Arrested Development

The Impacts of Pesticides on Children's Mental Health and Development

A GREENPEACE study
conducted in six states of India
in collaboration with:
DHARAMITRA, ICRA, SEWA,
JANACHETNA, SIRPI,
KHETI VIRASAT, SYO & YMC
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Principal Investigator: Ms Kavitha Kuruganti

Field Co ordinator: Ms Shalini

Advisors to the Research Project:

Dr Elizabeth Guillette,
Assistant Scientist, Department of Anthropology
University of Florida

Dr Romeo Quijano,
Professor, Department of Pharmacology & Toxicology,
University of the Philippines,

Dr Vijaya Raman,
Assistant Professor, Clinical Psychology
St. John's Medical College & Hospital, Bangalore

Dr S G Kabra,
Senior Physician, SDM Hospital, Jaipur

Friends from **NIMHANS**, Bangalore, mostly clinical psychologists

Dr Ravi Narayan and **Dr Francis** from Community Health Cell, Bangalore

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EXECUTIVE SUMMARY

1. Greenpeace India undertook a study called "Arrested Development" during April – December 2003 in India. The **objective** was to assess possible chronic effects of pesticides on children from different cotton-farming locations in India. The chronic effects that the study sought to assess were in the form of developmental abilities of children. The study is unique in that it is the first of its kind in India, with field-level research conducted in many states with a sizeable sample, with effects on children as its main focus.

2. The six locations were chosen from states and districts where cotton cultivation and pesticide use are high, and from where earlier reports of pesticide-related problems have emerged. The problems here could have been environmental, human health or agronomic. These locations are:

   - Bharuch in Gujarat (Halder, Kavitha and Samlod villages)
   - Bhatinda in Punjab (Bangi Nihal Singh, Jajjal and Mahi Nangal villages)
   - Raichur in Karnataka (Khanapur, Manjerla and Poorthipli villages)
   - Theni in Tamil Nadu (Rassingapuram, Silamalai and Visuvaspuram villages)
   - Yavatmal in Maharashtra (Dahelitanda, Kopamandvi and Sunna villages)
   - Warangal in Andhra Pradesh (Atmakur, Oglapur and Peddapur villages)

3. These are important cotton belts of the country and cotton cultivation implies intensive and high use of a dangerous cocktail of pesticides - organophosphorus, organochlorine, carbamate and synthetic pyrethroids, in addition to "new generation" pesticides like spinosad and nicotinoid (CNI) pesticides.

4. Two age groups of children were chosen for assessing developmental abilities – 4-5 year old children and 9-13 year old children. In all, 448 children in the age group of 4-5 years and another 451 children in the age group of 9-13 years were studied for possible chronic impacts from pesticides.

5. The study adopted a "comparative" or "cross sectional" design, where the effects on exposed children were sought to be established and understood in comparison with Reference/Control groups, wherein the children are similar in all major respects to the children in the study location, but differ significantly in terms of their exposure to pesticides. Thus, the study and reference locations are similar in all important and relevant socio-economic, genetic and cultural aspects but very dissimilar with regard to pesticide use and exposure.

6. A Rapid Assessment Tool (RAT) designed and used earlier in a similar scientific study in Mexico was used for the purpose of documenting the abilities of children, with suitable adaptation to the Indian conditions, after consultation with experts. This is based on a play approach, where the tool is individually and verbally administered. The tools administered are interpreted by the child as normal play. Later, the measurements of various abilities to perform and function in normal childhood activities by these children were analysed for each group, and compared between the Study and Reference location, for each age group and for each state.

7. The sample of 899 children[1] was chosen within a village while paying attention to adequate inclusion of all classes, communities, both sexes and all parts of a village. Similarly, a total of 749 less-pesticide-exposed children were assessed in the reference locations.

[1] 75 children in the 4-5 age group each, and 75 children from the 9-13 age group each from each state, from six states: in the end, 899 children were studied in all

8. **<u>The main findings from the study are</u>**:

Broadly, three different kinds of tests were administered to the children, each one to test particular abilities. These are:

- Analytical abilities, with three sub-tests in the case of 9-13 year old children, and four sub-tests in the case of 4-5 year old children.
- Motor abilities, with five sub-tests for 9-13 year old children, and five for 4-5 year old children.
- Concentration and memory with two sub-tests each for both age groups.

In the various abilities that the children were tested for, **in 86% of the tests in the younger age group and 84.2% of the tests in the older age group, the Reference location children displayed better performance abilities than the Exposed/Study group children. In 70.8% of these tests for 4-5 year olds and 70% of these tests in the case of 9-13 year olds, the results in favor of the Less-Exposed children were statistically significant.** In the 4-5 year old age group, only 6.6% of the total tests were significantly conclusive in favor of the Study location children, while it was 4.2% in the case of the 9-13 year old children. The remaining are tests where both groups have performed equally well, or have performed without any significance to the results.

This is a remarkable difference in abilities, and the trends are more or less consistent across different locations as well as the two age groups. These trends of better performance by the less-exposed children are reflected in different tests: for analytical abilities in the form of mental ability tests using wooden blocks, in the form of jigsaw puzzles, in the form of cognitive abilities; for fine motor skills and for stamina as well as for abilities of concentration and memory. The only tests where the less-exposed children did not perform better than the study location children were ball-catching exercises for measuring gross motor abilities amongst the 4-5 year olds, and the tactile perception tests for measuring analytical abilities amongst the 9-13 year olds. Even here, the fact that the less-exposed children did not perform better did not mean that the study group children performed better – the results are being presented as such only for statistically significant results, and therefore, the above picture.

Though all the study locations show similar trends of low abilities in the children, the locations where it is starker are Tamil Nadu (for both age groups), Punjab (for both age groups), Gujarat (more so in the case of 9-13 year old children), Maharashtra (in the case of 9-13 year old children) and Andhra Pradesh (in the case of 4-5 year old children).

These results of better performance by less-exposed children reinforce findings from another similar study on pesticides and also follow an expectable pattern from high use of pesticides (that too, ones that impair neuro-endocrinal systems).

9. It is not unknown that pesticides impact human health in various ways. Children are particularly vulnerable, given their particular physiology and behaviour patterns. Many studies have focused on the extent to which pesticides turn up in consumers' food and water (and soft drinks) in the form of residues. There has been much written about the economic and farming crisis that cotton farmers in this country have landed themselves into with indiscriminate use of pesticides. There are very few studies however which attempt to correlate pesticides to the health impacts that they cause. This is one such study, with sizeable samples and significant results.

10. This study captures the more insidious effects of pesticides in the long term (the chronic effects), as reflected in the development of children. This is a great cause for concern and

alarm since the very basic right to healthy development is being taken away from these children.

11. At another level, there are many successful instances of organic farming on cotton benefiting farmers in a variety of ways, including economic benefits. Unfortunately, such efforts have not received any support from the government and have therefore not been scaled up. The government has not pro-actively taken up an assessment of the alarming situation with regard to pesticides nor has it taken any steps to ban at least those pesticides that have been banned in other countries. The pesticide industry meanwhile continues to be unaccountable and continues to (aggressively) promote its poisonous products in a variety of ways.

12. Hazardous and toxic substances like pesticides require the scientific approach of a Precautionary Principle to be applied in their manufacture, distribution, marketing, storage and use. The current legislations, policies and practices in India do not adhere to this precautionary principle. They do not also conform to the FAO Code of Conduct to which India is a signatory, and to which the pesticide industry associations have pledged their commitment.

13. **In this context, Greenpeace demands the following immediately from various parties:**

    - Demands to the State: 1. The government should adopt a rational pesticides policy (a draft version annexed to the main report), 2. greater support to organic farming (especially on cotton) in terms of resources and mechanisms for more research, extension and crop loan support and infrastructure, 3. a ban on atleast all those pesticides that have been banned in other countries, and 4. regulate the pesticides industry and all its operations in a better fashion

    - To the Pesticides Industry: 1. pro-actively withdraw Class I a, I b and II pesticides, 2. stop aggressive marketing and promotion of pesticides, 3. immediate provision by the industry for compensation to and rehabilitation of all the poisoning victims, including the children.

INTRODUCTION TO THE STUDY "Arrested Development"

This is a study undertaken in six states of India by Greenpeace India, with the following objective:

- Assess the chronic effects of pesticides, especially on children and their development

Background and Rationale:

There are very few studies about the health effects of pesticides on farming community members in India, other than some valuable documentation available from Kasargod in Kerala[2].

Here, we are making a distinction between studies which have looked at pesticides from an urban consumer's perspective (in terms of residues in the human body, or in the food consumed) and ones that looked at the effects more from the farming community's perspective. While the former have been undertaken in more numbers, the latter are glaringly missing.

Other earlier studies:

Many ICAR (Indian Council of Agricultural Research) and ICMR (Indian Council of Medical Research) studies have focused on pesticide residues in our food, water and bodies.

Perusal of the residue data on pesticides in samples of fruits, vegetables, cereals, pulses, grains, wheat flour, oils, eggs, meat, fish, poultry, bovine milk, butter and cheese in India indicates their presence in sizeable amounts[3].

There have been studies to assess the amount of chemicals that a human body carries (also called as "body burden") in human milk, in human fat, in human blood and so on. It was discovered in such studies that Indians carry the highest body burden of organochlorine compounds in the world[4]. The levels of the residues in the food consumed or in the human body are clearly indicative of some of the potential health hazards that the ordinary public is exposed to, given that there are some known and predictable effects of pesticides.

When it comes to acute poisoning, much of the data is from hospital records, in addition to some documentation by agencies like the National Institute of Occupational Health (NIOH). The Poison Information Centre in NIOH, Ahmedabad reported that OP (organophosphorus) compounds were responsible for the maximum number of poisoning (73%) among all agricultural pesticides[5]. In a study on patients of acute OP poisoning (n=190), muscarinic manifestations such as vomiting (96%), nausea (82%), excessive salivation (61%) and blurred vision (54%), in addition to CNS (Central Nervous System) manifestations such as giddiness (93%), headache (84%), disturbances in consciousness (44%) were the common symptoms[6].

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[2] "Endosulfan Poisoning in Kasargod, Kerala, India": Report of a Fact Finding Mission by Dr Quijano, Romeo, Pesticide Action Network-Asia and the Pacific, November 2001; "Preliminary findings of the survey on the impact of aerial spraying on the people and the ecosystem – LMIPPE", Thanal Conservation Action and Information Network, October 2001
[3] "Pesticide Pollution: Trends and perspective": ICMR Bulletin, Vol. 31, No. 9, September 2001
[4] *ibid*
[5] "Acute poisonings due to agricultural poisonings reported to the NIOH Poison Information Centre": Dewan, A and Saiyed, H N, National Institute of Occupational Health, Ahmedabad, Page 136, 1998
[6] "A clinical, biochemical, neurobehavioural and socio-psychological study of 190 patients admitted to hospital as a result of acute organophosphorus poisoning": Agarwal, S.B., Environ Res 62-63, 1993

However, hospital records maintained in this country do not make a distinction between intentional poisoning and occupational/ accidental exposure to pesticides. There is a recognition that hospital-based surveillance systems also tend to underestimate and under-report the true picture of pesticide poisoning cases in the field. In fact, a few pilot studies taken up by the World Health Organisation and the International Program for Chemical Safety (IPCS) under their "Epidemiology of Pesticide Poisoning Programme" ended concluding that occupational and accidental exposure accounted for only a small proportion of poisonings in the surveys taken up[7].

In addition to acute poisoning, sprayers face occupational hazards of other kinds too. Compston et al reported reduced bone formation after exposure to organophosphates in 80 male agricultural workers[8]. The cumulative effects of low doses of organophosphates are also neuropsychological. A joint report by the UK Royal College of Physicians and Psychiatrists concluded that a wide range of often-severe symptoms such as excessive fatigue, poor concentration and suicidal thoughts are reported more frequently in populations exposed repeatedly. Chronic neuropsychological effects have been seen in 4-9% of patients exposed in occupation-related use.

The magnitude of toxicity risk involved in the spraying of methomyl, a carbamate pesticide in field conditions was assessed by NIOH in 1992 and the study showed significant cardio-toxic effects of methomyl. Other studies focused on reproductive toxicity by analyzing reproductive performance of couples where the males were pesticide sprayers, compared to unexposed couples[9]. Analysis gave the following incidence rates: abortions – 26% for exposed couples and 15% for unexposed couples; stillbirths – 8.7% Vs 2.6%; Neonatal deaths were at 9.2% in the exposed couples and 2.2% in the case of unexposed couples.

When it comes to women and children and the impacts of pesticides on them, there is very little systematic documentation. There have been instances of child rights groups in India pointing out to case studies of children affected in seed cotton fields, with some connections made to the pesticides used on the crop. Similarly, some unpublished material is available about women workers in tea plantations mostly from non-governmental groups. Activists campaigning against endosulfan poisoning in Kasargod in Kerala have also done extensive documentation of the effects seen mainly on children in the cashew plantation areas there.

In this context, we present some more information on Pesticides and Human Health in the following section.

Pesticides and Human Health:

Pesticides are chemicals that by design are meant to kill or harm living organisms. Anything that can kill or harm other living organisms has the potential to harm or kill human beings too.

