these socioeconomic conditions signal the presence of as yet unmeasured environmental influences which serve to ameliorate harmful direct effects that prenatal cannabis exposure might have. It is also possible that in less economically advantaged circumstances, a more pronounced “cannabis effect” might be seen.

Relevant also to the minimal findings of the present study is that the period of maternal cannabis use of interest occurred at least six years ago. Since the Ottawa Study began in 1978, the concentration of THC in the cannabis ingested by the subjects has been presumed to be in the range of one to two percent. Given the more recent information that the potency of “street grass” has increased in recent years to eighteen percent (Hutchings, 1989), it is possible that future studies may be more likely to uncover a direct effect of cannabis on postnatal behaviour. Adding to this likelihood is the apparent trend towards increased use of the drug in prenatal clinic populations. While earlier workers found thirteen to seventeen percent of their subjects to be cannabis users (e.g., Fried et al., 1980, Greenland et al., 1983, Hingson et al., 1982, Rosett et al., 1983), the most recent published reports have shown that cannabis users made up 27 percent (Zuckerman et al., 1989) to 34 percent (Tennes et al., 1985) of the study samples.

The method of data analysis adopted for the present study was a conservative one. Setting an alpha level of $p \leq .10$ for the selection of variables to be considered for discriminant function analysis and for consideration as potential covariates may be seen as erring on the side of overinclusion. As well, controlling for the influence

of post-natal covariates further reduced the likelihood of prenatal cannabis exposure accounting for a significant proportion of the variance in the outcomes.

The findings of the present study therefore indicate that, while prenatal cannabis exposure may not have a statistically significant impact on postnatal functioning as assessed by the tools used here, there are still many issues to be addressed and avenues to be explored before it can be definitively stated that a woman's use of cannabis during pregnancy, even in a low risk population, has no adverse effect on her child.

Table 18
Correlations between NEO and HEQ

	NEON	NEOE	NEOO	NEOA	NEOC
N=56					
Achievement					
p=	-.21 (.06)	.34 (.01)	.04 (.38)	-.002 (.50)	.19 (.08)
Aggression-External					
p=	.54 (.00)	-.53 (.00)	-.03 (.42)	-.43 (.00)	-.39 (.001)
Aggression-Home					
p=	.70 (.00)	-.52 (.00)	-.21 (.06)	-.57 (.00)	-.32 (.01)
Supervision					
p=	-.33 (.01)	.41 (.001)	.08 (.29)	.36 (.003)	.51 (.00)
Change					
p=	.27 (.02)	-.24 (.03)	.09 (.26)	-.01 (.41)	-.09 (.24)
Affiliation					
p=	-.24 (.04)	.24 (.04)	.04 (.38)	.16 (.12)	.15 (.13)
Separation					
p=	.15 (.13)	-.15 (.12)	-.05 (.26)	-.19 (.08)	-.005 (.48)
Sociability					
p=	-.23 (.04)	.29 (.02)	-.06 (.34)	.09 (.27)	-.01 (.48)
Social Status					
p=	-.20 (.07)	.06 (.34)	.37 (.003)	.11 (.20)	.33 (.01)
MARUSE					
p=	.23 (.04)	-.19 (.08)	.10 (.24)	-.32 (.01)	-.46 (.00)

Table 19
Correlations between NEO and Conners Parent Questionnaire

	Anxiety	CondProbs	Hyper. Index	Imp/Hyp	Learn. Probs.	Psychosom. Probs.
N=56						
NEON p=	.40 (.001)	.24 (.03)	.22 (.05)	.10 (.24)	.16 (.13)	.08 (.28)
NEOE p=	-.31 (.01)	-.27 (.02)	-.22 (.05)	-.21 (.06)	-.17 (.11)	-.20 (.07)
NEOO p=	.17 (.11)	.09 (.26)	.13 (.17)	.02 (.43)	.17 (.10)	-.05 (.36)
NEOA p=	-.23 (.05)	-.35 (.004)	-.26 (.03)	-.25 (.03)	-.15 (.14)	-.21 (.06)
NEOC p=	-.25 (.03)	-.29 (.01)	-.17 (.10)	-.25 (.03)	.01 (.46)	-.17 (.11)

Table 20
Correlations between HEQ and Conners Parent Questionnaire

	Anxiety	CondProbs	Hyper. Index	Imp/Hyp.	Learn. Probs.	Psychosom. Probs.
N=56						
Achievement p=	-.20 (.07)	.05 (.35)	-.01 (.48)	.02 (.43)	.05 (.36)	-.18 (.09)
Aggression-External p=	.47 (.00)	.32 (.01)	.34 (.01)	.31 (.01)	.18 (.09)	.17 (.11)
Aggression-Home p=	.34 (.01)	.47 (.00)	.48 (.00)	.33 (.01)	.34 (.01)	.21 (.06)
Aggression-Total p=	.42 (.001)	.46 (.00)	.47 (.00)	.36 (.003)	.32 (.01)	.21 (.06)
Supervision p=	-.20 (.07)	-.19 (.09)	-.13 (.16)	-.10 (.24)	-.11 (.22)	-.01 (.46)
Change p=	.21 (.06)	.17 (.11)	.24 (.04)	.36 (.003)	.06 (.33)	.14 (.15)
Affiliation p=	-.18 (.09)	-.30 (.01)	-.36 (.003)	-.24 (.04)	-.12 (.18)	-.24 (.04)
Separation p=	.34 (.01)	.09 (.25)	.29 (.01)	.34 (.01)	.05 (.36)	.35 (.15)
Sociability p=	-.04 (.38)	.03 (.41)	-.004 (.49)	-.12 (.20)	.13 (.16)	-.17 (.10)
SocialStatus p=	-.01 (.46)	-.12 (.19)	-.14 (.14)	-.34 (.01)	.17 (.10)	-.17 (.10)

Table 21
Correlations between early and present data

Neonatal tests and the NEO Five Factor Inventory

	NEON	NEOE	NEOO	NEOA	NEOC
Response decrement to light (n=21)	-.02 (p=.47)	-.13 (p=.29)	.52 (p=.01)	.42 (p=.03)	.10 (p=.34)
Response decrement to sound (n=20)	.09 (p=.36)	.07 (p=.38)	-.04 (p=.43)	-.30 (p=.10)	-.13 (p=.29)
Self-quieting (n=22)	.02 (p=.46)	-.28 (p=.10)	-.35 (p=.06)	-.08 (p=.36)	.07 (p=.38)
Irritability (n=31)	-.06 (p=.38)	.02 (p=.47)	-.19 (p=.23)	-.22 (p=.12)	-.14 (p=.23)
Tremors (4 days) (n=31)	.16 (p=.19)	-.07 (p=.35)	.06 (p=.38)	-.07 (p=.35)	-.04 (p=.42)
Startles (4 days) (n=31)	.18 (p=.17)	-.20 (p=.14)	-.05 (p=.40)	.01 (p=.48)	.02 (p=.47)
Tremors (9 days) (n=35)	.11 (p=.26)	.17 (p=.17)	.10 (p=.29)	-.37 (p=.02)	-.28 (p=.05)
Startles (9 days) (n=35)	.18 (p=.16)	.11 (p=.27)	.05 (p=.40)	-.30 (p=.04)	-.07 (p=.34)
Tremors (30 days) (n=36)	.34 (p=.02)	-.18 (p=.16)	.22 (p=.10)	-.41 (p=.01)	.00 (p=.50)
Startles (30 days) (n=36)	.28 (p=.05)	-.13 (p=.23)	.05 (p=.38)	-.50 (p=.001)	.04 (p=.40)

NEON= Neuroticism
 NEOE= Extraversion
 NEOO= Openness

NEOA= Agreeableness
 NEOC= Conscientiousness

- Abel, E. (1973). Suppression of pup retrieving behavior in rats following administration of delta-9-tetrahydrocannabinol. Experientia, 29, 1527-1528.
- Abel, E. (1979). Behavioral teratology of marihuana extract in rats. Neurobehavioral Toxicology, 1, 285-287.
- Abel, E. (1980). Marihuana: The first twelve thousand years. New York; Plenum Press.
- Abel, E. (1981a). Marihuana and sex: A critical survey. Drug and Alcohol Dependence, 8, 1-22.
- Abel, E. (1981b). Behavioral teratology of alcohol. Psychological Bulletin, 90, 564-581.
- Abel, E. (1984). Effects of Δ 9-THC on pregnancy and offspring in rats. Neurobehavioral Toxicology and Teratology, 6, 29-32.
- Abel, E., Bush, R., Dintcheff, B., & Ernst, C. (1981). Critical periods for marihuana-induced intrauterine growth retardation in the rat. Neurobehavioral Toxicology and Teratology, 3, 351-354.
- Abel, E., Day, N., Dintcheff, B., & Ernst, C. (1979). Inhibition of postnatal maternal performance in rats treated with marijuana extract during pregnancy. Bulletin of the Psychonomic Society, 14, 353-354.
- Abel, E., Dintcheff, B., & Day, N. (1980). Effects of marihuana on pregnant rats and their offspring. Psychopharmacology, 71, 71-74.
- Abel, E., & Tan, S. (1987). Effects of delta-9-tetrahydrocannabinol, chlordiazepoxide (Librium), and their combination on pregnancy and offspring in rats. Reproductive Toxicology, 1, 37-40.
- Addiction Research Foundation (1981). Report of an ARF/WHO scientific meeting on adverse health and behavioral consequences of cannabis use, Toronto, Ontario, March 30 April 3, 1981.
- Astley, S., & Little, R. (1990). Maternal marijuana use during lactation and infant development at one year. Neurotoxicology and Teratology, 12, 161-168.
- Aulakh, C., Bhattacharyya, A., Hossain, M., & Pradhan, S. (1980). Behavioral and neurochemical effects of repeated administration of Δ 9-tetrahydrocannabinol in rats. Neuropharmacology, 19, 97-102.
- Bailey, J., Cunny, H., Paule, M., & Slikker, W. (1987). Fetal disposition of Δ 9-tetrahydrocannabinol (THC) during late pregnancy in the rhesus monkey. Toxicology and Applied Pharmacology, 90, 315-321.
- Banerjee, B., Galbreath, C., & Sofia, R. (1975). Teratologic evaluation of synthetic Δ 9-tetrahydrocannabinol in rats. Teratology, 11, 99-102.

- Barnett, G., Chiang, C., & Licko, V. (1983). Effects of marijuana on testosterone in male subjects. Journal of Theoretical Biology, 104, 685-692.
- Bayley, N. (1969). Bayley scales of infant development. New York: Psychological Corporation.
- Beery, K. (1982). Developmental test of visual-motor integration. Cleveland: Modern Curriculum Press.
- Blackard, C., & Tennes, K. (1984). Human placental transfer of cannabinoids. The New England of Medicine, 311, 797.
- Borgen, L., Davis, W., & Pace, H. (1971). Effects of synthetic Δ^9 -tetrahydrocannabinol on pregnancy and offspring in the rat. Toxicology and Applied Pharmacology, 20, 480-486.
- Borgen, L., Davis, W., & Pace, H. (1973). Effects of prenatal Δ^9 -tetrahydrocannabinol on the development of rat offspring. Pharmacology Biochemistry and Behavior, 1, 203-206.
- Bornstein, M., & Sigman, M. (1966). Continuity in mental development from infancy. Child Development, 37, 251-274.
- Bornstein, R. (1983). Construct validity of the Knox cube test as a neuropsychological measure. Journal of Clinical Neuropsychology, 5, 105-114.
- Boyd, M. (1986). Socioeconomic indices and sexual inequality: A tale of scales. Canadian Review of Sociology and Anthropology, 23, 457-480.
- Bradley, R. & Caldwell, B. (1976). The relation of infants' home environments to mental test performance at fifty-four months: A follow-up study. Child Development, 47, 1172-1174.
- Brake, S., Hutchings, D., Morgan, B., Lasalle, E., & Shi, T. (1987). Delta-9-tetrahydrocannabinol during pregnancy in the rat: II. Effects on ontogeny of locomotor activity and nipple attachment in the offspring. Neurotoxicology and Teratology, 9, 45-49.
- Brazelton, T. (1973). Neonatal behavioral assessment scale. London: Wm. Heinemann & Sons.
- Caldwell, B., & Bradley, R. (1979). Home Observation for Measurement of the Environment. Little Rock : University of Arkansas.
- Carakushansky, G., Neu, R., & Gardner, L. (1969). Lysergide and cannabis as possible teratogens in man. The Lancet, i, 150-151.
- Charlebois, A., & Fried, P. (1980). Interactive effects of nutrition and cannabis upon rat perinatal development. Developmental Psychobiology, 13, 591-605.
- Costa, P., & McCrae, R. (1985). The NEO Personality Inventory. Odessa, Florida: Psychological Assessment Resources, Inc.

- Costa, P., & McCrae, R. (1989). The NEO Five Factor Inventory. Odessa, Florida: Psychological Assessment Resources Inc.
- Coyle, I., Wayner, M., & Singer, G. (1976). Behavioral teratogenesis: A critical evaluation. Pharmacology Biochemistry and Behavior, 4, 191-200.
- Cozens, D., Clark, R., Palmer, A., Hardy, N., Nahas, G., & Harvey, D. (1979). The effect of crude marihuana extract on embryonic and foetal development of the rabbit. In G. Nahas & W. Paton (Eds.) Marihuana: Biological effects, (pp. 469-477). Oxford: Pergamon Press.
- Dalterio, S. (1980). Perinatal or adult exposure to cannabinoids alters male reproductive functions in mice. Pharmacology Biochemistry and Behavior, 12, 143-153.
- Dalterio, S., Steger, R., Mayfield, D., & Bartke, A. (1984). Early cannabinoid exposure influences neuroendocrine and reproductive functions in male mice: 1 Prenatal exposure. Pharmacology Biochemistry & Behavior, 20, 107-113.
- deHaas, P. (1986). Attention styles and peer relationships of hyperactive and normal boys and girls. Journal of Abnormal Psychology, 14, 457-467.
- Dreher, M. (1984). Schoolchildren and ganja: Youthful consumption in rural Jamaica. Anthropology and Education Quarterly, 15, 131-150.
- Duffey, J., Ritter, D., & Fedner, M. (1976). Developmental test of visual-motor integration and the Goodenough draw-a-man test as predictors of academic success. Perceptual and Motor Skills, 43, 543-546.
- Fleischman, R., Hayden, D., Rosencrantz, H., & Braude, M. (1975). Teratologic evaluation of Δ^9 -tetrahydrocannabinol in mice, including a review of the literature. Teratology, 12, 47-50.
- Foltin, R., Fischman, M., Pedroso, J., & Pearlson, G. (1987). Marijuana and cocaine interactions in humans: Cardiovascular consequences. Pharmacology Biochemistry & Behavior, 28, 459-464.
- Fried, P. (1976). Short and long-term effects of pre-natal cannabis inhalation upon rat offspring. Psychopharmacology, 50, 285-291.
- Fried, P. (1980). Marihuana use by pregnant women: Neurobehavioral effects in neonates. Drug and Alcohol Dependence, 6, 415-424.
- Fried, P. (1982). Marihuana use by pregnant women and effects on offspring: An update. Neurobehavioral Toxicology and Teratology, 4, 451-454.
- Fried, P., Barnes, M., & Drake, E. (1985). Soft drug use after pregnancy compared to use before and during pregnancy. American Journal of Obstetrics and Gynecology, 151, 787-792.

Fried, P., Buckingham, M., & Von Kulmiz, P. (1983). Marijuana use during pregnancy and perinatal risk factors. American Journal of Obstetrics and Gynecology, 146, 992-994.

Fried, P. & Charlebois, A. (1979). Cannabis administered during pregnancy: First- and second-generation effects in rats. Physiological Psychology, 7, 307-310.

Fried, P., & Makin, J. (1987). Neonatal behavioral correlates of prenatal exposure to marihuana, cigarettes and alcohol in a low risk population. Neurotoxicology and Teratology, 9, 1-7.

Fried, P., & O'Connell, C. (1987). A comparison of the effects of prenatal exposure to tobacco, alcohol, cannabis, and caffeine on birth size and subsequent growth. Neurotoxicology and Teratology, 9, 79-85.

Fried, P., & Watkinson, B. (1988). 12- and 24-month neurobehavioral follow-up of children prenatally exposed to marihuana, cigarettes and alcohol. Neurotoxicology and Teratology, 10, 305-313.

Fried, P., & Watkinson, B. (1990). 36- and 48-month neurobehavioral follow-up of children prenatally exposed to marihuana, cigarettes and alcohol. Journal of Developmental and Behavioral Pediatrics, 11, 49-58.

Fried, P., Watkinson, B., Dillon, R., & Dulberg, C. (1987). Neonatal neurological status in a low-risk population after prenatal exposure to cigarettes, marijuana, and alcohol. Developmental and Behavioral Pediatrics, 8, 318-326.

Fried, P., Watkinson, B., Grant, A., & Knights, R. (1980). Changing patterns of soft drug use prior to and during pregnancy: A prospective study. Drug and Alcohol Dependence, 6, 323-343.

Fried, P., Watkinson, B., & Willan, A. (1984). Marihuana use during pregnancy and decreased length of gestation. American Journal of Obstetrics and Gynecology, 150, 23-27.

Fujimoto, G., Kostellow, A., Rosenbaum, R., Morrill, G., & Bloch, E. (1979). Effects of cannabinoids on reproductive organs in the female Fischer rat. In: G. Nahas & W. Paton (Eds.) Marihuana: Biological effects (pp. 441-447). Oxford: Plenum Press.

Gardner, M. (1982). Test of visual-perceptual skills (nonmotor). Seattle: Special Child Publications.

Geber, W., & Schramm, L. (1969a). Effect of marihuana extract on fetal hamsters and rabbits. Toxicology and Applied Pharmacology, 14, 276-282.

Geber, W., & Schramm, L. (1969b). Teratogenicity of marihuana extract as influenced by plant origin and seasonal variation. Arch. int. Pharmacodyn., 177, 224-230.

Gianutsos, G., & Abbatiello, E. (1972). The effect of prenatal Cannabis sativa on maze learning ability in the rat. Psychopharmacologia, 27, 117-122.

Gibson, G., Baghurst, P., & Colley, D. (1983). Maternal alcohol, tobacco, and cannabis consumption and the outcome of pregnancy. Australian and New Zealand

Journal of Obstetrics and Gynecology, 23, 15-19.

Golden, C. (1978). Stroop color and word test. Chicago: Stoelting Company.

Golub, M., Sassenrath, E., & Chapman, L. (1981a). Regulation of visual attention in offspring of female monkeys treated chronically with Δ^9 -tetrahydrocannabinol. Developmental Psychobiology, 14, 507-512.

Golub, M., Sassenrath, E., & Chapman, L. (1981b). Mother infant interaction in Rhesus monkeys treated chronically with delta-9-tetrahydrocannabinol. Child Development, 52, 389-392.

Golub, M., Sassenrath, E., & Chapman, L. (1982). An analysis of altered attention in monkeys exposed to delta-9-tetrahydrocannabinol during development. Neurobehavioral Toxicology and Teratology, 4, 469-472.

Goodine, L., & Fried, P. (1984). Infant feeding practices: Pre- and postnatal factors affecting choice of method and the duration of breastfeeding. Canadian Journal of Public Health, 75, 439-444.

Goyette, C., Conners, C., & Ulrich, R. (1978). Normative data on revised Conners parent and teacher rating scales. Journal of Abnormal Child Psychology, 6, 221-236.

Green, K., Sobel, R., Fineberg, E., Wynn, H., & Bowman, K. (1981). Subchronic and systemic toxicity of topically applied Δ^9 -tetrahydrocannabinol. Annals of Ophthalmology, 13, 422-429, 1974.

Greenland, S., Richwald, G., & Honda, G. (1983). The effects of marijuana use during pregnancy. II. A study in a lowrisk population. Drug and Alcohol Dependence, 11, 359-366.

Greenland, S., Staisch, K., Brown, N., & Gross, S. (1982). The effects of marijuana use during pregnancy I. A preliminary epidemiologic study. American Journal of Obstetrics and Gynecology, 143, 408-413.

Haley, S., Wright, P., Plank, J., Keplinger, M., Braude, M., & Calandra, J. (1973). The effect of natural and synthetic delta-9-tetrahydrocannabinol on fetal development. Toxicology and Applied Pharmacology, 25, 450 (abstract # 29).

Halikas, J., Weller, R. Morse, C., & Hoffman, R. (1983). Regular marijuana use and its effect on psychosocial variables: A longitudinal study. Comprehensive Psychiatry, 24, 229-235.

Harbison, R., & Mantilla-Plata, B. (1972). Prenatal toxicity, maternal distribution and placental transfer of tetrahydrocannabinol. The Journal of Pharmacology and Experimental Therapeutics, 180, 446-453.

Harclerode, J., Nyquist, S., Nazar, B., & Lowe, D. (1979). Effects of cannabis on sex hormones and testicular enzymes of the rodent. In: G. Nahas & W. Paton (Eds.) Marihuana: Biological effects (pp. 395-405). Oxford: Pergamon Press.

- Harris, D. (1963). Children's drawings as measures of intellectual maturity. New York: Harcourt, Brace & World Inc.
- Hatch, E., & Bracken, M. (1986). Effect of marijuana use in pregnancy on fetal growth. American Journal of Epidemiology, 124, 986-993.
- Hayes, J., Dreher, M., & Nugent, K. (1988). Newborn outcomes with maternal marihuana use in Jamaican women. Pediatric Nursing, 14, 107-110.
- Health and Welfare, Canada (1975). Dietary Standard for Canada.
- Health and Welfare Canada (1988). Canada's health promotion survey: Technical report. I. Rootman, R Warren, T. Stephens, & L. Peters (Eds.). Ottawa: Minister of Supply and Services Canada.
- Hecht, F., Beals, R., Lees, M., Jolly, H., & Roberts, P. (1968). Lysergic acid diethylamide and cannabis as possible teratogens in man. The Lancet, ii, 1087.
- Hembree, W., Nahas, G., Zeidenberg, P., & Huang, H. (1979). Changes in human spermatozoa associated with high dose marihuana smoking. In: G. Nahas & W. Paton (Eds.) Marihuana: Biological effects (pp. 429-439). Oxford: Pergamon Press.
- Hingson, R., Alpert, J., Day, N., Dooling, E., Kayne, H., Morelock, S., Oppenheimer, E., & Zuckerman, B (1982). Effects of maternal drinking and marijuana use on fetal growth and development. Pediatrics, 70, 539-546.
- Hingson, R., Zuckerman, B., Amaro, H., Frank, D., Kayne, H., Sorenson, J., Mitchell, J., Parker, S., Morelock, S., & Timperi, R. (1986). Maternal marijuana use and neonatal outcome: Uncertainty posed by self-reports. American Journal of Public Health, 76, 667-669.
- Huang, H., Nahas, G., & Hembree, W. (1979). Effects of marihuana inhalation on spermatogenesis of the rat. In: G. Nahas & W. Paton (Eds.) Marihuana: Biological effects (pp. 419-427). Oxford: Pergamon Press.
- Hutchings, D. (1989). Marijuana use during pregnancy. Effects on growth and development. talk given at Carleton University, January 18, 1989.
- Hutchings, D., Morgan, B., Brake, S., Shi, T., & Lasalle, E. (1987). Delta-9-tetrahydrocannabinol during pregnancy in the rat: I. Differential effects on maternal nutrition, embryotoxicity, and growth in the offspring. Neurotoxicology and Teratology, 9, 39-43.
- Idänpään-Heikkilä, J., Fritchie, G., Englert, L., Ho, B., & McIsaac, W. (1969). Placental transfer of tritiated-1- Δ^9 tetrahydrocannabinol. The New England Journal of Medicine, 281, 330.
- Jastak, S., & Wilkinson, G. (1984). The Wide Range Achievement Test-Revised. Wilmington, Delaware: Jastak Associates, Inc.
- Johnson, H., Diano, A., & Rosen, T. (1984). 24-month neurobehavioral follow-up of children of methadone-maintained mothers. Infant Behavior and Development, 7, 115-123.

- Joneja, M. (1976). A study of teratological effects of intravenous, subcutaneous and intragastric exposure to Δ^9 -tetrahydrocannabinol in mice. Toxicology and Applied Pharmacology, 36, 151-162.
- Kaufman, A. (1979). Intelligent testing with the WISC-R. New York: John Wiley & Sons.
- Kawash, G., Yeung, D., & Berg, S. (1980). Effects of administration of cannabis resin during pregnancy on emotionality and learning in rats' offspring. Perceptual and Motor Skills, 50, 359-365.
- Kennedy, J., & Waddell, W. (1972). Whole-body autoradiography of the pregnant mouse after administration of ^{14}C - Δ^9 -THC. Toxicology and Applied Pharmacology, 22, 252-258.
- Kerlinger, F., & Pedhazur, E. (1973). Multiple regression in behavioral research. New York : Holt, Rhinehart & Winston Inc.
- Klein, A. (1978). The validity of the Beery test of visual motor integration in predicting achievement in kindergarten, first, and second grades. Educational and Psychological Measurement, 38, 457-461.
- Kline, J., Stein, Z., & Hutzler, M. (1987). Cigarettes, alcohol and marijuana: Varying associations with birthweight. International Journal of Epidemiology, 16, 44-51.
- Knights, R., & Moule, A. (1967). Normative and reliability data on finger and foot tapping in children. Perceptual and Motor Skills, 25, 717-720.
- Knights, R., & Norwood, J. (1980). A neuropsychological test battery for children: Examiner's manual. Ottawa: Psychological Consultants.
- Kops, C. & Belmont, I. (1985). Planning and organizational skills of poor school achievers. Journal of Learning Disabilities, 18, 8-14.
- Law, B., Mason, P., Moffat, A., King, L., & Marks, V. (1984). Passive inhalation of cannabis smoke. Journal of Pharmacy and Pharmacology, 36, 578-581.
- Lester, B. & Dreher, M. (1989). Effects of marijuana use during pregnancy on newborn cry. Child Development, 60, 765-771.
- Lezak, M. (1983). Neuropsychological assessment (2nd. ed.). New York:Oxford University Press.
- Linn, S., Schoenbaum, S., Monson, R., Rosner, R., Stubblefield, P., & Ryan, K. (1983). The association of marijuana use with outcome of pregnancy. American Journal of Public Health, 73, 1161-1164.
- Ludwig, R., & Lazarus, P. (1983). Relationship between shyness in children and constricted cognitive control as measured by the Stroop color-word test. Journal of Consulting and Clinical Psychology, 5, 386-389.

- Lytton, H. (1982). Two-way influence processes between parents and child. Canadian Journal of Behavioral Science, 14, 259-275.
- Mantilla-Plata, B., Clewe, G., & Harbison, R. (1973). Teratogenic and mutagenic studies of Δ^9 -tetrahydrocannabinol in mice. Federation Proceedings, 32, 746 (abstract # 2995).
- Mantilla-Plata, B., Clewe, G., & Harbison, R., (1975). Δ^9 -tetrahydrocannabinol-induced changes in prenatal growth and development in mice. Toxicology and Applied Pharmacology, 33, 333-340.
- Matuszek, P. (1985). Review of Wide Range Achievement Test. In: J. Mitchell Jr. (Ed.) The ninth mental measurements yearbook. Lincoln, Nebraska: Buros Institute of Mental Measurements.
- McCarthy, P. (1972). McCarthy Scales of Children's Abilities. New York: The Psychological Corporation.
- McGahan, J., Dublin, A., & Sassenrath, E. (1984). Long-term delta-9-tetrahydrocannabinol treatment - Computed tomography of the brains of rhesus monkeys. AJDC, 138, 1109-1112, 1984.
- Mednick, B., & Michelsen, N. (1977). Neurological and motor functioning of 10-12 year old children who showed mild transient neurological symptoms in the first five days of life. Acta Neurologica Scandinavica, 56, 70-78.
- Miller, L., & Branconnier, R. (1983). Cannabis: Effects on memory and the cholinergic limbic system. Psychological Bulletin, 93, 141-156.
- Murphy, S. (1988). Effects of in utero exposure to alcohol, nicotine, and marijuana on the human figure drawings of four-year old children. Unpublished Honors Thesis, Carleton University, Ottawa.
- Nahas, G. (1979). Introduction marihuana and the cell. In: G. Nahas & W. Paton (Eds.) Marihuana: Biological effects (pp. xv-xix). Oxford: Pergamon Press.
- Newcomer, P., & Hammill, D. (1982). Test of language development - Primary. Austin Texas: Pro-ed.
- O'Connell, C., & Fried, P. (1984). An investigation of prenatal cannabis exposure and minor physical anomalies in a low risk population. Neurobehavioral Toxicology and Teratology, 6, 345-350.
- Pace, H., Davis, W., & Borgen, L. (1971). Teratogenesis and marijuana. Annals of the New York Academy of Sciences, 191, 123-131.
- Pedhazur, E. (1982). Multiple regression in behavioral research 2nd. ed. New York: CBS College Publishing.
- Persaud, T., & L. H. A. (1967). Cannabis in early pregnancy. The Lancet, ii, 1306.

Persaud, T., & Ellington (1968). Teratogenic activity of cannabis resin. The Lancet, ii, 406-407.

Prechtl, H. (1977). The neurological examination of the full-term newborn infant, 2nd edition. Clinics in Developmental Medicine, no. 63. Philadelphia: Lippincott.

Qazi, Q., Mariano, E., Beller, E., Milman, D., Crombleholme, W., & Buendia, M. (1983). Abnormalities in offspring associated with prenatal marihuana exposure. Pediatric Research, 17, 153A (abstract # 401).

Raven, J., Court, J., & Raven, J. (1983). Manual for Raven's progressive matrices and vocabulary scales. London: H. K. Lewis & Co.

Reitan, R. (1971). Trail making test results for normal and brain-damaged children. Perceptual and Motor Skills, 33, 575-581.

Reynell, J. (1969). Reynell developmental language scales. Windsor, Berkshire: NFER.

Rosencrantz, H. (1979). Effects of cannabis on fetal development of rodents. In: G. Nahas & W. Paton (Eds.) Marihuana: Biological effects (pp. 479-499). Oxford: Pergamon Press.

Rosencrantz, H., Fleischman, R., & Grant, R. (1981). Toxicity of short-term administration of cannabinoids to rhesus monkeys. Toxicology and Applied Pharmacology, 58, 118-131.

Rosett, H., Weiner, L., Lee, A., Zuckerman, B., Dooling, E., & Oppenheimer, E. (1983). Patterns of alcohol consumption and fetal development. Obstetrics and Gynecology, 61, 539-546.

Sameroff, A., & Chandler, M. (1975). Reproductive risk and the continuum of caretaking casualty. In: Horowitz, F., Hetherington, E., Scarr-Salaptek, S., Siegal, G. (Eds.) Review of Child Developmental Research, 4, Chicago: University of Chicago Press.

Sampson, P., Streissguth, A. Barr, H. & Bookstein, F. (1986). Application of partial least squares methodology to the behavioral teratology of alcohol. Technical Report #94. Seattle, Washington: Department of Statistics, University of Washington.

Scher, M., Richardson, G., Coble, P., Day, & Stoffer, D. (1988). The effects of prenatal alcohol and marijuana exposure: Disturbances in neonatal sleep cycling and arousal. Pediatric Research, 24, 101-105.

Schildkraut, J., & Efron, D. (1971). The effects of Δ^9 tetrahydrocannabinol on the metabolism of norepinephrine in the rat brain. Psychopharmacologia, 20, 191-196.

Schwartz, R. (1984). Marijuana: A crude drug with a spectrum of underappreciated toxicity. Pediatrics, 73, 455-458.

Shipley, W. (1975). Test review. In: O. Buros (Ed.) Intelligence tests and reviews (p. 289). New Jersey: The Gryphon Press.

Siegel, P., Siegel, M., Krimmer, E., Doyle, W., & Barry, H. (1977). Fluctuating dental asymmetry as an indicator of the stressful prenatal effects of $\Delta 9$ -tetrahydrocannabinol in the laboratory rat. Toxicology and Applied Pharmacology, **42**, 339-344.

Sines, J. (1983). The home environment questionnaire. Iowa City: Psychological Assessment and Services.

Smith, C., Almirez, R., Berenberg, J. & Asch, R. (1983). Tolerance develops to the disruptive effects of $\Delta 9$ -tetrahydrocannabinol on primate menstrual cycle. Science, **219**, 1453-1545.