The effects of pesticides on human health have generally been classified into two broad impacts: 1. acute effects and 2. chronic effects. The factors that contribute to the impact of pesticides on human beings are mainly three[10], presented here in layperson terms:

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[7] "Estimating the global impact of Acute Pesticide Intoxication": A protocol for Community Based Surveillance: Corbett, Stephen and Zuo, Yeqin, November 2002: an unpublished document
[8] "Reduced bone formation after exposure to organophosphates": Compston J E, Vedi S, Stephen AB: Lancet November 20, 1999
[9] "Reproductive performance in population exposed to pesticides in cotton fields in India": Rupa DS, Reddy, PP and Reddy, OS: Environmental Research 55: 123-128, 1991
[10] "Pesticides – Killers in our midst", from "Warning: Pesticides are dangerous to your health", Dr Moses, Marion: Pesticide Action Network Asia and the Pacific, November 1999

- how hazardous or poisonous a pesticide is, meaning the toxicity (the less it takes to kill, the more toxic), most popularly understood by the WHO classifications[11] – incidentally, this is not about long term effects
- how pesticides get into the body (by inhalation, by ingestion/swallowing, by dermal contact or exposure or through the eyes)
- how long the pesticides stay in the body (organochlorines for instance, take a longer time to break down; also, children and women have less efficient detoxifying mechanisms).

Acute or Immediate effects: These are effects seen within a very short time after exposure to pesticides. After pesticides go through the skin, they get into the blood stream and go throughout the body and once they get into the system, they can cause poisoning. Signs and symptoms of systemic poisoning include headaches, dizziness, nausea, vomiting, cramping, breathing difficulties and blurred vision. If the poisoning is severe and proper treatment is not available, death can occur. Most serious poisonings and deaths from pesticides occur in developing countries.

In 1990, the WHO noted that at least three million persons were intoxicated by pesticides throughout the world every year and that 20,000 of them died. Chronic poisonings were not included in this data[12]. According to estimates made in 1994, there were 2 to 5 million annual occupational cases of poisoning, with 40,000 fatalities[13].

According to Pesticides Action Network Asia and the Pacific, the numbers are higher. It is estimated that around 200,000 people are killed worldwide every year from pesticide poisoning. Daily, 68,000 farmers and workers are poisoned by pesticides and yearly, an estimated 25 million workers suffer pesticide poisoning around the world.

Nearly three-quarters of a million chemicals and chemical compounds are in use in agriculture throughout the world — and several thousand new ones appear on the scene every year. They are introduced into the production process so quickly there is little time to assess their potential harm to workers. In 1991 only 20 per cent of the world's pesticides were used in developing countries, yet they accounted for 99 per cent of the poisonings arising from their use[14].

It is important to mention here that India continues to allow production, marketing and use of certain Class I pesticides in the country – these include methyl parathion, phorate and phosphamidon in Class Ia (Extremely Hazardous), Oxydemeton-methyl, edifenphos, methamidophos, methomyl, monocrotophos etc., in Class Ib. In addition, many moderately hazardous (WHO Class II) pesticides are also implicated in earlier studies and reports of acute poisoning: these include, carbaryl, cypermethrin, endosulfan, fenvalerate, profenophos, quinalphos etc.

Here, it should also be added that some of these pesticides are so dangerous that there is no situation where they could be safely used in agriculture. The only way to deal with them is to eliminate their production and use. The Food and Agriculture Organisation of the UN (FAO) recommends that WHO Ia and Ib pesticides should not be used in developing countries, and if possible class II should also be avoided.

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[11] WHO classification measures acute toxicity and Class Ia and Ib are the most toxic, classified respectively as Extremely Hazardous and Highly Hazardous pesticides
[12] "The public health impact of pesticides used in agriculture", WHO/UNEP, 1990
[13] "Chemicals in the working environment", World Labour Report, ILO, 1994
[14] "Safety and Health in Agriculture", International Labour Conference 88th Session, ILO report, June 2000

Delayed, Chronic or Long term effects: These are effects which occur months or years after exposure, and are also induced by repeated occupational exposure to low concentrations of pesticides.

Chronic effects are the result of low levels of exposure over a long period of time. These can occur even if there are no acute effects. Some of the major health impacts from chronic exposure are cancers, reproductive and endocrine disruption, neurological damage, immune system damages etc.

There is a large body of evidence that pesticide exposure is a risk factor for cancer in humans, especially children. Studies done in the USA, several European countries, Brazil and China show that children whose parents are occupationally exposed to pesticides or whose parents use pesticides in and around the home are more likely to get leukemia, brain cancer, non-Hodgkin Lymphoma, soft tissue sarcoma and Wilm's tumour[15].

Potential neurological effects of pesticides include effects on memory, judgement and intelligence as well as personality, moods and behaviour[16]. Pesticides are also linked to allergies to a variety of chemicals, to respiratory diseases, neuro-muscular impairments, neuro-behavioural effects etc.

Many widely used pesticides are known to cause birth defects, sterility, increased spontaneous abortions, stillbirths etc. Many pesticides are known to be toxic to the embryo and foetus in laboratory animals. Teratogenesis (deformities created in the foetus) is another form of chronic toxicity in foetuses of women exposed to chemicals during their pregnancy. Persistent anorexia, weakness, malaise, and certain neurobehavioral effects are usually seen in repeated exposures.

Studies have shown a link between a variety of reproductive health impacts in women and pesticide exposure. Studies have documented increased incidence of miscarriages, stillbirths and delayed pregnancy among women agricultural workers and wives of men employed in pesticide mixing and spraying. Carbamate and organophosphate insecticides have been reported to increase birth prematurely and spontaneous abortion rates.

For instance, a study conducted in the USA by the School of Public Health, University of North Carolina found that mothers who lived near crops where certain pesticides were sprayed faced a 40 to 120 percent increase in risk of miscarriage due to birth defects[17]. Another study found that one month of maternal exposure to workplace pesticides during the first two months of pregnancy resulted in a 2.4 times increased risk towards stillbirth, due to congenital defects, compared to mothers with no such exposure[18].

As per a study published by Farm Family Health, 1999 Fall edition, a study called Ontario Farm Family Health Study found that exposure to phenoxy herbicides in the pre-conception period was associated with a higher risk of an early miscarriage (less than 12 weeks' pregnant). If the husband did not normally wear protective equipment during pesticide application, the estimated risk of an early miscarriage was approximately five times higher, compared to pregnancies not exposed to any pesticides. Many early miscarriages (before 12 weeks' gestation) are found to have serious genetic defects. There are many possible reasons for these genetic defects, among them abnormalities or errors in the genetic information carried in the sperm. Exposure to toxic agents during the three months prior to conception could cause this type of damage to the sperm.

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[15] "Warning: Pesticides are dangerous to your health", Pesticide Action Network Asia and the Pacific, 1999
[16] *ibid*
[17] Bell, Erin: Epidemiology, March 2001; 22: 148-156
[18] Occupational and Environmental Medicine, 1997; 54: 511-518

In California, mothers living and working in agricultural areas with high pesticide use had a higher risk for giving birth to children with limb reduction defects. (Schwartz, 1988). Another study of pregnant women in Iowa and Michigan found that women exposed to multiple pesticides had an increased risk of giving birth to a child with cleft palate. (Gordon, 1981). Researchers found higher rates of numerous birth defects in children born to Norwegian farmers exposed to pesticides, including hormone effects like hypospadia and undescended testicles. (Kristensen and others, 1997).

Chronic effects and their correlation to pesticides has been a challenging agenda, but it is now proven that pesticides are a major cause of many illnesses.

In addition to the acute and chronic effects mentioned above, pesticides are also known to exacerbate the conditions of existing diseases and illnesses. For instance, people with asthma and allergies, especially children, can react to low levels of pesticides that do not affect those without them. Pesticides can also cause irregular heart rhythms and people with heart disease may have a worsening of their condition when exposed. Pesticide exposure can also weaken the immune system and the most susceptible are children, pregnant women, those with chronic medical illnesses and cancer survivors[19].

While the various potential effects of pesticides are being mentioned here, it is very important to note that only some effects are known of only some chemicals that we are exposed to.

For instance, in India, the health and environmental effects of less than 50 percent of the registered pesticides are known. Compounding the problem is the fact that individual active ingredients are tested for their toxicological and other effects whereas the effects of the 'solvent' used for the formulations or the formulations themselves are not put through these tests. And worse yet is the reality of an individual being exposed to a cocktail of known and unknown pesticides at any point of time. The possible synergistic effects of these combined and mixed exposures have never been studied. This situation of multiple exposure is dismally addressed by the current regulations. Even where toxicological tests are conducted, there has been more than ample research and documentation done about sheer inadequacies of such tests even in the developed world.

A few words here about organophosphorus pesticides that are most commonly used in this country (high volume as well as value). The most common effect of these pesticides is neurotoxicity and effect on the central nervous system.

Common neurotoxicity symptoms[20] include impairment of intellectual abilities such as intelligence, attention, concentration, abstract reasoning, academic skills, cognitive efficiency and flexibility (dementia). Impairment of motor coordination due to neurotoxicity includes effects on fine motor speed, fine motor coordination, gross motor coordination, gross motor strength etc. Sensory and visuo-spatial effects include: visual disturbances, difficulty drawing or constructing, auditory disturbances, numbness and tingling, touch sensation disturbances and so on. Memory and learning can be affected: short term memory and learning (encoding) as well as long term memory.

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[19] "Warning: Pesticides are dangerous to your health", Pesticide Action Network Asia and the Pacific, 1999
[20] "Neuropsychological toxicology: identification and assessment of human neurotoxic syndromes", Hartmann, David E, 1988

METHODOLOGY OF THE STUDY

The study has adapted a methodology from a similar scientific study in another developing country.

Study Design:

The design is a comparative one ("cross-sectional") where comparison of developmental abilities between pesticides-exposed [Study group/Exposed group] children and less-exposed [Reference/Control] children has been taken up.

The control locations were very similar to the study locations with regard to many relevant and important parameters, except in that they consume significantly lower amounts of pesticides.

The Methodology:

The methodology closely follows an earlier scientific study in Mexico[21] for chronic effects (described more in the Tools Employed section). The adaptation was done in consultation with paediatric and child psychiatry experts in India.

Selection of Study Locations:

This study has tried to assess the impacts of pesticides in cotton farming locations, since cotton consumes the largest quantities of pesticide in this country as well as of the most hazardous types (See Annexure 1, 2.A and others). Ironically, it is also in cotton cultivation that organic farming alternatives are one of the most well-established and successfully practiced.

The rationale for selection of the states - Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Punjab and Tamil Nadu as study states, was based on cotton growing extent and pesticide consumption magnitudes (See Annexure 2.B and 2.C) at the national level.

Within the state, districts were chosen based on:

- earlier reports of pesticides-related problems,
- pesticide consumption quantities and
- cotton cultivation extents.

The selection of districts was also supported by the recommendation of various Institutes, Research Centers and pesticide dealers. Relevant agriculture universities were consulted along with local NGOs working on the issue. The districts were not necessarily the highest pesticide consuming districts in the state, but were definitely in the top three districts. See Annexure 3 for district and *tehsil* level information, on pesticide use/cotton cultivation.

Further, within the district, study blocks/tehsils were selected based on cotton cultivation extents aggregated for the past 4-5 years, as well as recommendations by the pesticide dealers. One other factor that influenced the selection of the block/tehsil was the partner organisations' ability to follow up on the project, by taking up work related to promotion of non-chemical alternatives. Areas that the organizations worked in / can potentially work in, were therefore chosen, within the high-cotton-growing tehsils.

[21] "An Anthropological Approach to the Evaluation of Preschool Children Exposed to Pesticides in Mexico" by Guillette A., Elizabeth; Maria Mercedes Meza; Maria Guadalupe Aquilar; Alma Delia Soto and Idalia Enedina Garcia, Environmental Health Perspectives, Vol 106, No 6: June 1998

Once the study block/tehsil was finalized, a similar process was adopted to zero in on three (contiguous) villages as the study villages – large cotton-growing areas, based on data from the past five years for all villages in a tehsil, and based on recommendations by local pesticide dealers.

All the study villages were also away from any contaminating industries, up to a range of 25 kilometers at least, in a process of eliminating other confounding variables.

State	Study Location			Control Location		
	District	Tehsil/Block	Villages	District	Tehsil/Block	Villages
Andhra Pradesh	Warangal	Atmakur	Atmakur, Oglapur, Peddapur	Medak	Narayankhed	Abbenda
Karnataka	Raichur	Raichur	Khanapur, Manjerla, Poorthipli	Same as above	Same as above	Same as above
Punjab	Bhatinda	Talwandi Sabo	Bangi Nihal Singh, Jajjal, MahiNangal	Ropar	Anandpursahib	Dher, Gambhirpur, Surewal
Gujarat	Bharuch	Bharuch	Halder, Kavitha, Samlod	Bharuch	Wagra	Bhesali, Rahiyad
Maharashtra	Yavatmal	Pandarkauda	Dehlatandi, Kopamandvi, Sunna	Yavatmal	Darwa	Bhandegaon
Tamil Nadu	Theni	Bodi	Rasinghapuram, Silamalai, Visuvasapuram	Madurai	Uslampatti	Ayodhyapatti

Selection of control locations:

Comparable control locations were selected from the same states (less pesticide consuming area) without compromising on the basic parameters of socio-cultural composition of the communities, diet, income levels, ethnicity and presence of other variables like contaminating industries around etc. In the case of Karnataka however, due to resource constraints, it was decided to treat a less-pesticide consuming area of Andhra Pradesh (the control for AP), as the control for Karnataka too. This was a district that borders Karnataka and Andhra Pradesh and therefore, similar conditions could be ensured. Therefore, the study relied on six study locations and five control locations in all. These controls were located in other districts within the state in three cases, and in other tehsils in the same district in two instances.

Controls, however, varied significantly from the study locations when it comes to pesticide consumption. Calculated on the basis of information provided by the study and control village members, the difference is in the range of 1:20 times for pesticide use, between the control and study locations, in terms of quantities[22].