Snyder, R. (1971). Congenital mercury poisoning. The New England Journal of Medicine, **284**, 1014-1016.

Sofia, R., Strasbaugh, J., & Banerjee, B. (1979). Teratologic evaluation of synthetic $\Delta 9$ -tetrahydrocannabinol in rabbits. Teratology, **19**, 361-366.

Statistics Canada (1988). Census divisions & subdivisions, Ontario: Part II, Profile Series, catalogue #94-112. Ottawa: Statistics Canada.

Stone, M., & Wright, B. (1983). Measuring attending behavior and short-term memory with Knox's cube test. Educational and Psychological Measurement, **43**, 803-814.

Strauss, M., & Wright, B. (1983). Measuring attending behavior and short-term memory with Knox's cube test. Educational and Psychological Measurement, **43**, 803-814.

Streissguth, A. (1986). Smoking and drinking during pregnancy and offspring learning disabilities: A review of the literature and development of a research strategy. In: M. Lewis (Ed.) Learning disabilities and prenatal risk. Chicago: University of Illinois Press, pp. 28-67.

Streissguth, A., Martin, D., Barr, H., Sandman, B., Kirchner, G., & Darby, B. (1984). Intrauterine alcohol and nicotine exposure: Attention and reaction time in 4-year-old children. Developmental Psychology, **20**, 533-541.

Tabachnick, B., & Fidell, L. (1983). Using multivariate statistics. New York: Harper & Row.

Tennes, K., Avitable, N., Blackard, C., Boyles, C., Hassoun, B., Holmes, L., & Kreye, M. (1985). Marijuana: Prenatal and postnatal exposure in the human. In: T. Pinkert (Ed.) Current research on the consequences of maternal drug use (pp. 48-60). Washington: U.S. Government Printing Office.

Tennes, K., & Blackard, C. (1980). Maternal alcohol consumption, birthweight, and minor physical anomalies. American Journal of Obstetrics and Gynecology, **138**, 774-780.

Thomas, A., and Chess, S. (1977). Temperament and development. New York: Brunner/Mazel.

- Thomas, R. (1975). The toxicologic and teratologic effects of Δ^9 -tetrahydrocannabinol in the zebrafish embryo. Toxicology and Applied Pharmacology, 32, 184-190.
- Uyeno, E. (1973). Δ^9 -tetrahydrocannabinol administration during pregnancy of the rat. Proc. West. Pharmacol. Soc., 16, 64-67.
- Vardaris, R., Weisz, D., Fazel, A., & Rawitch, A. (1976). Chronic administration of delta-9-tetrahydrocannabinol to pregnant rats: Studies of pup behavior and placental transfer. Pharmacology Biochemistry & Behavior, 4, 249-254.
- Wall, M., Sadler, B., Brine, D., Taylor, H., & Perez-Reyes, M. (1983). Metabolism, disposition, and kinetics of delta-9-tetrahydrocannabinol in men and women. Clinical Pharmacology and Therapeutics, 34, 352-363.
- Wechsler, D. (1974). Wechsler intelligence scale for children - Revised. New York: The Psychological Corporation.
- Woodcock, R. (1987). Woodcock Reading Mastery Tests-Revised. Circle Pines, Minnesota: American Guidance Service.
- Wright, P., Smith, S., Keplinger, M., Calandra, J., & Braude, M. (1976). Reproductive and teratologic studies with Δ^9 -tetrahydrocannabinol and crude marijuana extract. Toxicology and Applied Pharmacology, 38, 223-235.
- Wu, T., Tashkin, D., Djahed, B., & Rose, J. (1988). Pulmonary hazards of smoking marijuana as compared with tobacco. The New England Journal of Medicine, 318, 347-351.
- Zimmerman, A., Zimmerman, S., & Raj, A. (1979). Effects of cannabinoids on spermatogenesis in mice. In: G. Nahas & W. Paton (Eds.) Marihuana: Biological effects (pp. 407-418). Oxford: Pergamon Press.
- Zimmerman, M. (1981). The home observation for measurement of the environment: A comment on Elardo and Bradley's review. Developmental Review, 1, 301-313.
- Zuckerman, B., Frank, D., Hingson, R., Amaro, H., Levenson, S., Kayne, H., Parker, S., Vinci, R., Aboagye, K., Fried, L., Cabral, H., Timperi, R., & Bauchner, H. (1989). Effects of maternal marijuana and cocaine use on fetal growth. The New England Journal of Medicine, 320, 762-768.

Appendix A

Comparison of "new recruits" with longtime participants of the Ottawa Prenatal Prospective Study

**Comparison of "new recruits" with longtime participants of the
Ottawa Prenatal Prospective Study**

MARUSE = 1 Cannabis users

	New Recruits (n=4)	Longtime Subjects (n=24)	p
Mother's age at child's birth $\bar{x}$, sd	22.7 (4.3)	26.0 (4.5)	.20
Mother's educational level, $\bar{x}$	3.0	3.7	.43
Father's educational level, $\bar{x}$	1.5	4.1	.03
Mother's Raven score, $\bar{x}$ %ile	72.5 (33.0)	80.4 (21.4)	.53
Mother's NEOscores, $\bar{x}$ (sd)			
NEON	60.3 (10.4)	51.2 (8.2)	.06
NEOE	48.7 (15.7)	50.4 (13.7)	.83
NEOO	53.5 (9.7)	53.8 (8.9)	.95
NEOA	53.7 (10.0)	50.2 (15.0)	.66
NEOC	43.2 (5.1)	45.7 (11.4)	.68
Highest occupational status of parents, $\bar{x}$	43.87	55.01	.16
Income level, $\bar{x}$	4.7	7.2	.04
# of 2 salary households	3	11	.59
% 1 parent households	25%	29%	1.0
# of children in family $\bar{x}$	1.3	2.6	.0002
Birth order $\bar{x}$ (sd)	1.0 (.00)	1.5 (.72)	.15
Sex ratio M:F	3:1	14:10	
Language of Home Eng:Eng + other	4:0	22:2	1.0

Appendix A (continued)

	New Recruits (n=4)	Longtime Subjects (n=24)	p
Language of Instruction Eng/Fre/Bil	1/3/0	13/10/1	
Having problems in school n (%)	3 (75)	7 (29)	.23
Needed visual correction	0	1	1.0
Subject to eye or ear infections	1	4	1.0
Age in months, $\bar{x}$	81.8	94.4	.15
Home Environment Scales $\bar{x}$ (sd)			
Achievement	34.8 (0.5)	46.5 (8.9)	.02
Aggression-External	66.5 (13.3)	53.0 (10.1)	.03
Aggression-Home	56.5 (13.2)	52.3 (10.3)	.47
Aggression-Total	63.3 (14.0)	53.3 (11.9)	.14
Supervision	40.3 (7.0)	40.3 (9.6)	.27
Change	62.3 (15.1)	53.5 (7.1)	.07
Affiliation	49.8 (5.0)	52.9 (7.8)	.44
Separation	51.5 (11.9)	51.8 (12.5)	.96
Sociability	55.3 (8.7)	53.1 (10.9)	.71
Social Status	36.8 (19.3)	54.4 (10.9)	.01
Test Results			
Full Scale I.Q.	123.0 (10.2)	119.1 (10.8)	.50
Verbal I.Q.	121.5 (15.5)	117.2 (14.3)	.59
Performance I.Q.	119.3 (3.5)	117.3 (9.3)	.69
Verbal Comprehension	13.4 (1.4)	12.8 (2.0)	.58
Perceptual Organization	12.8 (.24)	12.8 (1.4)	.93
Freedom from Distractibility	11.7 (.83)	11.6 (1.9)	.93
Syntax Quotient	102.5 (3.0)	107.2 (11.1)	.41
Passage Comprehension	110.5 (23.1)	94.9 (15.9)	.10
WRAT-Reading	114.0 (15.8)	96.3 (13.5)	.03
WRAT-Spelling	96.5 (12.4)	91.5 (15.5)	.54
WRAT-Arithmetic	98.2 (7.9)	98.7 (9.2)	.92
Stroop Interference	50.3 (2.6)	53.3 (3.7)	.13
Knox Cube	8.5 (8.7)	9.5 (6.5)	.79
Visual Discrimination	16.0 (2.6)	15.0 (3.3)	.59
Visual Memory	13.5 (3.0)	13.3 (2.8)	.89
Visual Spatial Relations	13.3 (3.9)	13.9 (3.6)	.68

Appendix A (continued)

	New Recruits (n=4)	Longtime Subjects (n=24)	p
Visual Form Constancy	11.3 (1.7)	13.2 (3.6)	.31
Visual Sequential Memory	12.8 (3.5)	13.1 (2.6)	.82
Visual Figure Ground	10.0 (4.2)	15.5 (4.0)	.02
Visual Closure	11.3 (4.4)	13.1 (4.3)	.43
Perceptual Quotient	119.0 (4.5)	128.2 (13.9)	.21
Trails-A	1.7 (.57)	1.1 (.65)	.12
Draw-A-Man	101.5 (11.9)	102.5 (13.0)	.91
Beery VMI	6.5 (1.3)	9.9 (2.6)	.02
Finger Tapping Dominant Hand	-.05 (2.0)	.23 (.98)	.65
Finger Tapping NonDominant Hand	-.24 (1.6)	-.02 (2.1)	.85
Conners Rating Scales			
Anxiety	.29 (.23)	.27 (.70)	.94
Conduct Problems	.43 (1.3)	.51 (1.3)	.91
Hyperactivity Index	.69 (1.8)	.47 (1.2)	.76
Impulsivity-Hyperactivity	.86 (1.7)	.45 (1.4)	.60
Learning Problems	.38 (1.8)	.45 (1.3)	.93
Psychosomatic Problems	.23 (.73)	.36 (1.2)	.83

Appendix A (continued)
MARUSE = 0
(controls)

	New Recruits (n=2)	Longtime Subjects (n=26)	p
Mother's age at child's birth $\bar{x}$ (sd)	22.0 (1.4)	30.0 (4.2)	.01
Mother's educational level, $\bar{x}$	5.0	4.6	.77
Father's educational level, $\bar{x}$	3.0	5.2	.07
Mother's Raven score $\bar{x}$ (sd)	95.0 (0)	83.5 (16.4)	
Mother's NEO scores $\bar{x}$ (sd)			
NEON	43.5 (4.9)	48.5 (9.9)	.49
NEOE	58.5 (3.5)	54.5 (10.7)	.61
NEOO	62.0 (8.5)	51.1 (10.1)	.15
NEOA	60.5 (9.2)	60.1 (14.0)	.97
NEOC	50.0 (11.3)	55.6 (8.8)	.39
Highest occupational status of parents, $\bar{x}$	47.0	61.2	.09
Income level, $\bar{x}$	8.0	9.8	.16
# of 2 salary households	1	22	.78
% 1 parent households	0	7.7	1.0
# of children in family, $\bar{x}$	2.0	2.4	.56
Birth order $\bar{x}$ (sd)	1.0 (0)	1.9 (.8)	.14
Sex ratio M:F	1:1	15:11	
Language of Home Eng:Eng + other	2.0	22.4	1.0
Language of Instruction Eng/Fre/Bil.	1/1/0	12/12/2	n.s
Having problems in school n (%)	0 (0)	5 (19)	1.0

Appendix A (continued)
MARUSE = 0
(controls)

	New Recruits (n=2)	Longtime Subjects (n=26)	p
Needed visual correction	0	2	n.s.
Subject to eye or ear infections	0	23	1.0
Age in months, $\bar{x}$	74.5	105.8	.005
Home Environment Scales, $\bar{x}$ (sd)			
Achievement	41.0 (0)	49.4 (10.8)	.29
Aggression-External	52.0 (12.7)	48.2 (7.6)	.52
Aggression-Home	42.5 (4.9)	45.4 (10.1)	.70
Aggression-Total	45.5 (2.1)	45.7 (10.5)	.98
Supervision	44.5 (16.2)	51.8 (10.3)	.36
Change	51.0 (2.8)	49.8 (7.6)	.84
Affiliation	59.0 (0)	55.5 (9.8)	.62
Separation	45.0 (0)	51.7 (8.2)	.27
Sociability	54.0 (0)	54.6 (9.5)	.93
Social Status	57.0 (1.4)	58.8 (8.6)	.77
<u>Test Results</u>			
Full Scale I.Q.	112.0 (7.1)	124.6 (12.8)	.19
Verbal I.Q.	112.5 (2.1)	120.8 (12.1)	.35
Performance I.Q.	108.5 (9.2)	123.1 (15.8)	.22
Verbal Comprehension	13.3 (1.4)	13.7 (2.0)	.80
Perceptual Organization	10.8 (2.5)	13.8 (2.3)	.09
Freedom from Distractibility	10.2 (2.6)	11.7 (2.2)	.35
Syntax Quotient	115.0 (5.7)	110.9 (11.8)	.64
Passage Comprehension	76.0 (0)	107.3 (10.7)	.001
WRAT-Reading	93.0 (2.8)	105.0 (15.0)	.28
WRAT-Spelling	89.5 (21.9)	97.0 (15.5)	.52
WRAT-Arithmetic	95.0 (7.1)	97.7 (15.5)	.81
Stroop Interference	61.0 (9.9)	54.5 (4.7)	.09
Knox Cube	12.0 (0)	9.0 (6.2)	
Visual Discrimination	17.0 (2.8)	16.7 (3.0)	.88
Visual Memory	16.0 (2.8)	14.8 (3.3)	.61
Visual Spatial Relations	9.0 (1.4)	15.2 (3.1)	.01
Visual Form Constancy	14.5 (.71)	13.4 (3.6)	.67
Visual Sequential Memory	17.5 (.71)	14.1 (3.6)	.19
Visual Figure Ground	8.0 (2.8)	16.5 (2.5)	.0001

Appendix A (continued)
MARUSE = 0
(controls)

	New Recruits (n=2)	Longtime Subjects (n=26)	p
Visual Closure	10.0 (1.4)	14.8 (4.3)	.14
Perceptual Quotient	123.0 (2.8)	136.0 (15.5)	.24
Trails-A	1.84 (.06)	.93 (.57)	.04
Draw-A-Man	85.5 (.71)	106.9 (12.4)	.03
Finger Tapping Dominant Hand	.17 (2.1)	.12 (.64)	.94
Finger Tapping NonDominant Hand	-1.2 (1.9)	-.06 (.85)	.10
Conners Rating Scales			
Anxiety	.37 (.14)	.06 (.59)	.47
Conduct Problems	-.06 (1.4)	-.39 (.68)	.53
Hyperactivity Index	.20 (1.8)	-.39 (.84)	.39
Impulsivity-Hyperactivity	.54 (2.4)	-.25 (.82)	.26
Learning Problems	.24 (.78)	-.23 (1.2)	.59
Psychosomatic Problems	-.64 (.09)	-.05 (.6)	.18

Appendix B

Correlations between MARUSE and dependent variables

Appendix B

Correlations between MARUSE and dependent variables

	FSIQ	VIQ	PIQ	VERBCOMP
MARUSE p=	-.17 (.10)	-.09 (.25)	-.17 (.10)	-.19 (.08)
	PERCPORG	FREEDIST	PERCQUOT	VISMEM
MARUSE p=	-.20 (.07)	-.001 (.50)	-.29 (.02)	-.25 (.03)
	VISFIGRD	VISPATRL	VISFORCN	WISEQMEM
MARUSE p=	-.16 (.12)	-.15 (.14)	-.08 (.27)	-.20 (.07)
	VISDISCR	VISCLOS	KNOXSS	STROOP
MARUSE p=	-.24 (.04)	-.19 (.08)	.01 (.47)	-.23 (.04)
	PASSCOMP	WRATREAD	WRATSPEL	WRATARIT
MARUSE p=	-.25 (.03)	-.18 (.09)	-.14 (.15)	.05 (.36)
	SYNTAXQT	VMI	DRAWAMAN	TRAILSA
MARUSE p=	-.21 (.06)	-.22 (.05)	-.13 (.18)	.18 (.09)
	DOMTAP	NDOMTAP	CONDPROB	ANXIETY
MARUSE p=	.03 (.40)	.03 (.42)	.39 (.001)	.17 (.12)
	HYPERACT	IMPHYP	LERNPROB	PSYCHSOM
MARUSE p=	.37 (.003)	.29 (.02)	.25 (.03)	.23 (.04)

Appendix B

Correlations between MARUSE and dependent variables

Abbreviations:

FSIQ = Full Scale I.Q. of WISC-R

VIQ = Verbal I.Q. of WISC-R

PIQ = Performance I.Q. of WISC-R

VERBCOMP = Verbal Comprehension Factor of WISC-R

PERCPORG = Perceptual Organization Factor of WISC-R

FREEDIST = Freedom from Distractibility Factor of WISC-R

PERCQUOT = Perceptual Quotient of Test of Visual Perceptual Skills

VISMEM = Visual Memory of TVPS

VISFIGRD = Visual Figure Ground of TVPS

VISPATRL = Visual Spatial Relations of TVPS

VISFORCN = Visual Form Constancy of TVPS

WISEQMEM = Visual Sequential Memory of TVPS

VISDISCR = Visual Discrimination of TVPS

VISCLOS = Visual Closure of TVPS

KNOXSS = Knox Cube Standard Score

STROOP = Stroop Interference Score

PASSCOMP = Passage Comprehension subtest of Woodcock Reading Mastery Test

WRATREAD = Reading subtest of Wide Range Achievement Test

WRATSPEL = Spelling subtest of WRAT

WRATARIT = Arithmetic subtest of WRAT

SYNTAXQT = Syntax Quotient of the Test of Language Development-Primary

VMI = Beery Test of Visual-Motor Integration

DRAWAMAN = Draw-A-Man Test

TRAILSA = Trail Making Test, Part A

DOMTAP = Finger Tapping Dominant Hand

NDOMTAP = Finger Tapping Non-Dominant Hand

CONDPROB = Conduct Problems of Conners Rating Scale

ANXIETY = Anxiety Problems of Conners Rating Scale

HYPERACT = Hyperactivity Index Problems of Conners Rating Scale

IMPHYP = Impulsivity-Hyperactivity Problems of Conners Rating Scale

LERNPROB = Learning Problems

PSYCHSOM = Psychosomatic Problems

Appendix C
Case Reports

Case Reports

Brazelton scoring:

Habituate to light
Habituate to sound

1 = no habituation over ten trials
-
-
-
9 = ceases responding in one or two trials

Self-quiet (missing)

= didn't require self-quieting
1 = cannot quiet self
-
-
-
9 = consistently quiets self for sustained periods

Tremors

9 = tremulousness seen consistently in all states
-
-
-
1 = no tremors

Startles

9 = 11 or more startles including Moro
-
-
-
1 = no startles

Orientation
(to inanimate object)

1 = doesn't focus on object
-
-
-
9 = follows object smoothly repeatedly focuses

Prechtl scoring:

Hand to mouth = average # of hand to mouth episodes per assessment

Tremor = **1= absent** **(score given is categories averaged over**
 2=rare **three observation periods during test)**
 3=marked

Startles = average # over three observation periods during test

Knee Resistance = 1=none
 2=weak
 3=moderate
 4=strong
 5=abnormal
 -=(missing data)

Moro Tremor 1=absent
 2=rare
 3=marked

Strabismus 1=absent
(inturning of 2=inconsistent
the eye) 3=consistent

Optical blink 1=absent
 2=weak
 3=full & repeatable

Optical blink habituation = # times the response is elicited
before habituation

Forearm Recoil = 1=none
 2=weak to 45 degrees
 3= marked full flex
 4= rapid forceful
 - (missing data)

Babinski = 1=absent
 2=weak, some tone
 3=good, marked tone
 4=abnormal

MDI = Mental Development Index of Bayley Scales of Infant
Development ($\bar{x}$ =100, SD=15)

PDI = Psychomotor Development Index of Bayley Scales of Infant
Development ($\bar{x}$ =100, SD=15)

GCI = General Cognitive Index of McCarthy Scales of Children,s
Abilities ($\bar{x}$ =100, SD=16)

Peabody = Peabody Picture Vocabulary Test Standard Score ($\bar{x}$ =100, SD=15)

Reynell = Reynell Developmental Language Scales ($\bar{x}$ =0, SD=1)

x-----x = Expressive Language Score
o-----o = Language Comprehension Score

HOME Test = Home Observation for Measurement of the Environment
($\bar{x}$ =5, SD=2)

Conners Ratings = Conners Parent Questionnaire ($\bar{x}$ =0, SD=1)

Means for MARUSE = 0 on infant and preschool tests

Brazelton Test (4 days of age)

Response decrement to light: 5.73

Response decrement to sound: 7.0

Self-quieting: 4.23

Tremors: 5.87

Startles: 3.33

Orientation: 5.57

Prechtl Test (9 days of age)

Hand to mouth: 0.36

Tremor: 1.79

Startle: 0.21

Knee resistance: 3.27

Moro tremor: 1.69

Strabismus: 1.25

Optical blink: 2.13

Optical blink habituation: 3.94

Prechtl Test (30 days of age)

Hand to mouth: 0.13

Tremor: 1.94

Startle: 0.00

Knee resistance: 3.48

Moro tremor: 2.12

Strabismus: 1.13

Optical blink: 2.19

Optical blink habituation: 3.56

Forearm recoil: 3.0

Babinski: 2.5

12 month MDI: 103.65

12 month PDI: 88.95

24 month MDI: 117.00

24 month expressive language: 0.41

24 month PDI: 106.33

24 month language comprehension: 1.02

36 month GCI: 116.14

36 month expressive language: 0.33

36 month language comprehension: 1.19

48 month GCI: 126.65

48 month expressive language: 0.82

48 month language comprehension: 1.43

60 month GCI: 125.26

60 month expressive language: 0.91

60 month language comprehension: 1.15

48 month Peabody Picture Vocabulary Test (PPVT): 114.60

60 month PPVT: 119.05

HOME Test:

Emotional Responsivity of Mother: 7.48

Avoidance of punishment: 6.90

Organization of the Environment: 6.62

Provision of Appropriate Play Materials: 7.00

Maternal Involvement with Child: 6.95

Opportunity for Variety in Daily Routine: 7.00

Total HOME: 7.95

Conners Parent Questionnaire:

Anxiety: 0.08

Conduct Problems: -0.37

Hyperactivity Index: -0.34

Impulsivity-Hyperactivity: -0.20

Learning Problems: -0.19

Psychosomatic Problems: -0.09

ID Number 783
 MARTOT 19 jts/wk
 ALCTOT .25 oz. aa/day
 NICTOT 2.4 mg/day

Brazelton-4 Day

Response To Light	Habituate To Light	Response To Sound	Habituate To Sound	Self Quiet	Tremors	Startles	Orientation
yes	5	yes	8	-	7	5	3

Prechtl - 9 Day

Prechtl - 30 Day

Hand to Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Hand to Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Forearm Recoil	Babinski
.17	2.67	1.67	3	3	3	3	8	.83	2.0	.00	3	3	2	3	8	3	3

Age = 83 Months

Quot. Quot. Comp.

I.D. #783

D.Q. is a six year old girl born to a woman who was a heavy user of cannabis, a moderate drinker and a light smoker. She was born at 41 weeks gestation after a rapid (two hour) labor and weighed 3660 grams. The umbilical cord was wrapped around the child's neck and she required suctioning to clear airways. Apgar scores were normal (8 and 9). At the four day testing she exhibited tremors and startles which were still apparent at nine days of age. Consistent strabismus was also noted. At thirty days of age the startles had diminished and the tremors were still in evidence.

Developmental test scores at 12 and 24 months were well above the mean. She was noted to be cooperative, outgoing and friendly. It was also noted that she would "become tense at times and display body tremors". At 36 months her GCI was above average but her expressive language score was slightly below average. Difficulty with articulation was noted on her file. At 48 months her GCI was again above average but two-thirds of the way through the language assessment, she refused to continue. The 60 month assessment yielded above average scores again and she was described as "happy, talkative, impulsive at times". At the 72 month testing she was described as "quite stubborn" and "would turn off on hard tasks". The resultant GCI was slightly below average.

At the present testing D.Q. was chatty and generally cooperative though somewhat distractible. Her Full Scale I.Q. fell in the Superior range and most of her test scores were at the norm mean or above for her age. The exception was the reading comprehension test where her inability to read English (having been schooled totally in French) resulted in a standard score of 78, one and a half standard deviations below the mean.

Her mother rated her at two standard deviation above the mean on Conduct Problems and close to one standard deviation above the mean on Impulsivity/Hyperactivity. Other scores were close to the mean. Her mother scored at the 50th percentile on the Raven and rated herself highly on Extraversion (T=63) and low on Conscientiousness (T=32). Most of the HEQ scores were very close to the mean. The highest score was on Sociability (T=62).

D.Q. is the youngest of three children in a two parent home with an income in the \$40,000.00 to 49,999.00 range.

ID Number 1011
 MARTOT 15 jts/wk
 ALCTOT 0.17 oz.aak/day
 NICTOT 0.27 mg/day

Brazelton-4 Day

Response To Light	Habituate To Light	Response To Sound	Habituate To Sound	Self Quiet	Tremors	Startles	Orientation
no	-	yes	9	4	8	7	8

Prechtl - 9 Day

Prechtl - 30 Day

Hand to Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Hand to Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Forearm Recoil	Babinski

Age = 124 Months

S.G. is a ten year old female born to a woman who was a heavy user of cannabis, a light smoker, and a moderate drinker. S.G. was born at 40 weeks gestation after an eight hour and ten minute labor and weighed 3260 grams. At the four day examination she did not respond to a light repeatedly directed at the eyes but did respond to and habituate quickly to the sound of a rattle. She exhibited marked startles and tremors and poor self-quieting.

Her mental development test score at 24 months was above one standard deviation above the mean and the psychomotor development test score was slightly above the mean. At this point her parents had separated and she was in a French daycare setting. These factors may have influenced her subsequent test results as there was some difficulty eliciting cooperation from the child. She appeared very shy and clung to her mother. Expressive language scores were much lower than average. She was generally very attentive and cooperative during the language comprehension tests. Her 60 months test scores were omitted from group statistical analysis because of lack of cooperation.

At 72 months she exhibited good cooperation and her General Cognitive Index was greater than two standard deviations above the mean and her age equivalent score on the Peabody Picture Vocabulary was 95 months.

At the present testing S.G. presented as a very quiet but attentive and cooperative girl. All of her test scores fell well above the mean for her age. Her Full Scale I.Q. was in the "Very Superior" range (i.e., the top 2%). Her mother rated her as well below average on Learning Problems and very close to the mean on the Hyperactivity Index. On the other scales of the Conners Parent Questionnaire she was scored close to or above one standard deviation above the mean, her highest score being on Psychosomatic Problems. She is presently being schooled in both French and English and is having no difficulty.

Her mother scored at the 95th percentile on the Raven and rated herself one standard deviation above the mean on Extraversion and Openness, at the mean on Neuroticism, and almost one standard deviation below the mean on Agreeableness and Conscientiousness. Most of the Home Environment Questionnaire scores were close to the mean with the exception of Achievement and Supervision, which were one standard deviation or more below the mean and Separation, Sociability, and Social Status, which were more than one standard deviation above the mean.

S.G. is the middle of three children. It is a one parent household with an income in the \$40,000.00 to 49,999.00 category.

I.D. #1251

K.W. is a ten year old boy born to a woman who was a heavy user of cannabis and a light smoker. He was born at 37 weeks gestation, following a three hour and twenty-eight minute labor and weighed 2940 grams. It was a breech delivery. The mother stated that she had consumed two joints of cannabis prior to onset of delivery. Apgars were low to normal (i.e., 6 and 8).

At four day testing, the child responded to light directed at the eyes but did not habituate over ten trials. He did not respond to sound. Tremors and startles were marked. By nine and thirty days tremors and startles had diminished and muscle tone and reflexes were good. At thirty days the optical blink could be elicited and habituation occurred in three trials.

Early developmental test scores were at or below the mean. At 24 months he was described by the testers as an "independent, stubborn little fellow." Also noted was that "the mother does not believe in discipline." At 36 months, the GCI was 66. During this testing the child was uncooperative and would run away from the testing table. At 48 months he was somewhat more cooperative and his scores were closer to the mean but noted on his file was that he didn't cooperate on the "content" part of the expressive language test. At this age he was in junior kindergarten five afternoons a week. At 60 months he was in a bilingual senior kindergarten. His GCI was in the average range and his age equivalent score on the Peabody Picture Vocabulary test was 58 months. His tests since then have typically been very close to the mean.

At the present testing K.W. was cooperative and generally attentive but tended to want to give up when tasks became difficult. His Full Scale I.Q. was in the Average range as were his Stroop and Passage Comprehension scores although they were below the mean. His perceptual abilities were above average

(i.e., the Perceptual Quotient was at the 92nd percentile).

His behaviour ratings were within the average range with the exception of Impulsivity/Hyperactivity where he was rated at close to two standard deviations above the mean. The HEQ scores were generally in the average range. Low scores were given on Supervision (T=25), Sociability (T=36) and Social Status (T=36).

K.W.'s mother scored at the 95th percentile on the Raven and rated herself below average on all scales of the NEO. On the Extraversion, Agreeableness, and Conscientiousness scales she rated herself lower than one standard below the mean.

K.W. is the only child in a one parent home with an income in the \$10,000.00-14,999.00 range.

I.D.# 2211

H.B. is a nine year old girl born to woman who was a moderate user of cannabis, a moderate drinker and a non-smoker. She was born at 40 weeks gestation after a six hour and ten minute labor and weighed 3770 grams. The umbilical cord was wrapped once around the child's neck. The Apgar scores were optimal (i.e., 10 and 10). At the four day testing, she did not respond to either sound or light and showed tremors and poor self-quieting. She was noted to have a "hoarse cry". At nine days, tremors were still noticeable and the optical blink could not be elicited. At 30 days the tremors had lessened and muscle tone and reflexes were good. Data is missing on some measures such as the Moro tremor and optical blink as the mother would not allow them to be assessed.

Developmental test scores have consistently been at or well above the mean although she often required much coaxing on the early tests. Noted on her file was the presence of fine tremors when tense: "these episodes appear when she is very intent, lasting 3-4 seconds". By 36 months, she was cooperating fully on all tests and was no longer shy. Her expressive language score consequently increased markedly.

H.B. was involved with a play group and then nursery school from age two and a half. At four years she was in junior kindergarten five afternoons a week and at five years she was in a bilingual kindergarten five mornings a week. At age six she was in French Immersion Grade One but was taken out the following year after she developed school phobia. At the recent testing she was in Grade Four and having no difficulty.

At the present testing H.B. presented as an open, chatty child who was cooperative and attentive throughout the testing. Her Full Scale I.Q. fell in the "Very Superior" range as did her Verbal I.Q. . Her Performance I.Q. was in the Superior range. Other scores were all at or well above the mean for her age.

H.B.'s mother rated her at or well below one standard deviation below the mean on Conduct Problems, Impulsivity/Hyperactivity, and the Hyperactivity Index. The other scores were within one standard deviation above or below the mean. The mother scored at the 95th percentile on the Raven and rated herself very low on Neuroticism (T=40) and Conscientiousness (T=32) and above the mean on Extraversion (T=59). Other scores were close to the mean. The HEQ scores were typically below the mean. Aggression in the Home was low (T=36) as was Separation (T=37) and Supervision (T=39). The Affiliation score was high (T=63).

H.B. is the oldest of three in a two-parent home with an income in the \$35,000.00 to 39,999.00 range.

ID Number	2771	Brazelton-4 Day	Response To Light	Habituate To Light	Response To Sound	Habituate To Sound	Self Quiet	Tremors	Startles	Orientation							
MARTOT	400 Jts/wk																
ALGTOT	0.12 oz.aal/day																
NICTOT	35.0 mg/day																
Prechtl - 9 Day			Prechtl - 30 Day														
Hand To Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Hand To Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Forearm Recoil	Rebined
.00	3.0	∞	4.0	3	2	3.0	8	.00	233	.33	4.0	3	1	3	8	3	2

MDI 24 12 PDI 24 36 48 60 72 Peabody 48 60 72

Reynell 24 36 48 60 72 Comp. 24 36 48 60 72

HOME TEST: Emotional Responsivity, Avoidance of Punishment, Organization Environment, Appropriate Play Material, Maternal Involvement, Variety in Routine, Total

CONNERS RATINGS: Conduct Problems, Learning Problems, Psycho-Somatic, Impulsive-Hyperactive, Anxiety, Hyperactivity Index

FSIQ VIQ PIQ Perc. Syntax Pass. Stroop

Age = 108 Months

Quot. Quot. Comp.