For the selection of control locations, recces were undertaken in possible locations and data on pesticide consumption collected (sometimes inferred from the discussions with farmers, where data was not available with the concerned authorities). After ensuring that pesticide consumption

[22] Information on pesticide use in this country is not maintained either crop-wise, or village-wise. Only district-level aggregates are available, where provided by the pesticide industry and filed to the department of agriculture.

was comparatively quite low, appropriate villages were chosen. For this, the first parameter was the socio-economic composition of the village – tribal villages were not compared with "normal" villages, for instance. If chosen from the same district, adequate distance (atleast fifty kilometers) was maintained from the study location. Diet patterns were adequately matched. Further, a sub-sample was looked at, to use height, weight and head circumference of the children as a proxy indicator for income and diet in the case of one state. Care was taken to see that other confounders like contaminating industries were not present around the control locations either.

The different ways in which control locations closely match with the study locations, in terms of mean age of children studied, gender distribution, physical growth indicators as proxy for income and diet etc., are given in the Findings section, at the beginning of the presentation of each study location's results.

Processes undertaken:

Initial recces to the study districts were undertaken in the month of February 2003 and meetings with potential partner organizations held, for Andhra Pradesh, Karnataka and Punjab. A similar process was undertaken for Gujarat, Maharashtra and Tamil Nadu in the month of July 2003.

An international advisory board was meanwhile constituted. Once the districts were finalized along with partner organizations, skill-shares were organized.

These trainings included field visits for pre-testing of tools. The first such training programme for the researchers and state co-ordinators was held in Delhi (for the states of AP, Karnataka and Punjab) between March 31st and April 3rd, 2003, with a field visit to Bhatinda included. The skill share was aimed at increasing the participants' understanding of impacts of pesticides on human health, as well as to the methodology and tools of the study. The second skill share for the remaining three states was organized between 1st and 3rd September 2003 in Bangalore. The first skill share was attended on all the 4 days by Dr Elizabeth Guillette from the University of Florida and the question forms were finalized soon afterwards. Consultations were also held with experts in St.John's Medical College's Paediatrics department for finalizing the question forms.

Field level data collection was undertaken during May – October in the first phase of the study, and during September – December 2003 in the second phase. During this phase, panchayats were informed about the purpose of the study. Parents and teachers were informed too and permission taken in an oral manner.

Quality control was ensured by involving a blinded researcher each in the states of Gujarat, Maharashtra and Tamil Nadu to re-do the tests with children on a sub-sample of children in each village, to see whether it matches with the results emerging from the larger sample. This verified the quality of the outputs. Gap-filling exercises were also undertaken towards the end of data-collection in the field.

In the course of the study the advisory board was constantly consulted for their inputs and guidance.

Mechanisms set up for field study, academic rigor and quality control:

The Advisory Board: For ensuring that the study has sufficient and rigorous scientific inputs, an Advisory Board was set up to help out in the design and monitoring of the study. The Advisory Board was an international one and more details are provided as Annexure 4. The Board consisted of medical and anthropological experts who provided specialist support in the areas of paediatrics, reproductive health, child psychology, toxicology, applied anthropology, epidemiology, pesticides etc. The role of the Board was to ensure that the study maintains the requirements of scientific vigor in terms of data collected, control group selection, methodologies followed, sample size, consideration of confounding variables and quality of conclusions drawn.

Partner organizations: In all these six states, local organizations conducted the field study. These organizations were carefully selected based on their work on sustainable agriculture, and/or with children and farmers. The partner organizations are also groups that are keen on following up in the area of organic farming in the study locations. Researchers were recruited for the purposes of the study by these organisations, who were adequately trained. An annexure provides more details about the organizations. (See Annexure 5).

National Coordinators: At the national level, there were two people responsible for the study: one was a National Field Coordinator responsible for the second phase of the study and another, the National Coordinator, had the overall responsibility for the study (from fund-raising to the authoring of the report). See Annexure 6 for more information on the Coordinators.

Researchers: There were 6 researchers and 1 coordinator for Andhra Pradesh, 3 researchers and one specialist (a doctorate in Human Biology) for Punjab, 4 researchers and 1 coordinator each for Karnataka and Gujarat and 4 researchers each for Maharashtra and Tamil Nadu. These researchers were responsible for primary data collection along with district data collection and documentation of acute poisoning cases. (Annexure 5 has more details).

Gender balance of the researchers was also ensured while forming a team. Each team consisted of male and female researchers to ensure good quality data collection and to further build a good rapport with the participants in the study.

Sampling of Children:

<u>Sample Size:</u> The study has analyzed a sample of 899 children in age groups of 4-5 and 9-13 years in the study location [448 in the younger age group and 451 in the older age group] and 749 children in the control (low pesticide consuming area) locations. Interviews were also held with the mothers of these children (853 mothers in the study location and 744 mothers in the control location).

<u>Sampling:</u> Children were chosen giving enough representation to the different parts of the village (layout of the village), to both sexes and to different ages within an age group. They were picked up in the 4-5 age group from the anganwadis [or pre-schools/kindergartens]. Majority of the children in the 9-13 age group were from schools in both the study and control locations. They were selected from different parts of the village to ensure fair representation to different communities and socio-economic status. The methods followed for selection were the same in the study and control locations. We show with further data in the findings section how the samples of control and study groups are very similar on all important and relevant aspects.

<u>Similarity of the groups</u>: Consultations with experts informed us that boys and girls are supposed to have differential performances with regard to different abilities (analytical, motor etc.) especially in the older age group. Literature presents contesting views too, the experts informed us. In our study however, we ensured a close match between the study and control locations when it comes to gender distribution[23]. Similarly with age. While closeness of age is supposed to be important especially in the 4-5 age group (given that brain development is rapid in the first seven years of a person's life), it is not supposed to be so in the case of 9-13 year old children

[23] Data is presented at the beginning of the findings section for each state

(relatively speaking). Mean age of study and control groups is presented in the findings section for each state for an understanding of the situation.

In addition to similarities in the community social structures (caste and religion structures, between the study and control areas), income and diet become important considerations. Diet is frequently implicated for birth defects, mental deficiencies and growth retardation, all of which are associated with pesticide exposure also. However, in developing countries, where traditions remain strong and diets retain symbolic cultural values, diet is considered to be fairly uniform regardless of income[24]. In the study, mothers were interviewed about the diets of the family. These match closely between the study and control locations (absolute quantities of diet intake cannot be obviously matched and controlled for in a social science research set up like this). We also ensured that both study and control locations had availability and access to iodised salt[25].

On the other hand, there is also another school, based on empirical research too, that there is almost a direct and linear relationship between income and diet/nutrition[26], and in turn, nutrition and growth[27]. Nutritional levels are supposed to affect cognitive abilities of children. In such a case, a valid and accepted way of looking at income and diet "matching" (controlling between the study and control areas) was to match the growth of children, as per their height, weight and head circumference. Therefore, the measurements of growth as obtained in height, weight and head circumference of children were used to look at the similarity between the study and control locations, and to use it as a proxy indicator for factors like income and diet. These details are also presented at the beginning of the findings section for each state. In those cases where the Reference location seems to have better nutritional status in terms of the marginal differences obtained by the physical growth measurements, statistical signficance tests (t-tests) were undertaken to ensure that the groups were similar.

Finally, maternal education is supposed to influence the developmental abilities of children. There are several studies on the influence of a mother and maternal education on a child's ability in these areas. While educated mothers are found to stimulate the learning environment for the children better[28], there are also studies pointing to the fact that working mothers might mean a negative correlation again. Our consultations with child psychology experts at NIMHANS[29], Bangalore says that maternal education need not necessarily convert into a better stimulating environment.

We tried to control for this factor too, between the study and reference locations. Wherever maternal education in the control locations was found to be higher, data was analysed separately for children who had uneducated mothers. The study found that these children perform equally well, or even better than the whole group average. Also, the trends in the results were consistent across different locations, whether the control location had more maternal education or not. This leads us to believe that maternal education in the context of this study is not a major influencing variable, possibly because the education levels in a majority of cases were just upto Class V.

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[24] "An ecological approach to nutritional anthropology" - Jerome NW, Kendal RF, Pelto GH. In: Nutritional Anthropoiogy:Contemporary Approaches to Diet and Culture (Jerome NW, Kendal RF, Pelto GH, ads). Pleasantville, NY:Redgrave Publishing Company, 1980;13-45.
[25] Iodine is a possible factor, as per experts
[26] Easterly *et al*
[27] Wheeler *et al*
[28] "Long-term Effects of Early Intervention" - Kagitcibasi, Cigdem, Diane Sunar, and Sevda Bekman. 1993. Unpublished paper. Department of Education, Bogazici University, Istanbul, Turkey
[29] National Institute of Mental Health and Nutritional Sciences, Bangalore, India

Tools employed:

A Rapid Assessment Tool for Children (RATC) was adapted from the earlier Mexican study to assess development of children, for distinct abilities. The tool measured varied aspects of child development in terms of abilities to perform, or function in normal childhood activities. A similar RATC tool was developed for 9-13 year old children also, with more complicated tests.

The tests (games) were standardized across the six states, and between the study and control areas for easy comparability. These were verbally and individually administered to the children. These are interpreted as normal play by the children. This meant less anxiety and high motivation. Demonstrations were provided beforehand especially for 4-5 year old children coupled with spending some time in their schools, by playing with them, to reduce initial inhibition and fear. Also, the games were played in the presence of their family members and/or teachers. Wherever the first level of test was not successfully done, the next level of test was not administered, to avoid building up of frustration and anxiety. Once a child is either hesitant or uncomfortable with a particular exercise, she/he was not forced to perform the same.

These tools were approved by child psychologists consulted in NIMHANS and St John's Medical college of Bangalore, for their suitability to the Indian conditions (rural children, specially).

LIMITATIONS OF THE STUDY AND ITS METHODOLOGY:

- the design of a study like this cannot be a rigorous experimental one since this is about human health – therefore, a cross-sectional design is the best for correlations to be made.

- impacts of particular pesticides could not be determined since there is a cocktail situation of consumption. Inferences can however be made based on the known effects related to the broad classes of pesticides and consumption quantities in the study districts (mostly organophosphorus pesticides, but also mixtures of innumerable varieties).

- a variety of confounding variables exist in the real life situation – the study tried to control for the more important ones (diet and income, socio-cultural/ethnic background, gender, media exposure to the extent that both control and study villages had TVs and radios, pre-schools etc.), and draw the inferences based on these. The strong underlying understanding of the situation is drawn from similar studies done earlier. Therefore, reliance on a tested methodology and known effects were used as the main pillars.

- the study realizes that a multitude of factors can be used to discount the findings here. Therefore, doing it across six different states was useful, since strong common trends across the states were used to draw conclusions. For instance, in one state the control location had satellite television access and the children performed better here; in another state, the study location had access to satellite television but its corresponding control location did better in this instance too.

- the biggest limitation is not knowing what all to study, since the impacts could be many and unknown too.

FINDINGS OF THE STUDY

At the National Level:

This chapter presents the findings mainly location-wise – every study location compared with its reference location, for each age group. Before that, the following table gives an overall picture, from all the locations, on the total number of tests administered, and the results that went in favor of the control locations and ones that were statistically significant. Following this section, is a description of all the tests administered in this study.

First, the overall results for the younger age group of 4-5 year old children.

Type of Test[30], **4-5 year old children**	**Total sets of groups the test was administered to**	**No. of times results in favor of the Reference location**	**No. of times results in favor of Reference location, with statistical significance**
Analytical Abilities			
Mental Ability, using wooden blocks	24	24	24
Tactile Perception, using wooden blocks	12	12	9
Jigsaw puzzles, using birds, flowers and animals	17	14	12
Cognitive ability in the form of human drawing	6	6	5
Motor Skills			
Gross Motor Skills: Eye-hand Coordination with large ball	18	16	9
Motor Skills: Eye-hand Coordination with tennis ball	18	13	9
Stamina test with Jumping Jacks	6	5	4
Fine Motor Skills			
Eye-Hand Coordination with Raisins	6	5	5
Sense of Balance tests	18	15	12
Concentration and Memory			
Ability to Concentrate: Immediate Recall test	6	5	5
Memory test: 30-minute recall	6	3	3
OVERALL	**137**	**118**	**97**

In percentage terms, the above tests show that in 86% of the cases, the Control location performed better than the Exposed group; further, in 70.8% of the cases, the results were statistically significant.

It should be mentioned here that the tests which did not go in favor of the Control group did not necessarily go in favor of the Study group children. As the above table shows, Gross Motor

[30] The name of the test is a functional definition for the purpose of the study, with the kind of ability indicated in the name of the test – all tests are developmental abilities of children in an overall sense

Abilities in the form of ball-catching (large ball and tennis ball) showed results where the Control group did perform better, but only in 50% cases did they perform significantly better. In the case of 30-minute memory tests, where the Study group performed better, they did so with very little margin and so, with low significance. Results went conclusively in favor of the study group children only in the case of 6.6% of tests in this age group.

Another table given below presents the overall results from all the six locations for the older group of children in the 9-13 year age group. Here, the number of tests in each location was 20.

Type of Test[31], **9-13 year old children**	**Total sets of groups the test was administered to**	**No. of times results in favor of the Reference location**	**No. of times results in favor of Reference location, with statistical significance**
Analytical Abilities			
Mental Ability, using wooden blocks	30	26	20
Tactile Perception, using wooden blocks	12	8	5
Jigsaw puzzles, using birds, flowers and animals	18	16	15
Motor Skills			
Gross Motor Skills: Eye-hand Coordination with tennis ball	18	17	11
Stamina test with Jumping Jacks	6	5	5
Fine Motor Skills			
Eye-Hand Coordination with Raisins	6	5	5
Nose-tapping for Body Awareness	6	6	6
Sense of Balance tests	12	9	8
Concentration and Memory			
Ability to Concentrate: Immediate Recall test	6	5	5
Memory test: 30-minute recall	6	4	4
OVERALL	**120**	**101**	**84**

A trend similar to the results in the 4-5 year age group can be found for this age group too: in 84.2% of the cases, the Reference group children performed better on various abilities compared to the exposed children. In 70% of the instances, the results were statistically significant, in favor of the Reference group children. Once again, the remaining results did not automatically go in favor of the Study group children. In 15.8% of the cases, the Study group performed better, but only in 4.2% of the cases the results were significantly better. In this age group, though most of the tactile perception tests saw the reference location children performing better, only 50% of the instances were statistically significant.

For the 4-5 year age group, in states like Tamil Nadu, Punjab and Andhra Pradesh, in 74 to 90% of the tests, the Control group was better with statistical significance. In the 9-13 old age group,

[31] The name of the test is a functional definition for the purpose of the study, with the kind of ability indicated in the name of the test – all tests are developmental abilities of children in an overall sense

similar high performances are visible with control groups from Punjab, Tamil Nadu, Maharashtra and Gujarat.

DESCRIPTION OF THE TESTS:

The tests have been divided into broad abilities called Analytical Abilities, Motor Abilities and Abilities for Concentration and Memory. The following section gives a description of the test, and the manner in which data was analysed for each test.

Analytical abilities:

A standard set of games was played with both 4-5 year old children and 9-13 year old children to assess analytical abilities.

Mental Ability tests, with wooden blocks:

For the purposes of the study, the first set of tests was called Mental Ability tests. Here, the child is made to recreate shapes out of wooden blocks of different sizes and shapes, by looking at a printed picture on a paper. Four such tests for 4-5 year old children, and five tests for 9-13 year old children were administered, with each test becoming increasingly complex. Wherever a child could not repeatedly perform for two tests, further tests in the series were not taken up with the particular child to prevent anxiety and frustration from building up. Results are presented in terms of percentage number of children who could do the test successfully. The statistical significance was determined through chi-square tests.

Jigsaw puzzles:

The puzzles used birds/animals, flowers and fruits that the children could identify, made out of 2, 3, 4 and 5 pieces. For both the age groups, initial demonstrations of the concept of jigsaw puzzles were made by using the picture of a fish. This series also had an element of increasing levels of complexity added to it, where children who have performed a puzzle successfully are encouraged to take on the next one and so on. Once again, the results have been analysed in terms of percentage number of children who could do the test successfully and statistical significance determined through chi-square tests.

Tactile Perception tests, with wooden blocks:

There were two games played to assess the abilities of tactile perception, with the use of wooden blocks, called as Tactile Perception Test 1 and Test 2 for the purposes of the study. In Test 1, the child is asked to close its eyes, and a particular wooden block (of a particular shape and size) is placed in one of its hands. Behind a small screen, many wooden blocks of different sizes and shapes are placed and the child is asked to pick the block that is identical to the one in its hand. In Test 2, the child is again asked to close its eyes, and using both hands to search behind a small screen, is asked to pick up two identical blocks placed amongst many blocks of different sizes and shapes.

Non-verbal cognitive abilities, as manifested in drawing a human figure:

A test that was administered on 4-5 year old children to assess non-verbal cognitive abilities was to ask the child to draw a human figure, and to identify the various parts drawn. This was then scored against 5 points, with one point each assigned for a head drawn, facial features drawn, a trunk drawn, two hands drawn and two legs drawn.

Motor abilities:

The human nervous system is supposed to have three general, overlapping functions one of which is the motor function (the others being sensory and integrative functions). Based on sensory inputs and integration, the nervous system makes the muscles contract or glands to secrete, to perform specific functions. Pesticides are chemicals that are potentially neuro-toxic and therefore, disrupt these functions.

As part of this study, some gross motor abilities and fine motor abilities of children in the two different locations were assessed. In the case of 4-5 year old children, gross motor abilities were tested through a ball-catching exercise involving first a large ball, and then a tennis ball. The game included catching a ball five times each at distances of 1 metre, 2 metres and 3 metres by the child. The same process was repeated for the smaller ball. The number of times that the child could catch the ball, out of the 5 throws for each distance was recorded, and the average for the group calculated. For the 9-13 year old children, only the tennis ball was used, at distances of 2 metres, 3 metres and 4 metres. Once again, the number of times that the ball was caught out of five throws was recorded for each distance, and the group average rate of catching calculated.

Fine motor skills:

In addition to gross motor skills, another test, of dropping raisins with one's fingers from a specified height into a bottle lid placed on the floor, was used to assess **Fine Motor Abilities**. Here. a younger child got to do the test with the hand/wrist placed on a one-foot stool, while the height of the stool for the older children was one and a half feet. A child was given ten raisins/peas to drop into the lid, and the score noted as per the number of raisins/peas successfully dropped into the lid out of ten attempts. The average scores for each sample group were then calculated.

For the 9-13 year old children, another test called Nose-tapping or Body Awareness test was administered for assessing fine motor skills. Here, the child touches the tip of the middle finger to the tip of the nose, with eyes closed, for 25 times, by bringing in outstretched arms alternately to the nose. The test is measured in terms of number of times successful, out of 25 times. The group average is then calculated, and statistical significance for differences between reference and study children assessed through a t-test.

Sense of Balance tests:

Another set of tests was taken up to assess the sense of balance amongst the children. For the 4-5 year old children, there were three such tests:

1. to stand on one foot with eyes open,
2. to stand on one foot with eyes closed, and
3. to walk on a thin plank, toe-to-heel and walk back without putting a foot down.

For the first two tests, results are recorded in terms of number of seconds (calculated by a stop watch) that the child was able to perform the test successfully. The group average in terms of number of seconds was then calculated. For these tests, data was also analysed in terms of percentage number of children in specific brackets of time period.

The third test is reported in terms of percentage number of children able to do the test successfully. For the first two tests, statistical significance was assessed through t-tests, while for the third test, it was through chi-square tests.

Stamina test:

Assessment of motor abilities also consisted of a **stamina test** of "Jumping Jacks". The child is encouraged to push itself until it is breathless or exhausted (the child is asked to stop whenever it feels breathless and tired, in this test). In the case of 4-5 year children, it was found that coordination between hands and legs was more often than not missing. However, the child was encouraged to continue the exercise until it was ready to give up. The number of seconds that the child could continue doing the jumping jacks was recorded for each child and then group average calculated. T-tests for significance were done too. Since the number of children who could push themselves further than the others in their group was high in both the study and control samples, data was also analysed in terms of time period brackets i.e, percentage number of children who performed within that time bracket.

Tests for Concentration and Memory:

There were two games played for assessing abilities related to concentration and memory. One was an instant recall test (with six objects shown to 4-5 year old children and eight objects shown to 9-13 year old children) – after the child identifies the objects, the objects are quickly hidden behind the researcher in a pouch, and the child is asked to recall the objects seen. The number of objects recalled is recorded for each child, and the group average then calculated. Statistical significance was calculated by t-tests.

The second test was to get a child to recall a colored object promised to it, half an hour after the promise is made. The recording is done as percentage number of children who are able to recollect both the color and the object after half an hour. Chi-square test was administered to the data to understand the statistical significance of the results.

We present in the following sections results from each location.

ANDHRA PRADESH

In Andhra Pradesh, Warangal, which is the the second largest pesticide-consuming district in a cumulative sense over the past five years has been chosen as the Study location. Compared to other states like Punjab, pesticide use in this district is a relatively recent phenomenon and this is borne out by the exposure years reported by the mothers of the children studied. Warangal shot into national headlines with the large number of suicide deaths that cotton farmers in the area committed during the last decade. The reference location was from Medak district, a low-pesticide consuming district within Telangana region.

First, the profile of the children studied from both samples, in both age groups. In both locations, younger children were drawn from anganwadis in the village, while the large majority of older children were drawn from the village government school. Care was taken to see that the children came from different parts of the village (socio-economic background was varied within the village set up – different castes and classes were included).

Since this study used physical growth measurements as proxy indicators for income and diet, we present here information on the height (in centimeters), weight (in kilos) and head circumference (in centimeters) for both the study and control locations, separately for boys and girls.

The first table is for 4-5 year old children and the next for 9-13 year old children, from AP.

Location (sample size)	Mean age (in years)	Gender distribution [32]	Boys: 4-5 years			Girls: 4-5 years		
			Height	Weight	H.C.	Height	Weight	H.C.
AP Study (n=73)	4.40 ± 0.49	35 B + 38 G	97.7 ± 8.41	13.86 ± 2.07	49.2 ± 1.49	95.11 ± 5.55	13.1 ± 1.42	47.9 ± 1.87
AP Control (n=74)	4.77 ± 0.42	32 B + 42 G	99.6 ± 4.61	13.73 ± 1.43	48.9 ± 1.21	99.14 ± 6.14	14.1 ± 1.56	48.1 ± 1.62

As mentioned already, wherever the control group's physical growth parameters were better than the study group's, we used a statistical t-test to compare the similarity between the groups and found that when it comes to boys, the p-values indicate that the groups are extremely similar, while for the girls, the height was dissimilar between the study and control samples.

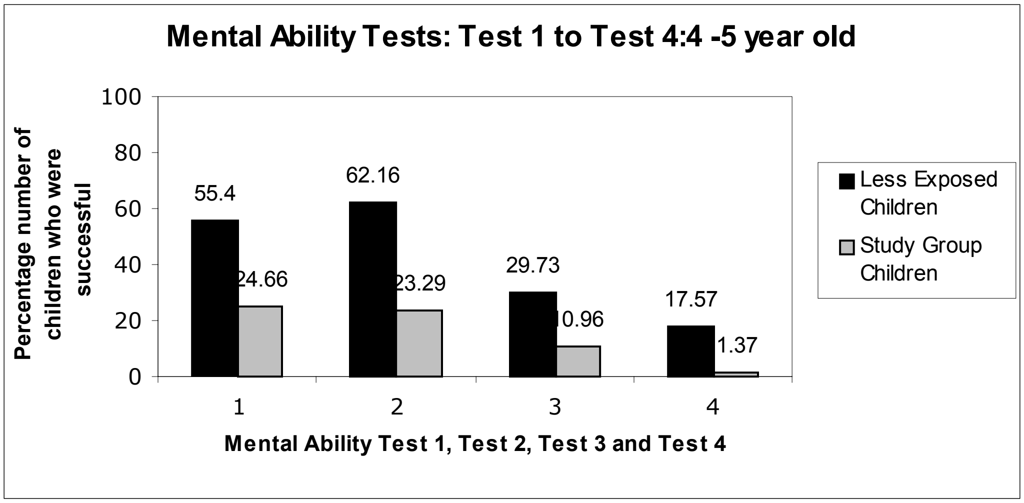
Location (sample size)	Mean age (in years)	Gender distribution	Boys: 9-13 years			Girls: 9-13 years		
			Height	Weight	H.C.	Height	Weight	H.C.
AP Study (n=74)	10.59 ± 1.12	42 B + 32 G	132.05 ± 8.65	26.3 ± 4.88	51.8 ± 1.23	128.71 ± 9.09	23.3 ± 4.21	51.1 ± 1.68
AP Control (n=75)	10.48 ± 1.38	42 B + 33 G	127.27 ± 6.04	23.01 ± 2.63	50.4 ± 1.50	126.65 ± 6.72	23.3 ± 3.90	50.9 ± 1.47

Results from Andhra Pradesh:

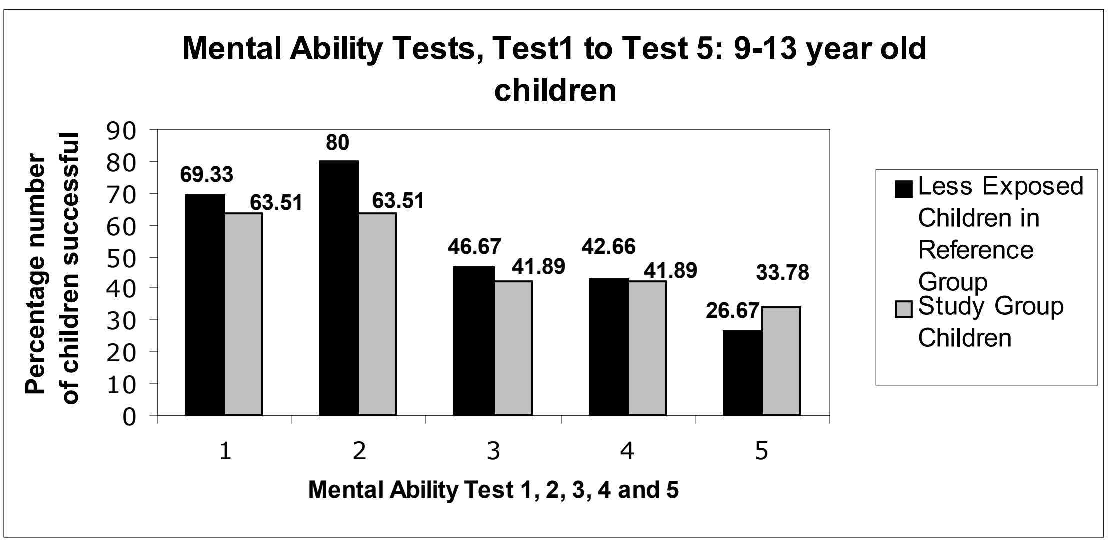
ANALYTICAL TESTS:
Mental Ability tests:

In the case of the 4-5 year age group, in all four mental ability tests administered, the control location children performed consistently better than the study location children. The margin of difference however went decreasing as the tests moved from one level to the other. While the difference was 30.74% points for the first test, when it came to Mental Ability Test 4, the difference between the control and study locations narrowed down to 16.20%. However, the ability to do this fourth test was with only 1.4% of the study location children, while 17.6% children could successfully do the test in the reference location. In all the four cases, the results were statistically significant, in favor of the less-exposed children.