I.D.#2771

M.P. is a nine year old male born to a woman who was both a heavy user of cannabis and a heavy smoker. She reported moderate use of alcohol and during the first and second trimesters ingested opium and cocaine (amounts not specified). The second of two children, M.P. was born following a 38+ week gestation and a five hour, fifty-four minute labor and weighed 3030 grams. At four days of age, he exhibited marked tremors and was unable to self-quiet. He did not respond to either light or sound. At nine and thirty days of age, the tremors were still pronounced but the optical and acoustical responses could be elicited. Developmental test scores have been consistently at or above the mean. At twelve months, it was noted that he exhibited right handed tremors while being tested.

His parents separated when he was 17 months old. From age two until he started school he was cared for by a sitter who came into the home while his mother worked. He was noted to be a "happy, talkative child" but occasionally was unco-operative on memory tests at 36 and 48 months of age.

He has always been schooled in English, with no difficulties.

At the present testing M.P. presented as a very quiet but attentive and co-operative boy, something of a contrast to his mother's rating of him as well above average on the Impulsivity-Hyperactivity and Hyperactivity Index scales of the Conners Questionnaire. All of his test scores fell at or well above the mean for his age. His Drawaman and Perceptual Quotient scores were above the 95th %ile and his I.Q. was in the "superior" range. His WRAT-R, Passage Comprehension and Syntax Quotient scores were all in the average range.

M.P.'s mother scored at the 95th %ile on the Raven and rated herself as being in the average range on the NEO Neuroticism, NEO Openess and NEO Agreeableness; above average on NEO Extraversion and more than one standard deviation below average on NEO Conscientiousness. The home environment ratings were average on most scales but high (i.e., > 1 S.D. above mean) on Achievement and Sociability. It is a one-parent home with an income in the \$20,000.00 to 24,000.00 category.

I.D. #2871

M.G. is a nine year old boy born to a heavy user of cannabis who was also a heavy smoker and a moderate drinker. He was born at 38 weeks gestation after a 19 hour and ten minute labor and weighed 3657 grams. Apgars were normal (i.e., 9 and 9). At the four day testing he did not respond to a light directed at his eyes but did respond to sound, although with relatively poor habituation. Tremors and startles were pronounced. At nine and thirty days, the optical blink to light could not be elicited. Reflexes were generally strong but tremors were still in evidence. Bayley test scores at 12 and 24 months were at the mean or well above. At 36, 48, and 60 months his test scores were around the mean. During these years he was cared for by his mother in his home with participation in a play group a few days a week at age 48 months. On these tests he was shy and quiet and needed a great deal of encouragement to speak (which could contribute to his low expressive language scores). At 72 months, coincident with his being in kindergarten five full days a week, his scores increased to two standard deviations above the mean. His age equivalent score on the Peabody Picture Vocabulary was 100 months.

At the present testing, M.G. was quiet and cooperative although his attention seemed to wander during the Passage Comprehension test. His I.Q. scores all fell within the Average range while his Perceptual Quotient was more than two standard deviations above the mean. The Stroop score was slightly above average. On all other tests he scored at or above the mean with the exception of the Beery Visual Motor Integration test which was more than one standard deviation below the mean (i.e., scaled score of 6).

Although the home is bilingual, English is the language spoken most often because the mother is English speaking. M.G. is being schooled in English with no difficulties. His mother rated him highly on Impulsivity/Hyperactivity, Anxiety, and the Hyperactivity Index. She rated herself highly on Neuroticism (T=58) and very low on Agreeableness (T=41) and Conscientiousness (T=28). Many of the HEQ scores were around the mean. However, Achievement, Supervision, and Social Status were at or below one standard deviation below the mean. Sociability and Separation were more than one standard deviation above the mean.

M.G. is the second of two children in a two parent home with an income in the \$25,000.00 to 29,999.00 range.

ID Number 2891
 MARTOT 19 lbs/wk
 ALCTOT 0.19 oz./day
 NICTOT 15.17 mg/day

Brazelton-4 Day	Response To Light	Habituate To Light	Response To Sound	Habituate To Sound	Self Quiet	Tremors	Startles	Orientation
	yes	7	yes	9	-	7	6	8

Prechil - 9 Day

Prechil - 30 Day

Hand to Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Hand to Mouth	Tremor	Startles	Knee Resistance	Moro Tremor	Strabismus	Optical Blink	Habituate Blink	Forearm Recoil	Babinski
.33	2.0	.33	3	3	1	3	6	.00	2.0	.00	4	2	1	1	0	4	3

Age = 113 Months

Quot. Quot. Comp.

I.D.# 2891

D.E. is a nine year old boy born to a woman who was a heavy user of cannabis, a heavy smoker and a moderate drinker. He was born at 39 weeks gestation after a 12 hour and forty-three minute labor, and weighed 3560 grams. At the four day examination he exhibited good habituation to light and sound but marked tremors and startles. Tremors were still evident at nine days but the startles had diminished. He appeared to have good muscle tone and reflexes at nine and thirty days although the optical blink could not be elicited at 30 days.

His developmental tests scores were well above the mean for his age. His 24 month MDI was 143, the PDI was 131. At 36 months, the testers noted him to be very active during the testing, "squirming and standing up a lot" but also quite attentive. From the age of 36 months he was in full time daycare. At 48 months he started junior kindergarten for five mornings per week with daycare in the afternoon. This continued through senior kindergarten the next year. His pre-school and early schooling took place in a facility dealing with behaviour problems that is connected with the Royal Ottawa Hospital. He is now in a special "support" class for behaviour problems within the public school system.

At the present D.E. presented initially as a very quiet child. he gradually warmed up and halfway through the session was very talkative. He cooperated well on all tests but tended to become distracted as the difficulty level increased. His Full Scale I.Q. was in the "Average" range as was his Verbal I.Q.; his Performance I.Q. was in the "High Average" range. His Perceptual Quotient was two standard deviations above the mean. His Passage Comprehension and Stroop Interference score were slightly below average.

D.E.'s mother rated him at least one standard deviation above the mean on four of the Conners scales and close to one standard deviation above on Psychosomatic Problems and Impulsivity/Hyperactivity. The HEQ scores were more than one standard deviation above the mean on Aggression in the Home, Aggression-External, Aggression-Total, Separation and Sociability. The scores on Social Status, Affiliation, Supervision, and Achievement were at one standard deviation or more below the mean. D.E.'s mother scored at the 95th percentile on the Raven and rated herself highly on Neuroticism (T=64) and low on Conscientiousness (T=32). For most of this child's life he was in a single-parent home. It is now a two parent home with an income in the \$40,000.00 to 49,999.00 range.

Appendix D

Comparison of siblings on home environment ratings

Appendix D
Comparison of siblings on home environment ratings

	MARUSE =1 (Cannabis users)	
	782	783
Achievement	48	48
Aggression-External	43	49
Aggression-Home	61	46
Aggression-Total	55	47
Supervision	56	45
Change	53	49
Affiliation	57	51
Separation	37	37
Sociability	62	62
Social Status	52	50
	5731	5732
Achievement	54	48
Aggression-External	43	43
Aggression-Home	43	46
Aggression-Total	41	44
Supervision	56	56
Change	64	67
Affiliation	63	61
Separation	60	60
Sociability	62	62
Social Status	56	56

Appendix D (continued)

MARUSE = 1 (Cannabis users)

	5881	5882
Achievement	41	41
Aggression-External	49	61
Aggression-Home	43	36
Aggression-Total	44	44
Supervision	51	45
Change	49	49
Affiliation	63	63
Separation	37	37
Sociability	54	54
Social Status	61	61
	6051	6052
Achievement	35	41
Aggression-External	55	55
Aggression-Home	61	53
Aggression-Total	61	55
Supervision	33	39
Change	53	53
Affiliation	43	49
Separation	45	52
Sociability	54	54
Social Status	43	43

Appendix D (continued)

MARUSE = 1 (Cannabis users)

	6151	6152
Achievement	48	48
Aggression-External	73	73
Aggression-Home	64	64
Aggression-Total	72	72
Supervision	45	39
Change	67	67
Affiliation	55	53
Separation	75	75
Sociability	46	46
Social Status	52	52

MARUSE = 0 (Controls)

	711	712
Achievement	41	41
Aggression-External	49	49
Aggression-Home	46	43
Aggression-Total	47	44
Supervision	56	62
Change	46	46
Affiliation	47	45
Separation	45	52
Sociability	62	62
Social Status	61	63

Appendix D (continued)

MARUSE = 0 (Controls)

	2271	2272
Achievement	60	66
Aggression-External	43	43
Aggression-Home	43	39
Aggression-Total	41	38
Supervision	68	68
Change	42	46
Affiliation	63	63
Separation	52	37
Sociability	62	62
Social Status	58	56
	2881	2882
Achievement	54	41
Aggression-External	43	43
Aggression-Home	43	43
Aggression-Total	41	41
Supervision	62	62
Change	53	53
Affiliation	59	59
Separation	45	45
Sociability	62	62
Social Status	65	61

Appendix E

Data Sheets

Data Sheet

ID# 711 Age in months 128 Sex M MARUSE Q

Test	Standardized score
Full Scale I.Q.	154
Verbal I.Q.	145
Performance I.Q.	155
Verbal Comprehension	17.8
Perceptual Organization	18.8
Freedom from Distractibility	14.3
Syntax Quotient	121
Passage Comprehension	122
WRAT Reading	126
WRAT Spelling	118
WRAT Arithmetic	126
Stroop Interference	63
Knox Cube	11
Visual Discrimination	19
Visual Memory	19
Visual Spatial Relations	18
Visual Form Constancy	15
Visual Sequential Memory	14
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	140
Trails A	0.24
Draw-A-Man	119
Beery VMI	15
Dominant Hand Tapping	0.04
NonDominant Hand Tapping	0.48
Anxiety	-0.36
Conduct Problems	0.13
Hyperactivity Index	-0.36
Impulsivity-Hyperactivity	-0.28
Learning Problems	-0.07
Psychosomatic Problems	0.08

Data Sheet

ID# 712 Age in months 98 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	126
Verbal I.Q.	118
Performance I.Q.	129
Verbal Comprehension	13.0
Perceptual Organization	14.8
Freedom from Distractibility	12.7
Syntax Quotient	109
Passage Comprehension	111
WRAT Reading	106
WRAT Spelling	89
WRAT Arithmetic	93
Stroop Interference	48
Knox Cube	15
Visual Discrimination	18
Visual Memory	15
Visual Spatial Relations	16
Visual Form Constancy	14
Visual Sequential Memory	14
Visual Figure Ground	13
Visual Closure	11
Perceptual Quotient	132
Trails A	1.4
Draw-A-Man	108
Beery VMI	8
Dominant Hand Tapping	0.0
NonDominant Hand Tapping	0.97
Anxiety	0.96
Conduct Problems	0.0
Hyperactivity Index	-0.20
Impulsivity-Hyperactivity	0.12
Learning Problems	-0.87
Psychosomatic Problems	-0.57

Data Sheet

ID# **782** Age in months **104** Sex **F** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	112
Verbal I.Q.	113
Performance I.Q.	108
Verbal Comprehension	12.5
Perceptual Organization	10.8
Freedom from Distractibility	10.7
Syntax Quotient	102
Passage Comprehension	104
WRAT Reading	97
WRAT Spelling	84
WRAT Arithmetic	93
Stroop Interference	50
Knox Cube	14
Visual Discrimination	15
Visual Memory	14
Visual Spatial Relations	13
Visual Form Constancy	5
Visual Sequential Memory	13
Visual Figure Ground	16
Visual Closure	12
Perceptual Quotient	119
Trails A	-0.37
Draw-A-Man	108
Beery VMI	11
Dominant Hand Tapping	-1.18
NonDominant Hand Tapping	-0.88
Anxiety	-0.86
Conduct Problems	1.21
Hyperactivity Index	-0.26
Impulsivity-Hyperactivity	0.08
Learning Problems	-0.53
Psychosomatic Problems	0.04

Data Sheet

ID# 783 Age in months 83 Sex F MARUSE 1

Test	Standardized score
Full Scale I.Q.	126
Verbal I.Q.	120
Performance I.Q.	126
Verbal Comprehension	14.3
Perceptual Organization	14.5
Freedom from Distractibility	10.0
Syntax Quotient	102
Passage Comprehension	78
WRAT Reading	80
WRAT Spelling	95
WRAT Arithmetic	113
Stroop Interference	56
Knox Cube	16
Visual Discrimination	16
Visual Memory	14
Visual Spatial Relations	13
Visual Form Constancy	17
Visual Sequential Memory	13
Visual Figure Ground	17
Visual Closure	18
Perceptual Quotient	139
Trails A	1.06
Draw-A-Man	95
Beery VMI	11
Dominant Hand Tapping	-1.55
NonDominant Hand Tapping	-1.54
Anxiety	-0.48
Conduct Problems	2.11
Hyperactivity Index	0.6
Impulsivity-Hyperactivity	0.93
Learning Problems	0.13
Psychosomatic Problems	0.04

Data Sheet

ID# 1011 Age in months 124 Sex F MARUSE 1

Test	Standardized score
Full Scale I.Q.	133
Verbal I.Q.	139
Performance I.Q.	120
Verbal Comprehension	13.7
Perceptual Organization	13.7
Freedom from Distractibility	12.0
Syntax Quotient	109
Passage Comprehension	119
WRAT Reading	119
WRAT Spelling	111
WRAT Arithmetic	91
Stroop Interference	63
Knox Cube	11
Visual Discrimination	13
Visual Memory	12
Visual Spatial Relations	11
Visual Form Constancy	19
Visual Sequential Memory	14
Visual Figure Ground	16
Visual Closure	14
Perceptual Quotient	130
Trails A	1.59
Draw-A-Man	74
Beery VMI	12
Dominant Hand Tapping	-0.26
NonDominant Hand Tapping	0.02
Anxiety	0.89
Conduct Problems	0.75
Hyperactivity Index	-0.06
Impulsivity-Hyperactivity	0.34
Learning Problems	-1.13
Psychosomatic Problems	1.54

Data Sheet

ID# 1031 Age in months 125 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	121
Verbal I.Q.	118
Performance I.Q.	120
Verbal Comprehension	13.5
Perceptual Organization	13.5
Freedom from Distractibility	10.3
Syntax Quotient	124
Passage Comprehension	110
WRAT Reading	112
WRAT Spelling	102
WRAT Arithmetic	95
Stroop Interference	54
Knox Cube	10
Visual Discrimination	16
Visual Memory	15
Visual Spatial Relations	14
Visual Form Constancy	15
Visual Sequential Memory	11
Visual Figure Ground	16
Visual Closure	19
Perceptual Quotient	137
Trails A	1.29
Draw-A-Man	95
Beery VMI	12
Dominant Hand Tapping	-0.99
NonDominant Hand Tapping	0.22
Anxiety	0.46
Conduct Problems	-0.64
Hyperactivity Index	-1.24
Impulsivity-Hyperactivity	-0.21
Learning Problems	-0.47
Psychosomatic Problems	0.11

Data Sheet

ID# 1251 Age in months 124 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	107
Verbal I.Q.	102
Performance I.Q.	112
Verbal Comprehension	10.0
Perceptual Organization	12.5
Freedom from Distractibility	10.3
Syntax Quotient	109
Passage Comprehension	95
WRAT Reading	93
WRAT Spelling	84
WRAT Arithmetic	95
Stroop Interference	48
Knox Cube	11
Visual Discrimination	13
Visual Memory	15
Visual Spatial Relations	14
Visual Form Constancy	11
Visual Sequential Memory	11
Visual Figure Ground	16
Visual Closure	10
Perceptual Quotient	121
Trails A	1.59
Draw-A-Man	104
Beery VMI	8
Dominant Hand Tapping	-0.03
NonDominant Hand Tapping	-0.18
Anxiety	-0.89
Conduct Problems	0.79
Hyperactivity Index	-0.36
Impulsivity-Hyperactivity	1.8
Learning Problems	-0.56
Psychosomatic Problems	-0.69