[32] Here, B indicates Boys and G indicates Girls



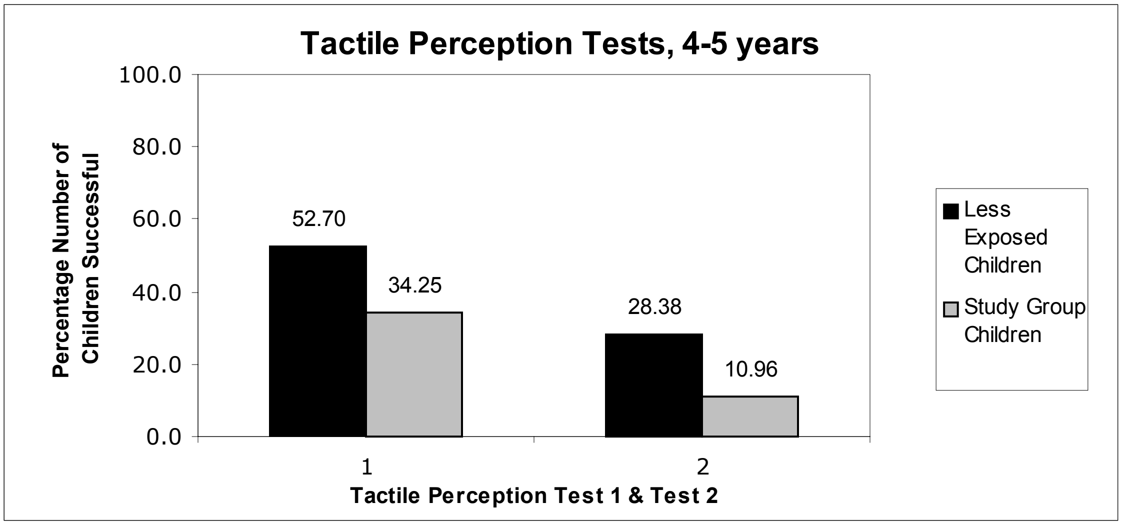
When it comes to the 9-13 age group, in the first four tests, the control group children performed better, with three of the four results showing statistical significance. When it came to Mental Ability Test 5, there was a dramatic fall in the number of children from control location who could do the test successfully. The results showed greater percentage of Study group children being able to do this test successfully (26.7% in control and 33.8% children in the exposed groups).



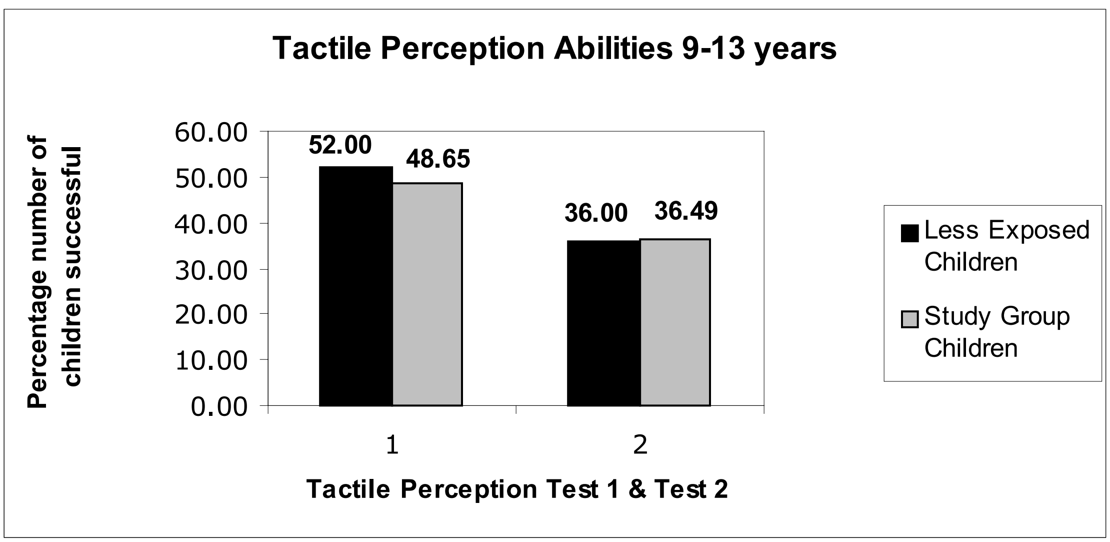
Overall, as can be expected, the 9-13 age group children performed better in these tests than the 4-5 year old children.

Tactile Perception tests:

In the case of 4-5 age group children, both Tactile Perception Test 1, and Test 2 saw the less-exposed children perform consistently better than the study location children. The difference in the ability was stark and statistically significant. In both the study and control samples, the ability to perform went down as the complexity increased.



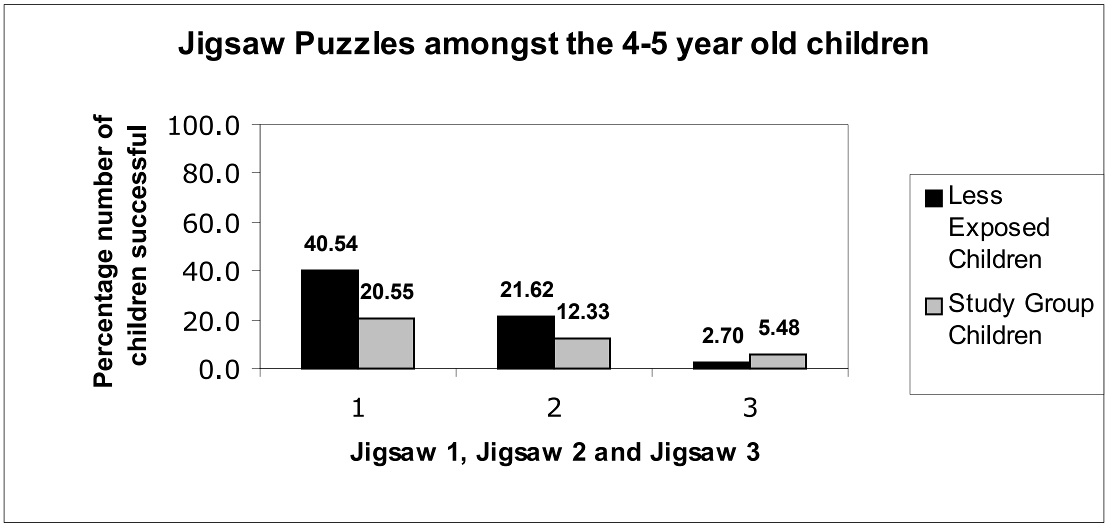
In the case of 9-13 year old children from this state, there were slightly mixed results on these tests. While Test 1 showed a clear better ability with the control group children, in the case of Test 2, both study and control group children performed equally well (36% each).



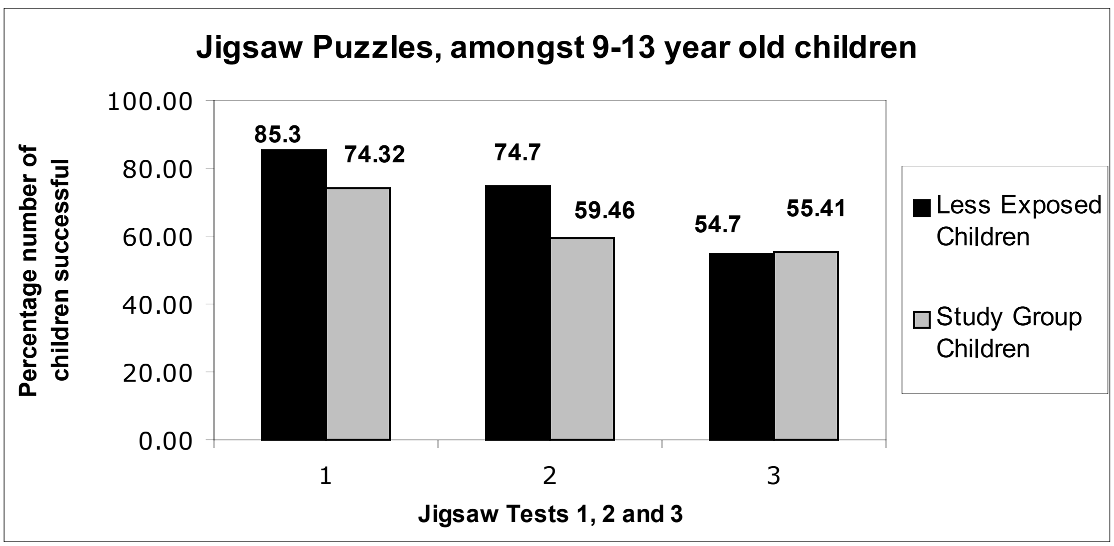
Jigsaw puzzles:

There were three jigsaw puzzles, referred to here as Jigsaw 1, Jigsaw 2 and Jigsaw 3 done by both samples of children. When it comes to 4-5 year old children, in the case of Jigsaw 1, the higher ability displayed by control group children is almost double the ability of the exposed children (40.5% children in the control location as opposed to only 20.5% children in the study location could do this 3-piece jigsaw successfully). In Jigsaw 2 also the control group children performed significantly better than the study group children. However, when it came to Jigsaw 3, the study group children performed better, by about 3 percentage points.

In the case of 9-13 year old children too, the same pattern is reflected. In the first two jigsaw tests, the control group children perform significantly better than the study location children. In



the case of Jigsaw Test 3, the study group perform marginally better by less than one percentage point. The following graph reflects the picture in bar diagrams.



Non-verbal Cognitive Abilities:

This test was administered to only the 4-5 year old children, where they were asked to draw a human figure, and points were scored against the main parts of the human body drawn, to a maximum of 5 points. The group average was then calculated for each sample. While the control location children scored an overall average point of 2.72 (±1.43), the exposed children were able to score only 1.82 (±1.95) points, with the p value for statistical significance being 0.0009.

Overall, when it came to analytical abilities, 10 tests were administered to the 4-5 age group, out of which 9 tests showed better results by the less-exposed group of children, 8 of them being statistically significant.

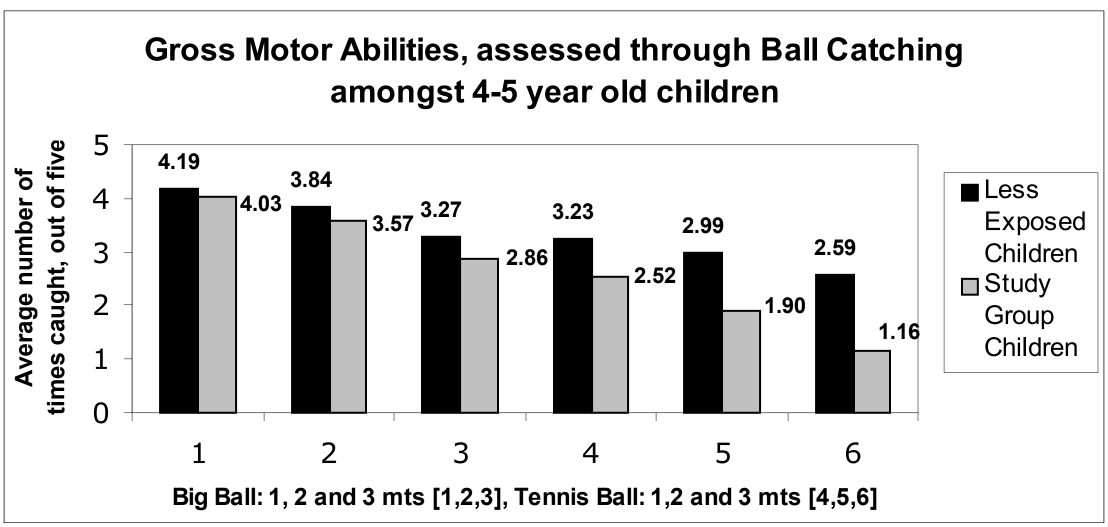
When it came to the 9-13 year old children, seven out of ten tests were in favor of the control group children. Out of this, six are conclusive by their statistical significance. Out of the remaining three tests, one test showed equal performance by both groups. Out of another two tests which went in favor of the study location children, one was statistically insignificant.

MOTOR ABILITIES:

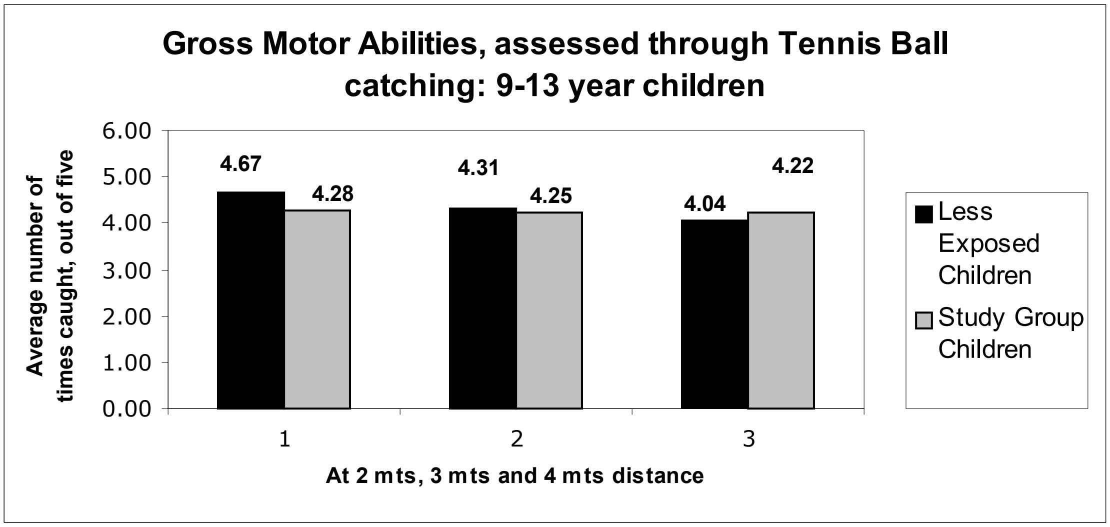
Eye-Hand Coordination with Large Ball: This game was played only with the 4-5 year age group. Here, out of three tests at three different distances, in all the three tests the control group scored higher averages. However, only one test was statistically significant. Nonetheless, an analysis of the ability to catch a ball at different increasing distances shows that as the distance increased, the difference in the ability also increased between the control and study groups (difference of 0.16 average points at 1 mt, 0.27 at 2 mts and 0.41 at 3 mts) and it is worthwhile to note that the difference at the third distance was statistically significant (p=0.05).