Data Sheet

ID# 1481 Age in months 125 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	123
Verbal I.Q.	98
Performance I.Q.	145
Verbal Comprehension	10.5
Perceptual Organization	17.3
Freedom from Distractibility	10.0
Syntax Quotient	113
Passage Comprehension	100
WRAT Reading	115
WRAT Spelling	100
WRAT Arithmetic	99
Stroop Interference	55
Knox Cube	11
Visual Discrimination	9
Visual Memory	19
Visual Spatial Relations	18
Visual Form Constancy	18
Visual Sequential Memory	18
Visual Figure Ground	16
Visual Closure	17
Perceptual Quotient	147
Trails A	0.39
Draw-A-Man	98
Beery VMI	13
Dominant Hand Tapping	-0.4
NonDominant Hand Tapping	-1.18
Anxiety	0.02
Conduct Problems	0.06
Hyperactivity Index	0.24
Impulsivity-Hyperactivity	0.34
Learning Problems	-0.47
Psychosomatic Problems	0.82

Data Sheet

ID# 1491 Age in months 123 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	101
Verbal I.Q.	101
Performance I.Q.	101
Verbal Comprehension	10.5
Perceptual Organization	10.5
Freedom from Distractibility	9.3
Syntax Quotient	91
Passage Comprehension	92
WRAT Reading	115
WRAT Spelling	100
WRAT Arithmetic	88
Stroop Interference	52
Knox Cube	-2
Visual Discrimination	19
Visual Memory	12
Visual Spatial Relations	14
Visual Form Constancy	15
Visual Sequential Memory	11
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	140
Trails A	1.44
Draw-A-Man	95
Beery VMI	11
Dominant Hand Tapping	-0.11
NonDominant Hand Tapping	0.28
Anxiety	-0.36
Conduct Problems	-0.74
Hyperactivity Index	0.3
Impulsivity-Hyperactivity	-1.53
Learning Problems	-0.08
Psychosomatic Problems	0.08

Data Sheet

ID# 1661 Age in months 117 Sex M MARUSE Q

Test	Standardized score
Full Scale I.Q.	131
Verbal I.Q.	128
Performance I.Q.	128
Verbal Comprehension	14.8
Perceptual Organization	14.8
Freedom from Distractibility	12.3
Syntax Quotient	109
Passage Comprehension	122
WRAT Reading	128
WRAT Spelling	133
WRAT Arithmetic	125
Stroop Interference	51
Knox Cube	6
Visual Discrimination	19
Visual Memory	14
Visual Spatial Relations	19
Visual Form Constancy	14
Visual Sequential Memory	12
Visual Figure Ground	17
Visual Closure	19
Perceptual Quotient	146
Trails A	0.67
Draw-A-Man	122
Beery VMI	16
Dominant Hand Tapping	0.88
NonDominant Hand Tapping	0.04
Anxiety	0.17
Conduct Problems	-1.39
Hyperactivity Index	-1.05
Impulsivity-Hyperactivity	-0.70
Learning Problems	-0.56
Psychosomatic Problems	-0.69

Data Sheet

ID# 1961 Age in months 118 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	125
Verbal I.Q.	120
Performance I.Q.	124
Verbal Comprehension	14.0
Perceptual Organization	13.5
Freedom from Distractibility	11.7
Syntax Quotient	106
Passage Comprehension	91
WRAT Reading	77
WRAT Spelling	72
WRAT Arithmetic	91
Stroop Interference	55
Knox Cube	6
Visual Discrimination	17
Visual Memory	14
Visual Spatial Relations	19
Visual Form Constancy	11
Visual Sequential Memory	11
Visual Figure Ground	12
Visual Closure	10
Perceptual Quotient	125
Trails A	1.44
Draw-A-Man	118
Beery VMI	9
Dominant Hand Tapping	0.12
NonDominant Hand Tapping	-0.97
Anxiety	0.02
Conduct Problems	1.89
Hyperactivity Index	2.0
Impulsivity-Hyperactivity	0.34
Learning Problems	2.82
Psychosomatic Problems	0.11

Data Sheet

ID# 2111 Age in months 115 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	120
Verbal I.Q.	109
Performance I.Q.	128
Verbal Comprehension	11.3
Perceptual Organization	13.5
Freedom from Distractibility	13.3
Syntax Quotient	109
Passage Comprehension	105
WRAT Reading	113
WRAT Spelling	99
WRAT Arithmetic	99
Stroop Interference	57
Knox Cube	13
Visual Discrimination	17
Visual Memory	16
Visual Spatial Relations	19
Visual Form Constancy	14
Visual Sequential Memory	12
Visual Figure Ground	19
Visual Closure	18
Perceptual Quotient	147
Trails A	1.25
Draw-A-Man	112
Beery VMI	14
Dominant Hand Tapping	0.12
NonDominant Hand Tapping	-0.96
Anxiety	0.46
Conduct Problems	-0.88
Hyperactivity Index	-1.24
Impulsivity-Hyperactivity	-1.36
Learning Problems	-1.13
Psychosomatic Problems	0.11

Data Sheet

ID# **2211** Age in months **115** Sex **F** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	139
Verbal I.Q.	145
Performance I.Q.	123
Verbal Comprehension	17.0
Perceptual Organization	14.0
Freedom from Distractibility	13.3
Syntax Quotient	113
Passage Comprehension	111
WRAT Reading	101
WRAT Spelling	99
WRAT Arithmetic	108
Stroop Interference	57
Knox Cube	13
Visual Discrimination	14
Visual Memory	16
Visual Spatial Relations	19
Visual Form Constancy	14
Visual Sequential Memory	11
Visual Figure Ground	14
Visual Closure	2
Perceptual Quotient	121
Trails A	-0.18
Draw-A-Man	109
Beery VMI	10
Dominant Hand Tapping	-0.48
NonDominant Hand Tapping	-0.51
Anxiety	0.46
Conduct Problems	-0.89
Hyperactivity Index	-1.24
Impulsivity-Hyperactivity	-1.35
Learning Problems	0.47
Psychosomatic Problems	-0.61

Data Sheet

ID# 2271 Age in months 115 Sex M MARUSE Q

Test	Standardized score
Full Scale I.Q.	139
Verbal I.Q.	137
Performance I.Q.	131
Verbal Comprehension	13.8
Perceptual Organization	15.3
Freedom from Distractibility	12.7
Syntax Quotient	128
Passage Comprehension	115
WRAT Reading	107
WRAT Spelling	109
WRAT Arithmetic	95
Stroop Interference	56
Knox Cube	13
Visual Discrimination	19
Visual Memory	16
Visual Spatial Relations	17
Visual Form Constancy	19
Visual Sequential Memory	17
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	158
Trails A	1.06
Draw-A-Man	112
Beery VMI	15
Dominant Hand Tapping	-0.03
NonDominant Hand Tapping	0.40
Anxiety	0.70
Conduct Problems	-1.18
Hyperactivity Index	-0.14
Impulsivity-Hyperactivity	1.38
Learning Problems	-1.04
Psychosomatic Problems	.85

Data Sheet

ID# **2272** Age in months **88** Sex **M** MARUSE **0**

Test	Standardized score
Full Scale I.Q.	125
Verbal I.Q.	112
Performance I.Q.	123
Verbal Comprehension	11.3
Perceptual Organization	15.3
Freedom from Distractibility	13.3
Syntax Quotient	98
Passage Comprehension	107
WRAT Reading	86
WRAT Spelling	84
WRAT Arithmetic	104
Stroop Interference	53
Knox Cube	17
Visual Discrimination	19
Visual Memory	15
Visual Spatial Relations	19
Visual Form Constancy	18
Visual Sequential Memory	19
Visual Figure Ground	15
Visual Closure	16
Perceptual Quotient	153
Trails A	0.55
Draw-A-Man	119
Beery VMI	12
Dominant Hand Tapping	0.59
NonDominant Hand Tapping	1.45
Anxiety	-1.0
Conduct Problems	-0.20
Hyperactivity Index	0.02
Impulsivity-Hyperactivity	0.95
Learning Problems	-0.31
Psychosomatic Problems	-0.57

Data Sheet

ID# 2351 Age in months 115 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	140
Verbal I.Q.	135
Performance I.Q.	136
Verbal Comprehension	15.0
Perceptual Organization	15.5
Freedom from Distractibility	15.3
Syntax Quotient	121
Passage Comprehension	126
WRAT Reading	121
WRAT Spelling	128
WRAT Arithmetic	129
Stroop Interference	59
Knox Cube	13
Visual Discrimination	17
Visual Memory	19
Visual Spatial Relations	12
Visual Form Constancy	12
Visual Sequential Memory	19
Visual Figure Ground	17
Visual Closure	19
Perceptual Quotient	147
Trails A	1.63
Draw-A-Man	107
Beery VMI	15
Dominant Hand Tapping	-0.33
NonDominant Hand Tapping	-0.97
Anxiety	0.46
Conduct Problems	0.06
Hyperactivity Index	-0.65
Impulsivity-Hyperactivity	-0.51
Learning Problems	-1.13
Psychosomatic Problems	0.11

Data Sheet

ID# **2491** Age in months **114** Sex **F** MARUSE **0**

Test	Standardized score
Full Scale I.Q.	119
Verbal I.Q.	120
Performance I.Q.	112
Verbal Comprehension	14.0
Perceptual Organization	12.5
Freedom from Distractibility	11.0
Syntax Quotient	94
Passage Comprehension	94
WRAT Reading	112
WRAT Spelling	94
WRAT Arithmetic	82
Stroop Interference	54
Knox Cube	12
Visual Discrimination	17
Visual Memory	7
Visual Spatial Relations	15
Visual Form Constancy	8
Visual Sequential Memory	19
Visual Figure Ground	14
Visual Closure	12
Perceptual Quotient	123
Trails A	0.48
Draw-A-Man	104
Beery VMI	10
Dominant Hand Tapping	0.10
NonDominant Hand Tapping	0.95
Anxiety	0.46
Conduct Problems	0.28
Hyperactivity Index	1.41
Impulsivity-Hyperactivity	-0.08
Learning Problems	3.47
Psychosomatic Problems	-0.61

Data Sheet

ID# 2581 Age in months 113 Sex M MARUSE Q

Test	Standardized score
Full Scale I.Q.	129
Verbal I.Q.	119
Performance I.Q.	133
Verbal Comprehension	13.0
Perceptual Organization	15.0
Freedom from Distractibility	14.0
Syntax Quotient	106
Passage Comprehension	107
WRAT Reading	111
WRAT Spelling	82
WRAT Arithmetic	108
Stroop Interference	53
Knox Cube	13
Visual Discrimination	19
Visual Memory	18
Visual Spatial Relations	10
Visual Form Constancy	10
Visual Sequential Memory	19
Visual Figure Ground	18
Visual Closure	10
Perceptual Quotient	135
Trails A	124
Draw-A-Man	107
Beery VMI	8
Dominant Hand Tapping	-0.03
NonDominant Hand Tapping	0.32
Anxiety	0.36
Conduct Problems	-1.39
Hyperactivity Index	-1.5
Impulsivity-Hyperactivity	-1.53
Learning Problems	-1.04
Psychosomatic Problems	-0.69

Data Sheet

ID# 2751 Age in months 115 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	100
Verbal I.Q.	107
Performance I.Q.	91
Verbal Comprehension	11.3
Perceptual Organization	9.5
Freedom from Distractibility	9.7
Syntax Quotient	119
Passage Comprehension	89
WRAT Reading	92
WRAT Spelling	96
WRAT Arithmetic	86
Stroop Interference	49
Knox Cube	0
Visual Discrimination	12
Visual Memory	13
Visual Spatial Relations	8
Visual Form Constancy	8
Visual Sequential Memory	9
Visual Figure Ground	14
Visual Closure	6
Perceptual Quotient	100
Trails A	0.48
Draw-A-Man	98
Beery VMI	10
Dominant Hand Tapping	-1.16
NonDominant Hand Tapping	-0.51
Anxiety	-0.86
Conduct Problems	-0.42
Hyperactivity Index	0.24
Impulsivity-Hyperactivity	0.34
Learning Problems	0.18
Psychosomatic Problems	0.11

Data Sheet

ID# 2771 Age in months 108 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	122
Verbal I.Q.	115
Performance I.Q.	124
Verbal Comprehension	12.5
Perceptual Organization	14.8
Freedom from Distractibility	10.3
Syntax Quotient	102
Passage Comprehension	110
WRAT Reading	112
WRAT Spelling	105
WRAT Arithmetic	108
Stroop Interference	50
Knox Cube	13
Visual Discrimination	14
Visual Memory	11
Visual Spatial Relations	15
Visual Form Constancy	12
Visual Sequential Memory	12
Visual Figure Ground	19
Visual Closure	14
Perceptual Quotient	128
Trails A	0.39
Draw-A-Man	126
Beery VMI	13
Dominant Hand Tapping	0.66
NonDominant Hand Tapping	0.41
Anxiety	0.70
Conduct Problems	0.13
Hyperactivity Index	1.9
Impulsivity-Hyperactivity	1.8
Learning Problems	0.88
Psychosomatic Problems	0.08

Data Sheet

ID# **2871** Age in months **108** Sex **M** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	105
Verbal I.Q.	108
Performance I.Q.	102
Verbal Comprehension	12.0
Perceptual Organization	11.8
Freedom from Distractibility	8.0
Syntax Quotient	121
Passage Comprehension	101
WRAT Reading	108
WRAT Spelling	120
WRAT Arithmetic	90
Stroop Interference	57
Knox Cube	10
Visual Discrimination	17
Visual Memory	14
Visual Spatial Relations	15
Visual Form Constancy	16
Visual Sequential Memory	11
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	143
Trails A	1.35
Draw-A-Man	99
Beery VMI	6
Dominant Hand Tapping	0.05
NonDominant Hand Tapping	0.40
Anxiety	1.23
Conduct Problems	0.13
Hyperactivity Index	1.0
Impulsivity-Hyperactivity	2.22
Learning Problems	0.40
Psychosomatic Problems	0.08

Data Sheet

ID# **2881** Age in months **111** Sex **F** MARUSE **0**

Test	Standardized score
Full Scale I.Q.	115
Verbal I.Q.	119
Performance I.Q.	106
Verbal Comprehension	13.0
Perceptual Organization	11.0
Freedom from Distractibility	12.3
Syntax Quotient	106
Passage Comprehension	97
WRAT Reading	96
WRAT Spelling	100
WRAT Arithmetic	85
Stroop Interference	53
Knox Cube	0
Visual Discrimination	17
Visual Memory	13
Visual Spatial Relations	15
Visual Form Constancy	10
Visual Sequential Memory	15
Visual Figure Ground	18
Visual Closure	16
Perceptual Quotient	135
Trails A	1.15
Draw-A-Man	124
Beery VMI	11
Dominant Hand Tapping	0.12
NonDominant Hand Tapping	-1.61
Anxiety	-0.86
Conduct Problems	-0.42
Hyperactivity Index	-0.35
Impulsivity-Hyperactivity	-0.51
Learning Problems	1.5
Psychosomatic Problems	0.11

Data Sheet

ID# 2882 Age in months 93 Sex M MARUSE Q

Test	Standardized score
Full Scale I.Q.	113
Verbal I.Q.	120
Performance I.Q.	102
Verbal Comprehension	13.3.10.8
Perceptual Organization	11.7
Freedom from Distractibility	115
Syntax Quotient	116
Passage Comprehension	117
WRAT Reading	114
WRAT Spelling	107
WRAT Arithmetic	52
Stroop Interference	4
Knox Cube	14
Visual Discrimination	10
Visual Memory	14
Visual Spatial Relations	7
Visual Form Constancy	6
Visual Sequential Memory	15
Visual Figure Ground	12
Visual Closure	108
Perceptual Quotient	0.75
Trails A	108
Draw-A-Man	8
Beery VMI	0.30
Dominant Hand Tapping	-0.78
NonDominant Hand Tapping	-1.0
Anxiety	-0.63
Conduct Problems	-0.63
Hyperactivity Index	-0.30
Impulsivity-Hyperactivity	-0.87
Learning Problems	0.30
Psychosomatic Problems	

Data Sheet

ID# **2891** Age in months **113** Sex **M** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	112
Verbal I.Q.	105
Performance I.Q.	118
Verbal Comprehension	11.3
Perceptual Organization	12.5
Freedom from Distractibility	13.0
Syntax Quotient	115
Passage Comprehension	95
WRAT Reading	87
WRAT Spelling	74
WRAT Arithmetic	85
Stroop Interference	49
Knox Cube	13
Visual Discrimination	17
Visual Memory	13
Visual Spatial Relations	12
Visual Form Constancy	12
Visual Sequential Memory	12
Visual Figure Ground	19
Visual Closure	14
Perceptual Quotient	130
Trails A	0.58
Draw-A-Man	112
Beery VMI	7
Dominant Hand Tapping	1.41
NonDominant Hand Tapping	1.04
Anxiety	1.23
Conduct Problems	1.68.1.68
Hyperactivity Index	0.97
Impulsivity-Hyperactivity	1.37
Learning Problems	0.85
Psychosomatic Problems	

Data Sheet

ID# **2931** Age in months **110** Sex **F** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	134
Verbal I.Q.	133
Performance I.Q.	129
Verbal Comprehension	15.5
Perceptual Organization	13.8
Freedom from Distractibility	14.7
Syntax Quotient	126
Passage Comprehension	113
WRAT Reading	117
WRAT Spelling	97
WRAT Arithmetic	99
Stroop Interference	55
Knox Cube	13
Visual Discrimination	19
Visual Memory	18
Visual Spatial Relations	19
Visual Form Constancy	14
Visual Sequential Memory	12
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	152
Trails A	1.15
Draw-A-Man	98
Beery VMI	10
Dominant Hand Tapping	0.58
NonDominant Hand Tapping	0.40
Anxiety	0.46
Conduct Problems	1.19
Hyperactivity Index	1.70
Impulsivity-Hyperactivity	1.61
Learning Problems	0.84
Psychosomatic Problems	1.54

Data Sheet

ID# 3421 Age in months 111 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	143
Verbal I.Q.	143
Performance I.Q.	133
Verbal Comprehension	17.8
Perceptual Organization	16.0
Freedom from Distractibility	11.7
Syntax Quotient	134
Passage Comprehension	123
WRAT Reading	124
WRAT Spelling	112
WRAT Arithmetic	108
Stroop Interference	49
Knox Cube	12
Visual Discrimination	19
Visual Memory	18
Visual Spatial Relations	15
Visual Form Constancy	16
Visual Sequential Memory	15
Visual Figure Ground	18
Visual Closure	19
Perceptual Quotient	152
Trails A	1.05
Draw-A-Man	100
Beery VMI	13
Dominant Hand Tapping	0.05
NonDominant Hand Tapping	-0.05
Anxiety	-0.36
Conduct Problems	-0.74
Hyperactivity Index	0.32
Impulsivity-Hyperactivity	1.38
Learning Problems	-0.08
Psychosomatic Problems	-0.69

Data Sheet

ID# 3882 Age in months 86 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	125
Verbal I.Q.	119
Performance I.Q.	126
Verbal Comprehension	13.8
Perceptual Organization	14.5
Freedom from Distractibility	10.7
Syntax Quotient	94
Passage Comprehension	95
WRAT Reading	72
WRAT Spelling	81
WRAT Arithmetic	77
Stroop Interference	58
Knox Cube	16
Visual Discrimination	19
Visual Memory	15
Visual Spatial Relations	17
Visual Form Constancy	9
Visual Sequential Memory	17
Visual Figure Ground	18
Visual Closure	7
Perceptual Quotient	133
Trails A	1.46
Draw-A-Man	90
Beery VMI	8
Dominant Hand Tapping	0.59
NonDominant Hand Tapping	0.98
Anxiety	0.47
Conduct Problems	0.0
Hyperactivity Index	-1.28
Impulsivity-Hyperactivity	-1.13
Learning Problems	-0.87
Psychosomatic Problems	-0.57

Data Sheet

ID# 3891 Age in months 104 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	123
Verbal I.Q.	127
Performance I.Q.	112
Verbal Comprehension	15.3
Perceptual Organization	11.5
Freedom from Distractibility	10.7
Syntax Quotient	91
Passage Comprehension	104
WRAT Reading	101
WRAT Spelling	94
WRAT Arithmetic	69
Stroop Interference	57
Knox Cube	14
Visual Discrimination	11
Visual Memory	9
Visual Spatial Relations	11
Visual Form Constancy	15
Visual Sequential Memory	13
Visual Figure Ground	16
Visual Closure	10
Perceptual Quotient	116
Trails A	0.39
Draw-A-Man	93
Beery VMI	6
Dominant Hand Tapping	0.01
NonDominant Hand Tapping	0.09
Anxiety	0.65
Conduct Problems	-0.27
Hyperactivity Index	-1.4
Impulsivity-Hyperactivity	-1.61
Learning Problems	-1.18
Psychosomatic Problems	-0.70

Data Sheet

ID# 3911 Age in months 100 Sex F MARUSE 1

Test	Standardized score
Full Scale I.Q.	128
Verbal I.Q.	122
Performance I.Q.	130
Verbal Comprehension	13.0
Perceptual Organization	13.8
Freedom from Distractibility	15.0
Syntax Quotient	102
Passage Comprehension	88
WRAT Reading	71
WRAT Spelling	83
WRAT Arithmetic	83
Stroop Interference	53
Knox Cube	12
Visual Discrimination	19
Visual Memory	15
Visual Spatial Relations	16
Visual Form Constancy	12
Visual Sequential Memory	16
Visual Figure Ground	17
Visual Closure	18
Perceptual Quotient	145
Trails A	1.3
Draw-A-Man	110
Beery VMI	11
Dominant Hand Tapping	0.02
NonDominant Hand Tapping	0.88
Anxiety	0.65
Conduct Problems	1.82
Hyperactivity Index	1.21
Impulsivity-Hyperactivity	0.08
Learning Problems	4.74
Psychosomatic Problems	-0.70

Data Sheet

ID# 4011 Age in months 101 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	117
Verbal I.Q.	122
Performance I.Q.	106
Verbal Comprehension	14.5
Perceptual Organization	11.3
Freedom from Distractibility	9.7
Syntax Quotient	102
Passage Comprehension	113
WRAT Reading	100
WRAT Spelling	99
WRAT Arithmetic	103
Stroop Interference	55
Knox Cube	8
Visual Discrimination	15
Visual Memory	19
Visual Spatial Relations	16
Visual Form Constancy	18
Visual Sequential Memory	16
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	154
Trails A	0.55
Draw-A-Man	96
Beery VMI	8
Dominant Hand Tapping	1.48
NonDominant Hand Tapping	1.2
Anxiety	0.96
Conduct Problems	-0.63
Hyperactivity Index	-0.41
Impulsivity-Hyperactivity	-0.72
Learning Problems	-0.31
Psychosomatic Problems	1.17

Data Sheet

ID# **4331** Age in months **93** Sex **M** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	125
Verbal I.Q.	124
Performance I.Q.	120
Verbal Comprehension	14.8
Perceptual Organization	13.0
Freedom from Distractibility	12.3
Syntax Quotient	124
Passage Comprehension	112
WRAT Reading	96
WRAT Spelling	90
WRAT Arithmetic	107
Stroop Interference	51
Knox Cube	16
Visual Discrimination	14
Visual Memory	13
Visual Spatial Relations	17
Visual Form Constancy	15
Visual Sequential Memory	13
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	142
Trails A	1.36
Draw-A-Man	134
Beery VMI	14
Dominant Hand Tapping	0.68
NonDominant Hand Tapping	1.33
Anxiety	-0.51
Conduct Problems	-1.25
Hyperactivity Index	0.02
Impulsivity-Hyperactivity	0.12
Learning Problems	0.24
Psychosomatic Problems	0.30

Data Sheet

ID# **4421** Age in months **97** Sex **M** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	102
Verbal I.Q.	86
Performance I.Q.	123
Verbal Comprehension	8.0
Perceptual Organization	12.8
Freedom from Distractibility	10.3
Syntax Quotient	81
Passage Comprehension	95
WRAT Reading	86
WRAT Spelling	80
WRAT Arithmetic	88
Stroop Interference	54
Knox Cube	15
Visual Discrimination	15
Visual Memory	9
Visual Spatial Relations	11
Visual Form Constancy	18
Visual Sequential Memory	11
Visual Figure Ground	14
Visual Closure	13
Perceptual Quotient	122
Trails A	0.64
Draw-A-Man	104
Beery VMI	14
Dominant Hand Tapping	-0.08
NonDominant Hand Tapping	-1.31
Anxiety	-0.02
Conduct Problems	0.2
Hyperactivity Index	1.76
Impulsivity-Hyperactivity	1.37
Learning Problems	1.91
Psychosomatic Problems	2.91

Data Sheet

ID# 5241 Age in months 89 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	119
Verbal I.Q.	122
Performance I.Q.	111
Verbal Comprehension	14.8
Perceptual Organization	13.3
Freedom from Distractibility	7.0
Syntax Quotient	111
Passage Comprehension	111
WRAT Reading	88
WRAT Spelling	84
WRAT Arithmetic	82
Stroop Interference	53
Knox Cube	0
Visual Discrimination	19
Visual Memory	15
Visual Spatial Relations	14
Visual Form Constancy	13
Visual Sequential Memory	10
Visual Figure Ground	11
Visual Closure	9
Perceptual Quotient	122
Trails A	-0.16
Draw-A-Man	95
Beery VMI	6
Dominant Hand Tapping	-1.12
NonDominant Hand Tapping	-0.55
Anxiety	-0.48
Conduct Problems	-0.57
Hyperactivity Index	-1.40
Impulsivity-Hyperactivity	-0.34
Learning Problems	-0.53
Psychosomatic Problems	-0.70

Data Sheet

ID# 5101 Age in months 96 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	118
Verbal I.Q.	114
Performance I.Q.	117
Verbal Comprehension	13.5
Perceptual Organization	13.8
Freedom from Distractibility	9.0
Syntax Quotient	115
Passage Comprehension	112
WRAT Reading	91
WRAT Spelling	83
WRAT Arithmetic	83
Stroop Interference	52
Knox Cube	8
Visual Discrimination	15
Visual Memory	12
Visual Spatial Relations	13
Visual Form Constancy	9
Visual Sequential Memory	14
Visual Figure Ground	13
Visual Closure	16
Perceptual Quotient	123
Trails A	0.22
Draw-A-Man	106
Beery VMI	7
Dominant Hand Tapping	-0.35
NonDominant Hand Tapping	-0.22
Anxiety	0.47
Conduct Problems	-0.63
Hyperactivity Index	-0.41
Impulsivity-Hyperactivity	-0.30
Learning Problems	0.8
Psychosomatic Problems	1.17

Data Sheet

ID# 5361 Age in months 93 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	133
Verbal I.Q.	115
Performance I.Q.	145
Verbal Comprehension	12.5
Perceptual Organization	16.3
Freedom from Distractibility	15.0
Syntax Quotient	113
Passage Comprehension	121
WRAT Reading	113
WRAT Spelling	98
WRAT Arithmetic	112
Stroop Interference	51
Knox Cube	0
Visual Discrimination	19
Visual Memory	19
Visual Spatial Relations	19
Visual Form Constancy	19
Visual Sequential Memory	15
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	160
Trails A	1.66
Draw-A-Man	110
Beery VMI	17
Dominant Hand Tapping	1.06
NonDominant Hand Tapping	-1.67
Anxiety	0.47
Conduct Problems	-0.43
Hyperactivity Index	-0.63
Impulsivity-Hyperactivity	0.12
Learning Problems	-1.42
Psychosomatic Problems	-0.57

Data Sheet

ID# 5421 Age in months 92 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	145
Verbal I.Q.	141
Performance I.Q.	141
Verbal Comprehension	16.8
Perceptual Organization	14.3
Freedom from Distractibility	16.5
Syntax Quotient	132
Passage Comprehension	99
WRAT Reading	117
WRAT Spelling	92
WRAT Arithmetic	99
Stroop Interference	53
Knox Cube	16
Visual Discrimination	19
Visual Memory	15
Visual Spatial Relations	14
Visual Form Constancy	15
Visual Sequential Memory	12
Visual Figure Ground	19
Visual Closure	19
Perceptual Quotient	145
Trails A	0.35
Draw-A-Man	141
Beery VMI	15
Dominant Hand Tapping	1.05
NonDominant Hand Tapping	-0.22
Anxiety	-0.02
Conduct Problems	0.42
Hyperactivity Index	0.02
Impulsivity-Hyperactivity	0.53
Learning Problems	-0.31
Psychosomatic Problems	-0.57

Data Sheet

ID# 5691 Age in months 82 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	129
Verbal I.Q.	123
Performance I.Q.	130
Verbal Comprehension	14.8
Perceptual Organization	13.8
Freedom from Distractibility	11.7
Syntax Quotient	117
Passage Comprehension	105
WRAT Reading	103
WRAT Spelling	92
WRAT Arithmetic	113
Stroop Interference	55
Knox Cube	18
Visual Discrimination	18
Visual Memory	16
Visual Spatial Relations	19
Visual Form Constancy	12
Visual Sequential Memory	18
Visual Figure Ground	19
Visual Closure	12
Perceptual Quotient	146
Trails A	2.28
Draw-A-Man	115
Beery VMI	8
Dominant Hand Tapping	0.61
NonDominant Hand Tapping	0.13
Anxiety	-0.51
Conduct Problems	-0.63
Hyperactivity Index	-0.85
Impulsivity-Hyperactivity	-0.18
Learning Problems	-1.4
Psychosomatic Problems	0.57

Data Sheet

ID# 5721 Age in months 83 Sex F MARUSE Q

Test	Standardized score
Full Scale I.Q.	107
Verbal I.Q.	108
Performance I.Q.	105
Verbal Comprehension	11.3
Perceptual Organization	11.0
Freedom from Distractibility	9.0
Syntax Quotient	106
Passage Comprehension	102
WRAT Reading	88
WRAT Spelling	68
WRAT Arithmetic	82
Stroop Interference	71
Knox Cube	0
Visual Discrimination	11
Visual Memory	11
Visual Spatial Relations	12
Visual Form Constancy	14
Visual Sequential Memory	10
Visual Figure Ground	17
Visual Closure	14
Perceptual Quotient	120
Trails A	0.86
Draw-A-Man	88
Beery VMI	7
Dominant Hand Tapping	0.58
NonDominant Hand Tapping	0.66
Anxiety	0.27
Conduct Problems	-1.18
Hyperactivity Index	-0.83
Impulsivity-Hyperactivity	-0.76
Learning Problems	-0.53
Psychosomatic Problems	0.04

Data Sheet

ID# 5881 Age in months 101 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	127
Verbal I.Q.	123
Performance I.Q.	126
Verbal Comprehension	13.8
Perceptual Organization	14.0
Freedom from Distractibility	11.0
Syntax Quotient	106
Passage Comprehension	98
WRAT Reading	89
WRAT Spelling	86
WRAT Arithmetic	108
Stroop Interference	52
Knox Cube	15
Visual Discrimination	18
Visual Memory	19
Visual Spatial Relations	16
Visual Form Constancy	12
Visual Sequential Memory	19
Visual Figure Ground	19
Visual Closure	18
Perceptual Quotient	153
Trails A	1.31
Draw-A-Man	100
Beery VMI	13
Dominant Hand Tapping	1.48
NonDominant Hand Tapping	1.42
Anxiety	-0.02
Conduct Problems	0.0
Hyperactivity Index	-1.06
Impulsivity-Hyperactivity	-1.13
Learning Problems	-0.87
Psychosomatic Problems	-0.56

Data Sheet

ID# **5882** Age in months **80** Sex **M** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	121
Verbal I.Q.	112
Performance I.Q.	128
Verbal Comprehension	12.0
Perceptual Organization	14.0
Freedom from Distractibility	12.0
Syntax Quotient	100
Passage Comprehension	74
WRAT Reading	82
WRAT Spelling	87
WRAT Arithmetic	108
Stroop Interference	54
Knox Cube	6
Visual Discrimination	12
Visual Memory	18
Visual Spatial Relations	18
Visual Form Constancy	12
Visual Sequential Memory	13
Visual Figure Ground	16
Visual Closure	10
Perceptual Quotient	130
Trails A	2.35
Draw-A-Man	99
Beery VMI	12
Dominant Hand Tapping	1.29
NonDominant Hand Tapping	1.23
Anxiety	-0.02
Conduct Problems	-0.43
Hyperactivity Index	-0.85
Impulsivity-Hyperactivity	-1.55
Learning Problems	-0.87
Psychosomatic Problems	-0.57