Eye-Hand Coordination with Tennis Ball: This test was administered to 4-5 year old children at distances of 1 metres, 2 metres and 3 metres, and for 9-13 year old children at distances of 2 metres, 3 metres and 4 metres.

In the case of 4-5 year old children, the ability to catch the ball was higher with the less-exposed children as an average score out of five, at all three distances. Once again, this ability was displayed as increasingly stark difference as the distance increased (average points of better ability or difference being 0.71, 1.09 and 1.43 points at 1 mt, 2 mts and 3 mts difference). The statistical significance values of the higher ability at the three distances respectively is p=0.004, p=<0.0001 and p=<0.0001. The following graph points out this difference clearly between the two samples of exposed and less-exposed children.



In the case of 9-13 year old children however, the tests show different results. In the first two distances, the control group children have performed better in terms of average score out of five points. However, the results are not significant statistically. At the third distance, the study group children have performed better in terms of their average score (scoring 4.22 points on an average for the group, as against 4.04 scored by the less-exposed group). However, this performance also has no statistical significance. At all the three distances, therefore, neither the control group nor study group has performed conclusively better.



Sense of Balance:

This ability was assessed through three tests for 4-5 year old children, and two tests for 9-13 year old children.

In the case of 4-5 year old children, the first test was to stand on one foot, with the child's eyes open and the length of time noted in terms of seconds. The second test was to stand on one foot, with eyes closed, once again with the time recorded in terms of number of seconds that the child was able to do this without hopping around, losing its balance and moving or putting its other foot down. The third test was the plank walk test, for the child to walk toe-to-heel on a plank of standard length, to turn around and walk back without putting its foot down from the plank.

The results for two tests were in favor of the control location with statistical significance [average time of 21.08 seconds for control location children, against an average of 11.92 seconds in the study location, with a p value of 0.01 in the difference seen; similarly, 74.32% of children in control location performed the plank tests successfully as against 31.51% in the exposed areas]. In the case of Balancing on one foot with eyes closed, the Study group children performed better than the control group children [5.72 seconds by the study group and 4.88 seconds by the less-exposed children]. However, the ability to do so was not statistically significant for the study group (p=0.22). Therefore, the two conclusive results in this set of tests went in favor of the less-exposed children.

When it came to 9-13 year old children, the tests consisted of Standing one one foot with eyes closed, and the Plank Walk test. Both the tests showed the better performance by less-exposed children in terms of averages [19.12 seconds on an average by control location children, against 16.24 seconds by the study location children in the case of standing on one foot; in the case of the plank test, 72% children in the control location did the test successfully against 62.1% children in study location]. However, the first test of standing on one foot did not have statistical significance (p value was 0.13).

The tests where the child was encouraged to balance itself on one foot with eyes closed or open did not have a time limit set by the researchers, and we came across children who could do it for very long periods of time, much longer than the rest of their counterparts.

Therefore, results from these tests are also being presented here as percentage number of children in particular time brackets of performance.

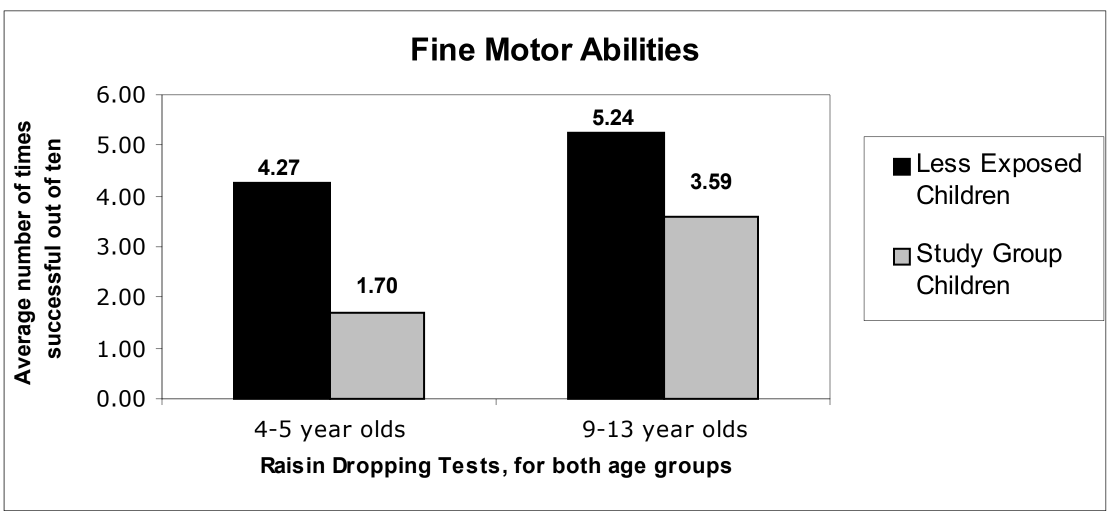
Particular time brackets in seconds	4-5 year old children				9-13 years	
	Eyes Open, %age number of children		Eyes Closed, %age number of children		Eyes Closed, %age number of children	
	Study	Control	Study	Control	Study	Control
0 – 30 seconds	91.7	87.7	97.3	100	83.8	80
31 – 60 seconds	5.6	9.6	2.7	0	16.2	17.3
61 – 90 seconds	2.8	0	0	0	0	1.3
91 – 120 seconds	0	0	0	0	0	1.3
> 120 seconds	0	2.7	0	0	0	0

As the above table shows, except for the test of standing on one foot with eyes closed for 4-5 year old children, the children in the control locations are more spread out into the upper time brackets of performance.

Fine Motor Abilities:

For the 4-5 year old children, this was tested through the eye-hand coordination test with raisins. The control location children performed significantly better than the study location children on this test too (4.27 average points ± 1.97 for the control and 1.70 ± 1.63 for study group children, with the p value being <0.0001).

In the case of 9-13 year old children, the pattern is repeated in favor of the less-exposed children. Their better ability at this coordination is reflected in statistical significance tests too, with the p-value being <0.001. In the case of 9-13 year old children, another test in the form of nose-tapping assessed the fine motor abilities. Once again, the control location children were better, with the statistical significance being p = 0.05.



Stamina:

The last test classified under motor skills for the purposes of the study is a test for stamina, assessed through the length of time that a child could do jumping jacks without getting tired or breathless. The time was measured on a stop watch uptil the time that the child itself announced that it wants to stop. The data was analysed in two forms here – one as average length of time for each sample, but also as percentage number of children falling into different time brackets of performing this test.

In both the age groups, the less-exposed children performed this test for significantly longer periods of time than the exposed children (the difference being 14.80 seconds in the case of 4-5 year old children and 64.50 seconds on an average, in the case of 9-13 year old children). The statistical significance of such difference is very high. However, realising that some children might be performing for much longer periods than the rest of the group (in both samples) we have analysed the data as per percentage number of children in specific time brackets, the results of which are given below.

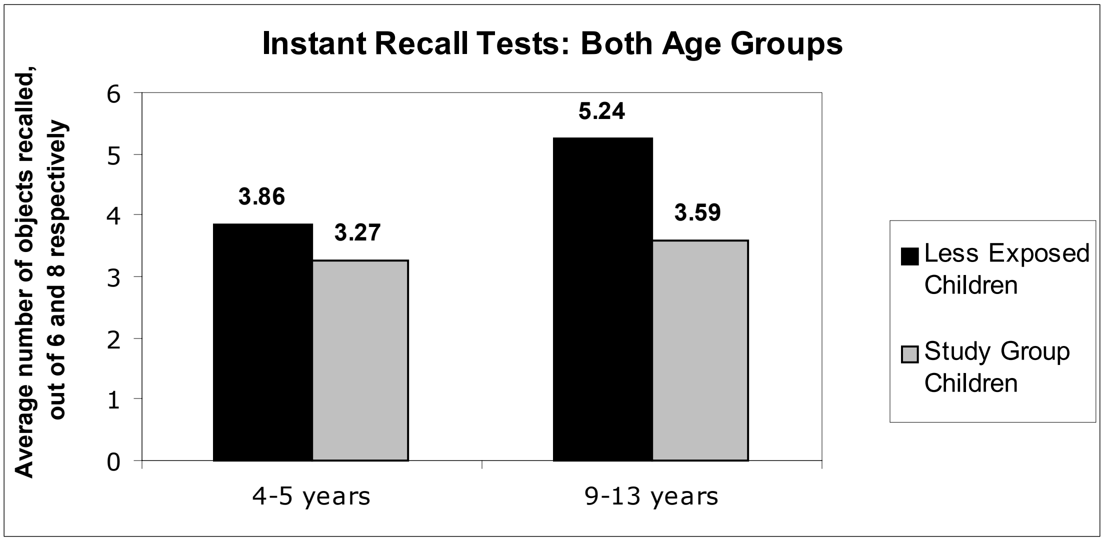
Time brackets, in seconds	**4-5 year old children**		**9-13 year old children**	
	Study	**Control**	**Study**	**Control**
0 – 50 seconds	94.4	94.3	91.9	29.3
51 – 100 seconds	5.6	5.7	8.1	36.0
101 – 150 seconds	0	0	0	22.7
151 – 200 seconds	0	0	0	9.3
> 200 seconds	0	0	0	2.7

Expectably, the contrast between the study and control group abilities is more apparent in the 9-13 year old children given these time brackets for classifying the abilities that the two sample groups have displayed. The control group in the 9-13 age group has more percent of children falling in the longer time brackets than the study group children.

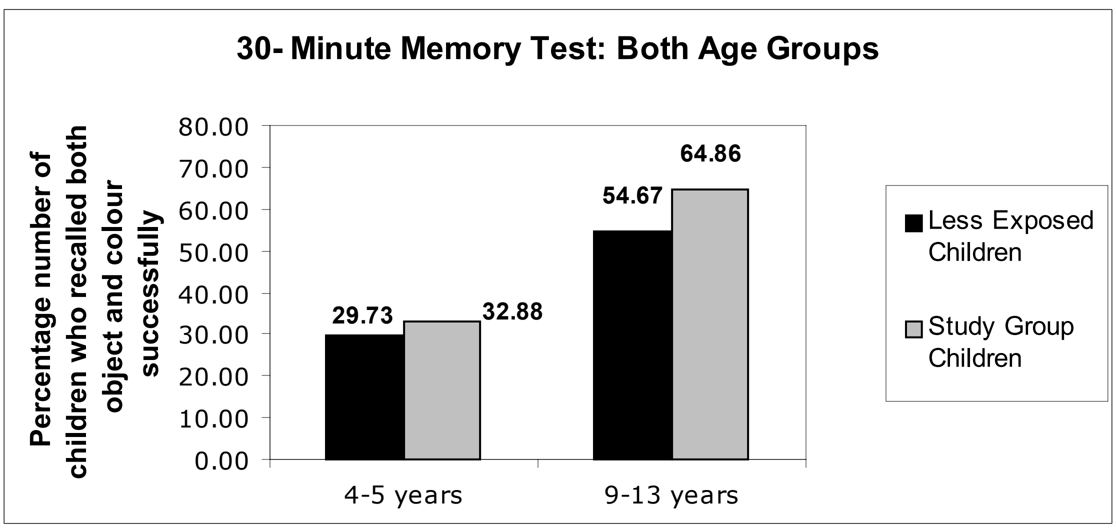
TESTS FOR CONCENTRATION AND MEMORY:

There were two tests each for each age group under this ability. One was an instant recall test and the other a 30-minute memory test. The first one has results presented as the average number of objects that each sample remembers out of 6 objects shown in the case of 4-5 year olds, and out of 8 objects shown in the case of 9-13 year olds. The next test is recorded in terms of percentage number of children able to recall the colored object promised to them.

In the case of both age groups, when it comes to the test for concentration / immediate recall, the less-exposed children are significantly better than the exposed group of children (with a difference of 0.59 average points in the case of 4-5 year old children, and a difference of 0.34 points for 9-13 year olds).



When it comes to the 30-minute memory test however, in both age groups, the study groups performed better than the control location children. In the case of 4-5 year old children, this difference was not statistically significant (p=0.56 on a chi-square test). Similarly, p value was 0.08 in the case of 9-13 year olds, even though the study group performed better than the control location.



Overall, out of the 23 tests administered to the two samples in the age group of 4-5 years, on 20 tests, the less-exposed children displayed better developmental abilities in Andhra Pradesh (17 with statistical significance). Three other tests saw the study group children perform better but with only one test being statistically significant in its results.

When it comes to 9-13 year old children, 20 tests were administered, out of which less exposed children were better in 15 tests, with one test being equal (8 test with statistical significance in support of the ability of the control group children). Five other tests that saw the study group children perform better did not have any statistical significance.

GUJARAT

Gujarat is another important cotton-growing and pesticide-consuming state of India. Here, the district of Bharuch was chosen as the study location. The control was also drawn from the same district but from another tehsil of the district. The sampling procedures and sample sizes were similar to Andhra Pradesh here.

First, we present the profile of the children in both samples, including physical growth measurements as proxies for diet and income. The first table is for 4-5 year old children and the next for 9-13 year old children.