Data Sheet

ID# 5911 Age in months 79 Sex F MARUSE 1

Test	Standardized score
Full Scale I.Q.	105
Verbal I.Q.	105
Performance I.Q.	105
Verbal Comprehension	11.0
Perceptual Organization	11.8
Freedom from Distractibility	8.7
Syntax Quotient	100
Passage Comprehension	75
WRAT Reading	88
WRAT Spelling	68
WRAT Arithmetic	100
Stroop Interference	54
Knox Cube	6
Visual Discrimination	19
Visual Memory	9
Visual Spatial Relations	11
Visual Form Constancy	19
Visual Sequential Memory	13
Visual Figure Ground	18
Visual Closure	10
Perceptual Quotient	130
Trails A	0.52
Draw-A-Man	93
Beery VMI	11
Dominant Hand Tapping	0.21
NonDominant Hand Tapping	0.80
Anxiety	0.65
Conduct Problems	-1.18
Hyperactivity Index	-0.26
Impulsivity-Hyperactivity	-1.19
Learning Problems	-0.53
Psychosomatic Problems	-0.70

Data Sheet

ID# 5731 Age in months 96 Sex F MARUSE 1

Test	Standardized score
Full Scale I.Q.	108
Verbal I.Q.	101
Performance I.Q.	115
Verbal Comprehension	10.5
Perceptual Organization	13.5
Freedom from Distractibility	9.3
Syntax Quotient	121
Passage Comprehension	113
WRAT Reading	121
WRAT Spelling	97
WRAT Arithmetic	88
Stroop Interference	53
Knox Cube	8
Visual Discrimination	15
Visual Memory	14
Visual Spatial Relations	16
Visual Form Constancy	14
Visual Sequential Memory	14
Visual Figure Ground	19
Visual Closure	16
Perceptual Quotient	139
Trails A	1.14
Draw-A-Man	106
Beery VMI	10
Dominant Hand Tapping	-0.26
NonDominant Hand Tapping	-0.77
Anxiety	-0.48
Conduct Problems	-1.18
Hyperactivity Index	-1.4
Impulsivity-Hyperactivity	-1.19
Learning Problems	-0.53.-0.70
Psychosomatic Problems	

Data Sheet

ID# 5732 Age in months 79 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	112
Verbal I.Q.	111
Performance I.Q.	111
Verbal Comprehension	12.5
Perceptual Organization	12.0
Freedom from Distractibility	9.7
Syntax Quotient	89
Passage Comprehension	119
WRAT Reading	117
WRAT Spelling	120
WRAT Arithmetic	113
Stroop Interference	54
Knox Cube	18
Visual Discrimination	14
Visual Memory	10
Visual Spatial Relations	14
Visual Form Constancy	13
Visual Sequential Memory	9
Visual Figure Ground	13
Visual Closure	10
Perceptual Quotient	113
Trails A	1.55
Draw-A-Man	94
Beery VMI	10
Dominant Hand Tapping	-0.09
NonDominant Hand Tapping	0.46
Anxiety	0.47
Conduct Problems	-1.25
Hyperactivity Index	-0.41
Impulsivity-Hyperactivity	-0.72
Learning Problems	0.24
Psychosomatic Problems	-0.57

Data Sheet

ID# 5931 Age in months 73 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	131
Verbal I.Q.	146
Performance I.Q.	108
Verbal Comprehension	14.8
Perceptual Organization	10.3
Freedom from Distractibility	14.7
Syntax Quotient	111
Passage Comprehension	76
WRAT Reading	88
WRAT Spelling	115
WRAT Arithmetic	105
Stroop Interference	54
Knox Cube	6
Visual Discrimination	19
Visual Memory	14
Visual Spatial Relations	13
Visual Form Constancy	6
Visual Sequential Memory	12
Visual Figure Ground	13
Visual Closure	9
Perceptual Quotient	119
Trails A	1.55
Draw-A-Man	94
Beery VMI	9
Dominant Hand Tapping	-0.71
NonDominant Hand Tapping	1.80
Anxiety	-0.51
Conduct Problems	0.40
Hyperactivity Index	0.02
Impulsivity-Hyperactivity	-0.72
Learning Problems	0.80
Psychosomatic Problems	-0.57

Data Sheet

ID# 6001 Age in months 74 Sex F MARUSE 1

Test	Standardized score
Full Scale I.Q.	118
Verbal I.Q.	119
Performance I.Q.	112
Verbal Comprehension	13.3
Perceptual Organization	12.3
Freedom from Distractibility	12.0
Syntax Quotient	121
Passage Comprehension	76
WRAT Reading	96
WRAT Spelling	71
WRAT Arithmetic	95
Stroop Interference	55
Knox Cube	-2
Visual Discrimination	9
Visual Memory	10
Visual Spatial Relations	13
Visual Form Constancy	16
Visual Sequential Memory	17
Visual Figure Ground	4
Visual Closure	9
Perceptual Quotient	108
Trails A	1.66
Draw-A-Man	85
Beery VMI	9
Dominant Hand Tapping	-2.15
NonDominant Hand Tapping	-1.44
Anxiety	0.65
Conduct Problems	0.93
Hyperactivity Index	1.46
Impulsivity-Hyperactivity	0.08
Learning Problems	2.76
Psychosomatic Problems	0.04

Data Sheet

ID# 6051 Age in months 86 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	106
Verbal I.Q.	114
Performance I.Q.	96
Verbal Comprehension	11.8
Perceptual Organization	9.3
Freedom from Distractibility	12.3
Syntax Quotient	96
Passage Comprehension	104
WRAT Reading	107
WRAT Spelling	97
WRAT Arithmetic	110
Stroop Interference	55
Knox Cube	16
Visual Discrimination	12
Visual Memory	15
Visual Spatial Relations	12
Visual Form Constancy	9
Visual Sequential Memory	15
Visual Figure Ground	9
Visual Closure	11
Perceptual Quotient	113
Trails A	1.26
Draw-A-Man	86
Beery VMI	5
Dominant Hand Tapping	0.48
NonDominant Hand Tapping	-0.09
Anxiety	-0.02
Conduct Problems	2.5
Hyperactivity Index	1.98
Impulsivity-Hyperactivity	2.62
Learning Problems	0.24
Psychosomatic Problems	-0.57

Data Sheet

ID# 6052 Age in months 74 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	114
Verbal I.Q.	112
Performance I.Q.	114
Verbal Comprehension	12.3
Perceptual Organization	12.5
Freedom from Distractibility	12.0
Syntax Quotient	106
Passage Comprehension	76
WRAT Reading	88
WRAT Spelling	61
WRAT Arithmetic	95
Stroop Interference	54
Knox Cube	6
Visual Discrimination	6
Visual Memory	13
Visual Spatial Relations	10
Visual Form Constancy	11
Visual Sequential Memory	10
Visual Figure Ground	15
Visual Closure	9
Perceptual Quotient	104
Trails A	2.17
Draw-A-Man	96
Beery VMI	5
Dominant Hand Tapping	0.21
NonDominant Hand Tapping	1.23
Anxiety	0.02
Conduct Problems	-0.43
Hyperactivity Index	-1.28
Impulsivity-Hyperactivity	-1.13
Learning Problems	-0.87
Psychosomatic Problems	2.04

Data Sheet

ID# 6071 Age in months 74 Sex F MARUSE 1

Test	Standardized score
Full Scale I.Q.	122
Verbal I.Q.	124
Performance I.Q.	114
Verbal Comprehension	15.0
Perceptual Organization	12.0
Freedom from Distractibility	10.7
Syntax Quotient	98
Passage Comprehension	76
WRAT Reading	89
WRAT Spelling	96
WRAT Arithmetic	100
Stroop Interference	54
Knox Cube	0
Visual Discrimination	19
Visual Memory	11
Visual Spatial Relations	17
Visual Form Constancy	16
Visual Sequential Memory	13
Visual Figure Ground	19
Visual Closure	11
Perceptual Quotient	137
Trails A	1.51
Draw-A-Man	100
Beery VMI	9
Dominant Hand Tapping	0.71
NonDominant Hand Tapping	0.70
Anxiety	-0.11
Conduct Problems	0.32
Hyperactivity Index	1.17
Impulsivity-Hyperactivity	0.93
Learning Problems	0.13
Psychosomatic Problems	3.0

Data Sheet

ID# 6151 Age in months 99 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	118
Verbal I.Q.	106
Performance I.Q.	124
Verbal Comprehension	11.3
Perceptual Organization	14.0
Freedom from Distractibility	12.3
Syntax Quotient	104
Passage Comprehension	94
WRAT Reading	91
WRAT Spelling	86
WRAT Arithmetic	93
Stroop Interference	43
Knox Cube	-4
Visual Discrimination	18
Visual Memory	12
Visual Spatial Relations	13
Visual Form Constancy	11
Visual Sequential Memory	19
Visual Figure Ground	14
Visual Closure	14
Perceptual Quotient	132
Trails A	0.55
Draw-A-Man	112
Beery VMI	11
Dominant Hand Tapping	2.39
NonDominant Hand Tapping	1.63
Anxiety	1.45
Conduct Problems	3.75
Hyperactivity Index	2.63
Impulsivity-Hyperactivity	2.20
Learning Problems	1.36
Psychosomatic Problems	2.04

Data Sheet

ID# 6152 Age in months 72 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	131
Verbal I.Q.	128
Performance I.Q.	128
Verbal Comprehension	15.0
Perceptual Organization	12.7
Freedom from Distractibility	13.7
Syntax Quotient	115
Passage Comprehension	75
WRAT Reading	89
WRAT Spelling	89
WRAT Arithmetic	95
Stroop Interference	54
Knox Cube	-4
Visual Discrimination	14
Visual Memory	10
Visual Spatial Relations	7
Visual Form Constancy	12
Visual Sequential Memory	11
Visual Figure Ground	8
Visual Closure	15
Perceptual Quotient	107
Trails A	1.51
Draw-A-Man	117
Beery VMI	7
Dominant Hand Tapping	0.71
NonDominant Hand Tapping	1.46
Anxiety	1.45
Conduct Problems	0.83
Hyperactivity Index	1.33
Impulsivity-Hyperactivity	2.61
Learning Problems	0.24
Psychosomatic Problems	0.30

Data Sheet

ID# **6451** Age in months **78** Sex **F** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	115
Verbal I.Q.	113
Performance I.Q.	114
Verbal Comprehension	12.8
Perceptual Organization	12.8
Freedom from Distractibility	11.0
Syntax Quotient	104
Passage Comprehension	122
WRAT Reading	133
WRAT Spelling	96
WRAT Arithmetic	95
Stroop Interference	49
Knox Cube	2
Visual Discrimination	19
Visual Memory	11
Visual Spatial Relations	19
Visual Form Constancy	12
Visual Sequential Memory	11
Visual Figure Ground	6
Visual Closure	7
Perceptual Quotient	116
Trails A	1.95
Draw-A-Man	115
Beery VMI	6
Dominant Hand Tapping	-1.65
NonDominant Hand Tapping	-1.97
Anxiety	0.25
Conduct Problems	0.25
Hyperactivity Index	0.50
Impulsivity-Hyperactivity	1.0
Learning Problems	0.25
Psychosomatic Problems	0.0

Data Sheet

ID# 6481 Age in months 76 Sex F MARUSE 0

Test	Standardized score
Full Scale I.Q.	107
Verbal I.Q.	111
Performance I.Q.	102
Verbal Comprehension	12.3
Perceptual Organization	9.0
Freedom from Distractibility	12.0
Syntax Quotient	119
Passage Comprehension	76
WRAT Reading	95
WRAT Spelling	105
WRAT Arithmetic	90
Stroop Interference	54
Knox Cube	12
Visual Discrimination	19
Visual Memory	14
Visual Spatial Relations	8
Visual Form Constancy	15
Visual Sequential Memory	17
Visual Figure Ground	6
Visual Closure	11
Perceptual Quotient	121
Trails A	1.8
Draw-A-Man	85
Beery VMI	10
Dominant Hand Tapping	-1.35
NonDominant Hand Tapping	-2.54
Anxiety	0.27
Conduct Problems	0.93
Hyperactivity Index	1.46
Impulsivity-Hyperactivity	2.20
Learning Problems	0.79
Psychosomatic Problems	-0.70

Data Sheet

ID# 6491 Age in months 73 Sex M MARUSE 0

Test	Standardized score
Full Scale I.Q.	117
Verbal I.Q.	114
Performance I.Q.	115
Verbal Comprehension	14.3
Perceptual Organization	12.5
Freedom from Distractibility	8.3
Syntax Quotient	111
Passage Comprehension	76
WRAT Reading	91
WRAT Spelling	74
WRAT Arithmetic	100
Stroop Interference	68
Knox Cube	1:2
Visual Discrimination	15
Visual Memory	18
Visual Spatial Relations	10
Visual Form Constancy	14
Visual Sequential Memory	18
Visual Figure Ground	10
Visual Closure	9
Perceptual Quotient	125
Trails A	1.88
Draw-A-Man	86
Beery VMI	9
Dominant Hand Tapping	1.68
NonDominant Hand Tapping	0.13
Anxiety	0.47
Conduct Problems	-1.05
Hyperactivity Index	-1.07
Impulsivity-Hyperactivity	-1.13
Learning Problems	-0.31
Psychosomatic Problems	-0.57

Data Sheet

ID# **6501** Age in months **85** Sex **M** MARUSE **1**

Test	Standardized score
Full Scale I.Q.	137
Verbal I.Q.	143
Performance I.Q.	121
Verbal Comprehension	14.8
Perceptual Organization	13.0
Freedom from Distractibility	12.0
Syntax Quotient	100
Passage Comprehension	120
WRAT Reading	118
WRAT Spelling	113
WRAT Arithmetic	110
Stroop Interference	50
Knox Cube	0
Visual Discrimination	15
Visual Memory	17
Visual Spatial Relations	12
Visual Form Constancy	9
Visual Sequential Memory	18
Visual Figure Ground	7
Visual Closure	16
Perceptual Quotient	125
Trails A	0.86
Draw-A-Man	92
Beery VMI	8
Dominant Hand Tapping	-1.52
NonDominant Hand Tapping	-0.22
Anxiety	0.47
Conduct Problems	-0.20
Hyperactivity Index	0.46
Impulsivity-Hyperactivity	2.20
Learning Problems	-0.87
Psychosomatic Problems	0.30

Data Sheet

ID# 6591 Age in months 88 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	116
Verbal I.Q.	108
Performance I.Q.	121
Verbal Comprehension	11.8
Perceptual Organization	13.0
Freedom from Distractibility	11.0
Syntax Quotient	100
Passage Comprehension	124
WRAT Reading	110
WRAT Spelling	94
WRAT Arithmetic	93
Stroop Interference	48
Knox Cube	16
Visual Discrimination	17
Visual Memory	15
Visual Spatial Relations	12
Visual Form Constancy	11
Visual Sequential Memory	11
Visual Figure Ground	15
Visual Closure	8
Perceptual Quotient	120
Trails A	2.07
Draw-A-Man	108
Beery VMI	7
Dominant Hand Tapping	2.65
NonDominant Hand Tapping	-0.68
Anxiety	-0.02
Conduct Problems	-0.63
Hyperactivity Index	-1.28
Impulsivity-Hyperactivity	-1.55
Learning Problems	-0.87
Psychosomatic Problems	-0.57

Data Sheet

ID# 6631 Age in months 76 Sex M MARUSE 1

Test	Standardized score
Full Scale I.Q.	124
Verbal I.Q.	122
Performance I.Q.	121
Verbal Comprehension	14.3
Perceptual Organization	12.5
Freedom from Distractibility	12.7
Syntax Quotient	106
Passage Comprehension	76
WRAT Reading	95
WRAT Spelling	83
WRAT Arithmetic	95
Stroop Interference	54
Knox Cube	16
Visual Discrimination	13
Visual Memory	11
Visual Spatial Relations	10
Visual Form Constancy	13
Visual Sequential Memory	11
Visual Figure Ground	12
Visual Closure	14
Perceptual Quotient	115
Trails A	1.98
Draw-A-Man	91
Beery VMI	5
Dominant Hand Tapping	0.31
NonDominant Hand Tapping	1.91
Anxiety	0.47
Conduct Problems	2.28
Hyperactivity Index	3.06
Impulsivity-Hyperactivity	1.78
Learning Problems	3.02
Psychosomatic Problems	1.17

END

25/02/91

FIN