Location (sample size)	Mean age	Gender distribution[33]	Boys: 4-5 years			Girls: 4-5 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Gujarat Study (n=75)	4.60 ± 0.49	37 B + 38 G	97.4 ± 4.90	12.49 ± 1.74	47.3 ± 1.27	99.18 ± 6.50	12.63 ± 1.58	47.4 ± 1.52
Gujarat Control (n=75)	4.53 ± 0.50	37 B + 38 G	97.7 ± 6.13	12.96 ± 1.93	47.8 ± 2.35	98.50 ± 4.65	12.76 ± 1.30	48.2 ± 1.62

As mentioned already, wherever the control group's physical growth parameters were better than the study group's, we used a statistical t-test to compare the similarity between the groups and found that the p values indicate great similarity between the samples (p values ranged from 0.10 to 1, for various measurements between samples of boys and samples of girls). This was done for both age groups, including 9-13 year old children, whose details are presented below:

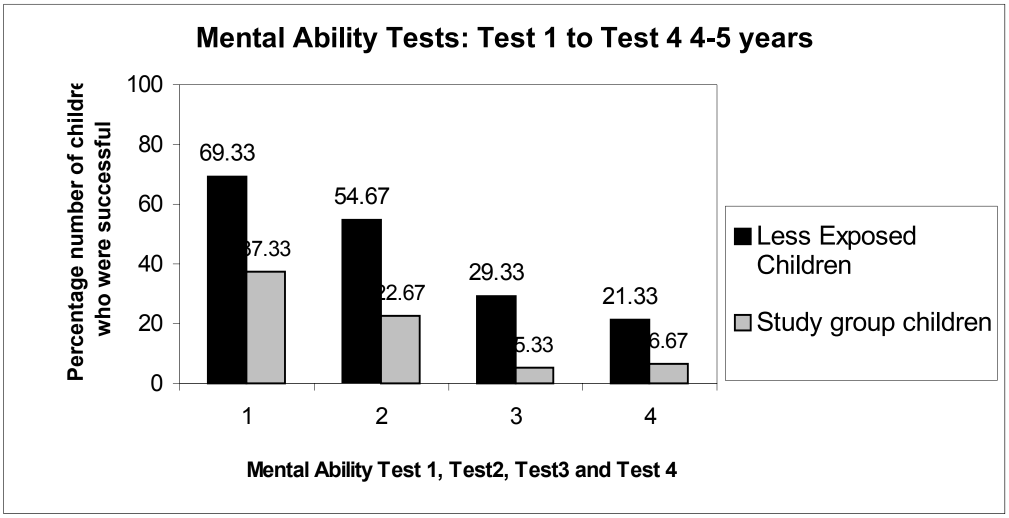
Location (sample size)	Mean age	Gender distribution	Boys: 9-13 years			Girls: 9-13 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Gujarat Study (n=75)	10.4 ± 1.15	38 B + 37 G	123.6 ± 17.3	22.4 ± 4.2	52.5 ± 6.6	123.2 ± 15.4	21.7 ± 3.7	49.0 ± 9.2
Gujarat Control (n=75)	10.8 ± 1.32	38 B + 37 G	126.03 ± 7.6	22.4 ± 3.3	50.7 ± 1.40	127.2 ± 8.6	22.6 ± 3.6	49.4 ± 7.6

Results from Gujarat:

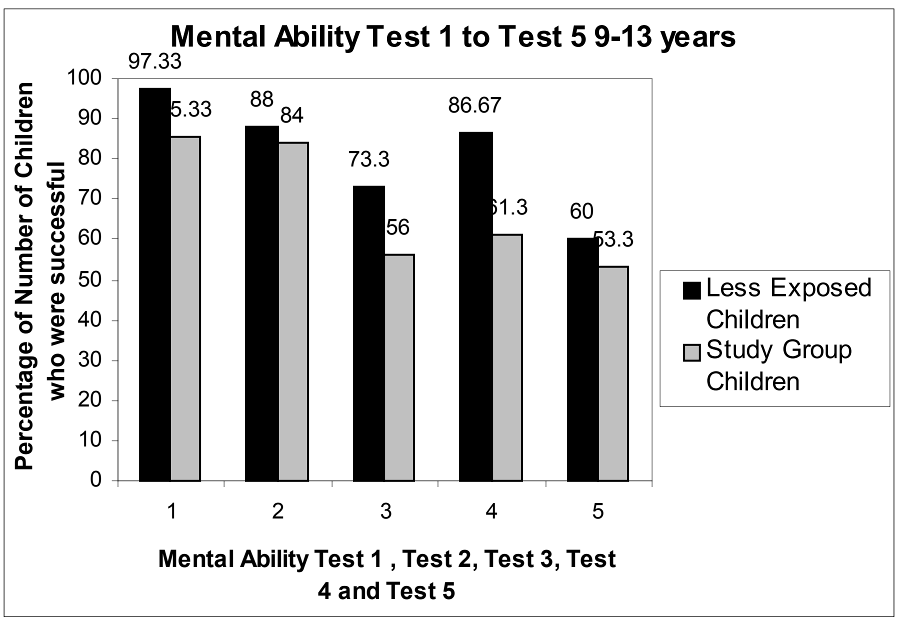
ANALYTICAL TESTS: Mental Ability tests:

In the case of both age groups, on all the mental ability tests administered, the control group children performed consistently better than the exposed children. Like in the case of Andhra Pradesh, when it came to 4-5 year old children, the margin of difference however went decreasing as the tests moved from one level to the other. While the difference was 32% points for the first test, when it came to Mental Ability Test 4, the difference between the control and study locations narrowed down to 14.66%. There was no such trend visible with the 9-13 year old children, even though the less-exposed children did better than the exposed group of children on all the mental ability tests. For the 9-13 age group, Mental Ability Test 5 did not have statistically significant results in favor of the control group.

[33] Here, B indicates Boys and G indicates Girls



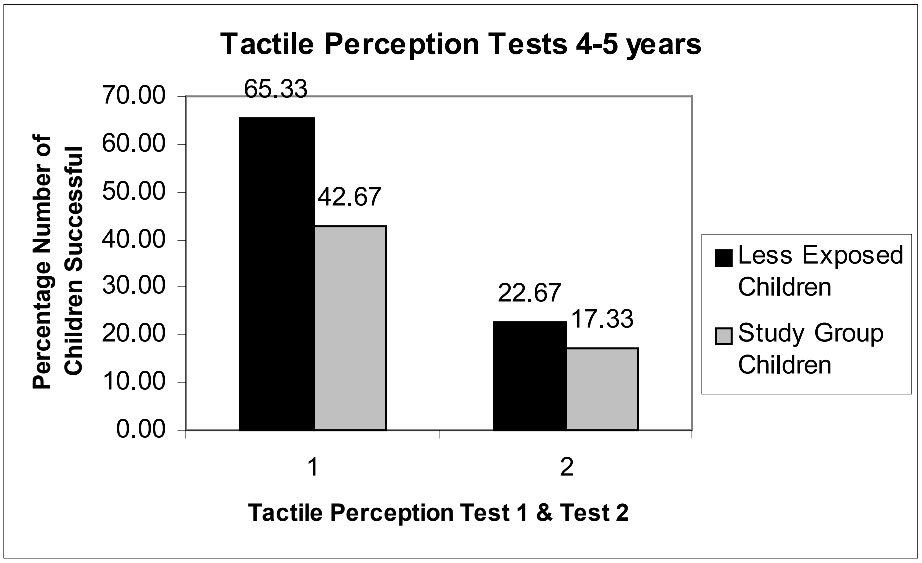
Overall, as can be expected, the 9-13 age group children performed better in these tests than the 4-5 year old children (on the first test for instance, 97.3% of children in the control location in the 9-13 age group could do better, whereas for the same test, it was only 69.3% successful children in the same location for the younger age group). The performance of 9-13 was better than 4-5 years in the study location also, expectably.

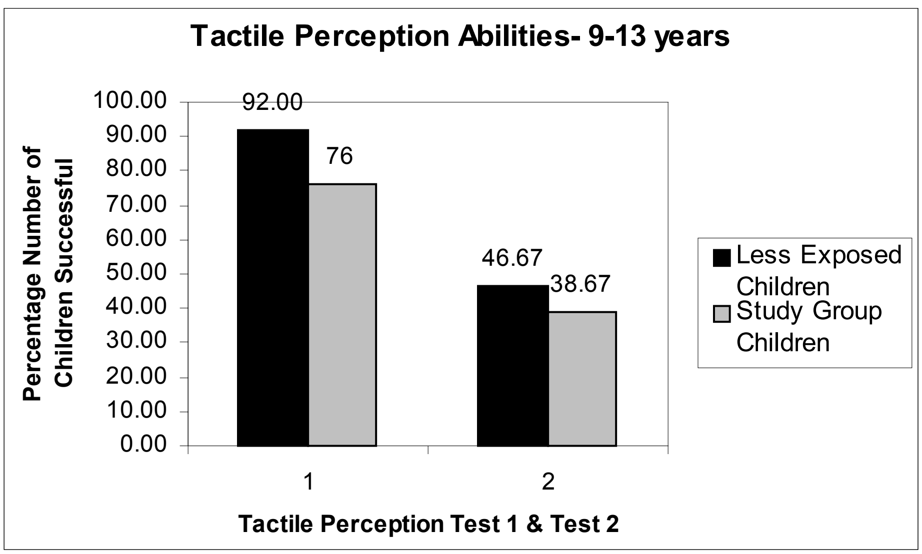


Tactile Perception tests:

In both the tests and both the age groups, the control group children performed better than the study group children in this set of tests. However, only on Test 1 were there statistically significant results in favor of the less-exposed children in both age groups.

It is interesting to note that in both age groups, the success rate in terms of percentage number of children who could do the test dropped dramatically within the sample, whether it was study or control, for both age groups. For instance, while 65.3% percent of 4-5 children in the control location did the first test successfully, only 22.67% of them could do the test at the next level.



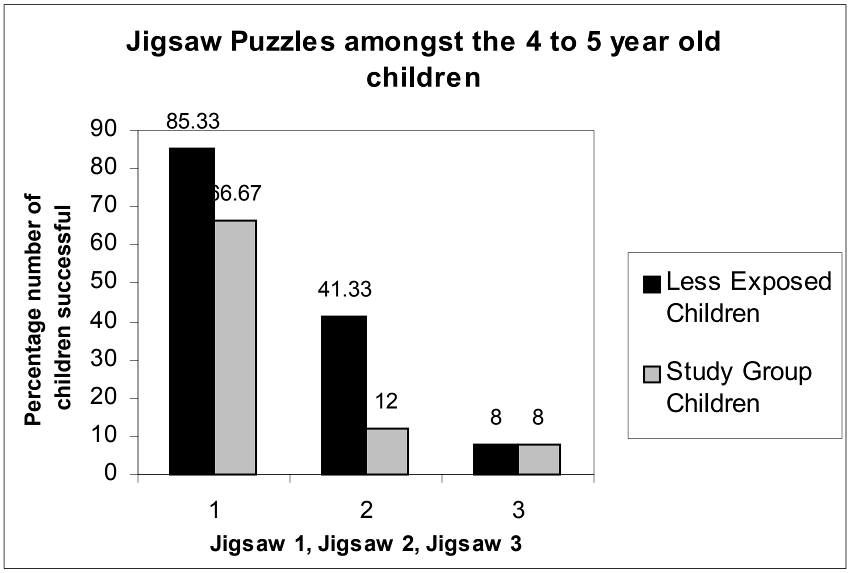


The difference in the ability to do the test decreased as the level of complexity increased, between the study and control group, in both age groups. That could be reason why the results in the second test are not statistically significant.

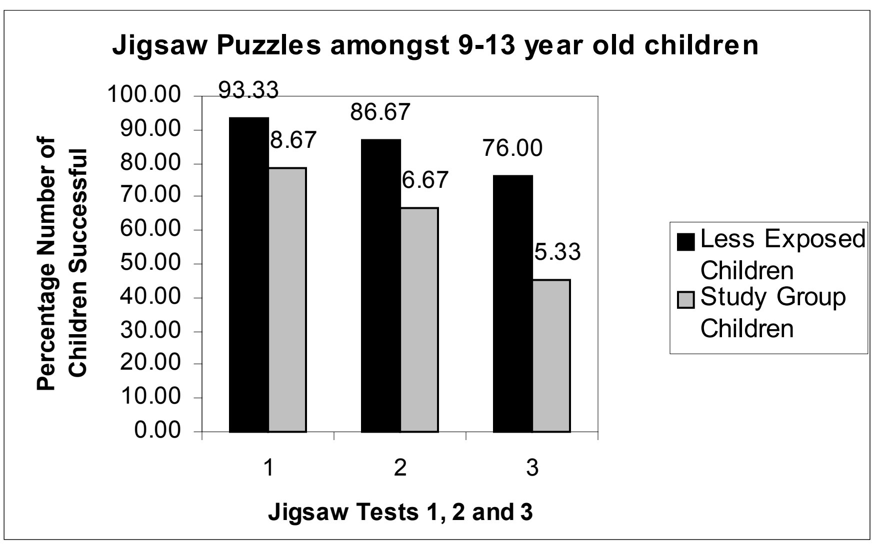
Jigsaw puzzles:

There were three jigsaw puzzles, referred to here as Jigsaw 1, Jigsaw 2 and Jigsaw 3 done by both samples of children.

When it comes to 4-5 year old children, in the case of Jigsaw 1, the control group children performed better in a significant manner. When it comes to Jigsaw 2, the number of children who could do the test successfully in the control group was more than three times the number in the exposed area, in percentage terms. However, when it came to Jigsaw 3, there was equal performance by both the samples.



This was not the case with the older group children, where the ability to perform in the less-exposed children, better than the study location children went on increasing as the level of the tests increased (the differential ability for Jigsaw 1 was 14.7% percentage points, while for Jigsaw 2 it was 20% and for Jigsaw 3, went up to 30.7%).



Non-verbal Cognitive Abilities:

This test was administered to only the 4-5 year old children, where they were asked to draw a human figure, and points were scored against the main parts of the human body drawn, to a maximum of 5 points. On this, the control group children were better with a difference of 0.68 average points over the study group children, at 2.55 average points out of 5.

While the control location children scored an overall average point of 2.55 (±2.02), the exposed children were able to score only 1.87 (±2.02) points, with the p value for statistical significance being 0.02.

Overall, when it came to analytical abilities, 10 tests were administered to the 4-5 age group, out of which 9 tests showed better results by the less-exposed group of children, all of them being statistically significant.

When it came to the 9-13 year old children, all tests out of the ten tests for analytical abilities administered were in favor of the control group children, with corresponding statistical significance.

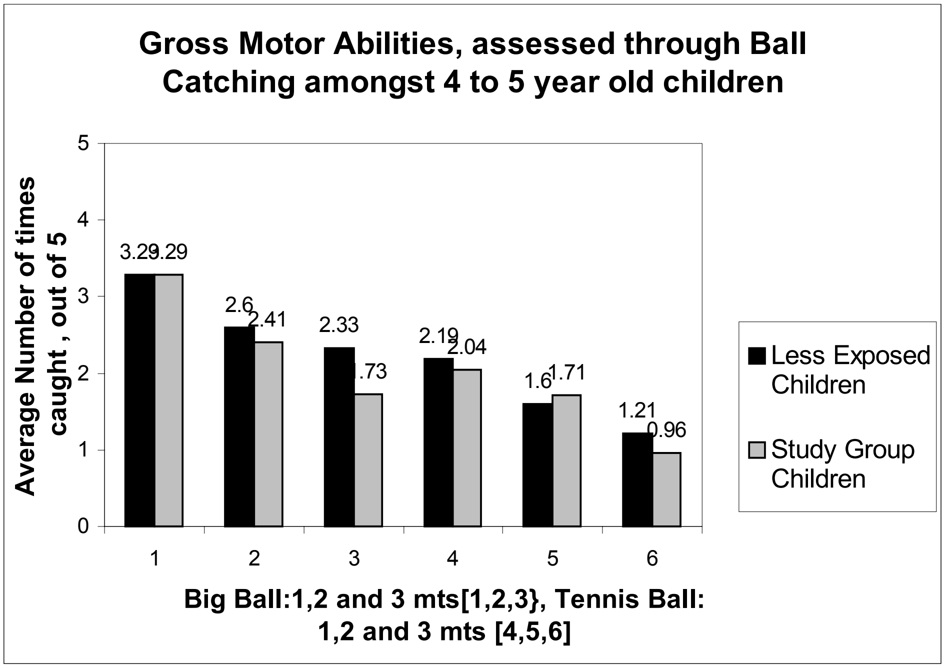
MOTOR ABILITIES:

Eye-Hand Coordination with Large Ball: This game was played only with the 4-5 year age group. Here, out of three tests at three different distances, the first one was equal between the study and control samples. The next two tests saw the less-exposed children display better abilities as a group, to catch the ball. The third test was also statistically significant, in favor of the control group.

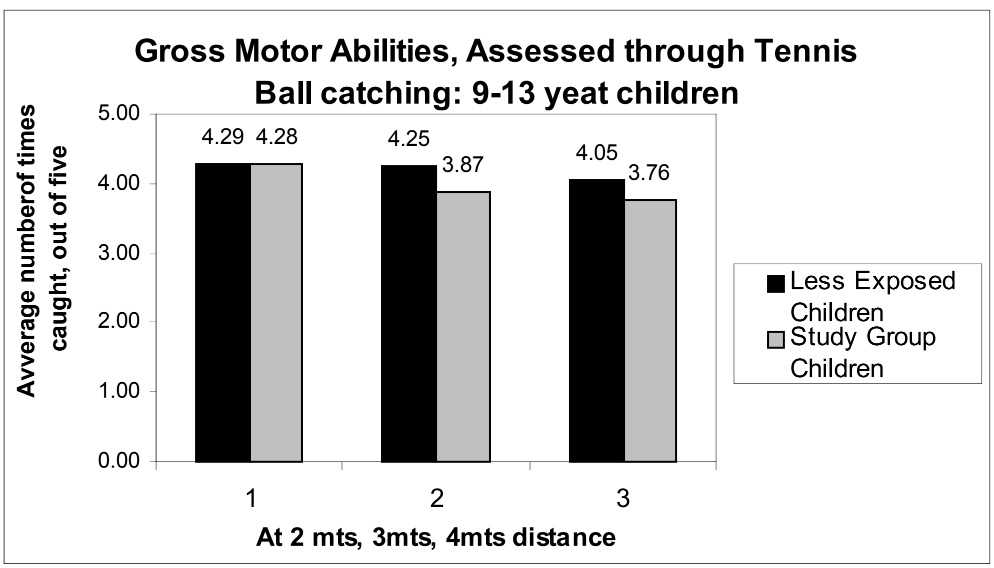
An analysis of the ability to catch a ball at different increasing distances shows that as the distance increased, the difference in the ability also increased between the control and study groups (difference of 0.00 average points at 1 mt, 0.19 at 2 mts and 0.60 at 3 mts) and it is worthwhile to note that the difference at the third distance was statistically significant (p=0.01).

Eye-Hand Coordination with Tennis Ball: This test was administered to 4-5 year old children at distances of 1 metres, 2 metres and 3 metres, and for 9-13 year old children at distances of 2 metres, 3 metres and 4 metres.

In the case of 4-5 year old children, the ability to catch the ball was higher with the less-exposed children as an average score out of five, at two of the three distances. However, the statistical significance of such a difference was not high. In the case of two metres distance, the study group children performed better than the control location children, without any statistical significance (p=0.32). Therefore, one could say that in the case of 4-5 year children, the tests with the tennis ball do not indicate anything about either group conclusively.



In the case of 9-13 year old children meanwhile, the ability to catch a tennis ball as part of this test was higher in the case of the less-exposed children at all three distances. While at the first distance (2 mts), this difference was not statistically significant (p=0.46), it was significant at the other longer distances (p=0.01 and 0.05 at 3 mts and 4 mts' distances, in favor of the control group). The difference in the ability to catch the ball went up for the second distance, and decreased for the third distance.



Sense of Balance:

This ability was assessed through three tests for 4-5 year old children, and two tests for 9-13 year old children.

In all the 3 tests done by the 4-5 year olds in both samples, as well as the 2 tests done by the 9-13 year olds, the less-exposed children did these tests better, with a good margin in the averages/percentages, and with statistical significance except for the plank test in the case of 4-5 year old children. For instance, when it came to Test 1 for 4-5 years of standing on one foot with eyes open, the control location children did the test for 17.27 seconds on an average while the exposed children did it for 10.81 seconds on an average. The p value of such a difference is 0.01.

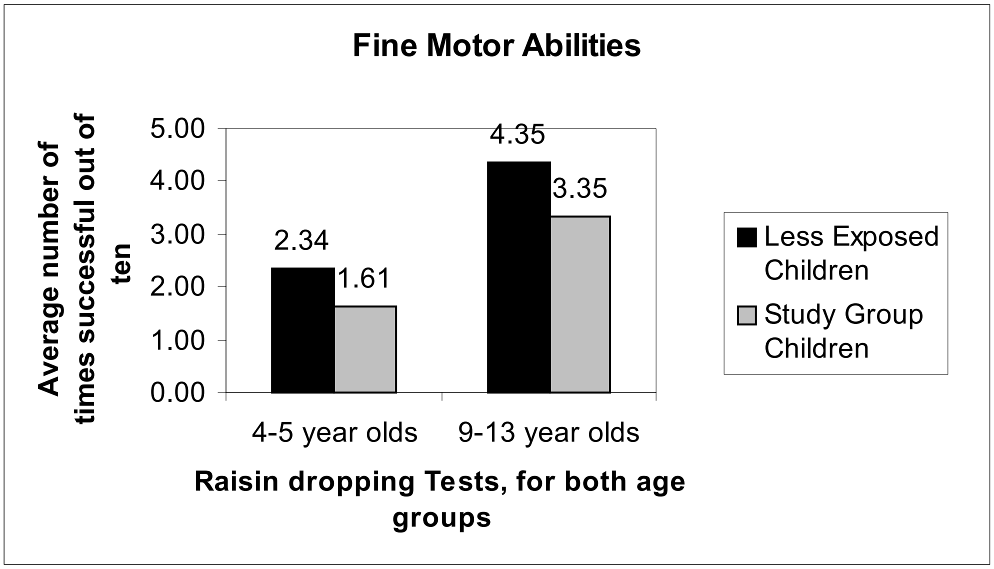
Like mentioned elsewehre, the tests where the child was encouraged to balance itself on one foot with eyes closed or open did not have a time limit set by the researchers, and we came across children who could do it for very long periods of time, much longer than the rest of their counterparts. Therefore, results from these tests are also being presented here as percentage number of children in particular time brackets of performance.

Particular time brackets in seconds	**4-5 year old children**				**9-13 years**	
	Eyes Open, %age number of children		**Eyes Closed, %age number of children**		**Eyes Closed, %age number of children**	
	Study	**Control**	**Study**	**Control**	**Study**	**Control**
0 – 30 seconds	94.4	85.3	98.6	100	90.7	77.3
31 – 60 seconds	5.6	10.7	1.4	0	8.0	18.8
61 – 90 seconds	0	2.7	0	0	0	1.3
91 – 120 seconds	0	1.3	0	0	1.3	1.3
> 120 seconds	0	0	0	0	0	1.3

As the above table shows, except for the test of standing on one foot with eyes closed for 4-5 year old children, the children in the control locations are more spread out into the upper time brackets of performance. This is similar to the results emerging out of Andhra Pradesh.

Fine Motor Abilities:

For the 4-5 year old children, this was tested through one test - eye-hand coordination test with raisins. The test was done by the 9-13 year old children. In both age groups, the less-exposed children did significantly better than the exposed location children. This difference is more in the case of 9-13 year old children. This is borne out by the p value of significance also.



In the 4-5 age group, the results were: 2.34 average points ± 1.91 for the control and 1.61 ± 1.44 for study group children, with the p value being 0.01. In the case of 9-13 year old children, the results were: 4.35 average points ± 1.87 for the control and 3.35 ± 1.88 for study group children. Here, the p value of significance is 0.0007.

In the case of 9-13 year old children, another test in the form of nose-tapping assessed the fine motor abilities. Once again, the control location children were better, with the statistical significance being $p < 0.0001$. The results, recorded in terms of the number of times out of 25 times that a child misses the tip of the nose are: 18.03 ± 3.83 for control location and 20.71 ± 3.39 for the study location. Note that greater the number of such misses, lesser the fine motor ability being assessed.

Stamina:

The last test classified under motor skills for the purposes of the study is a test for stamina, assessed through the length of time that a child could do jumping jacks without getting tired or breathless. The data was analysed in two forms here – one as average length of time for each sample, but also as percentage number of children falling into different time brackets of performing this test.

In both the age groups, the less-exposed children performed this test for significantly longer periods of time than the exposed children, with the difference in the ability, expressed as an average being quite stark. The p values are also low (0.0001 and <0.0001 respectively for the younger and older age groups). However, based on the standard deviation values received for these tests, realising that some children might be performing for much longer periods than the rest of the group (in both samples) we have analysed the data as per percentage number of children in specific time brackets, the results of which are given below.

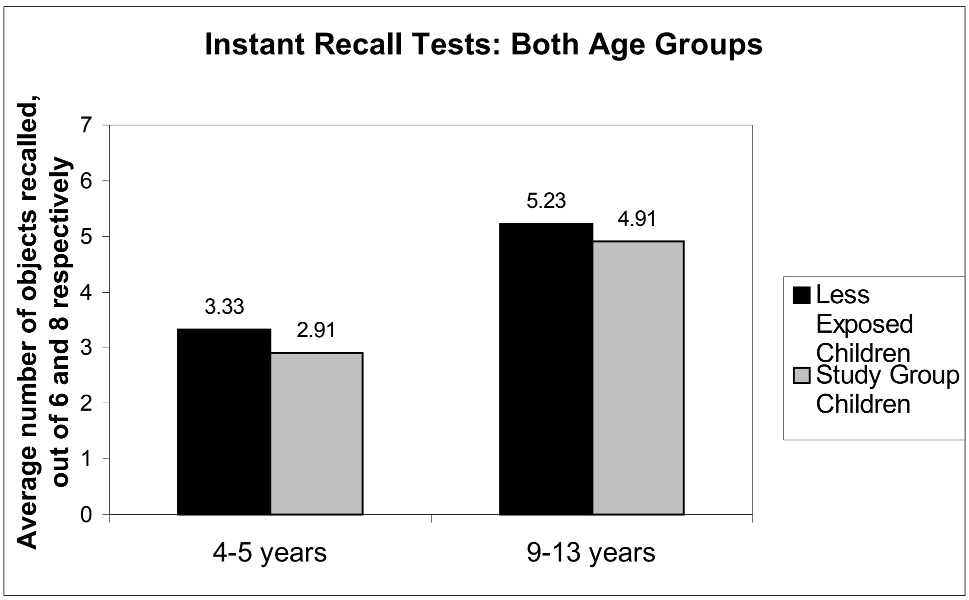
Time brackets, in seconds	**4-5 year old children**		**9-13 year old children**	
	Study	**Control**	**Study**	**Control**
0 – 50 seconds	97.1	83.8	91.9	29.3
51 – 100 seconds	2.9	8.1	8.1	36.0
101 – 150 seconds	0	8.1	0	22.7
151 – 200 seconds	0	0	0	9.3

> 200 seconds	0	0	0	2.7

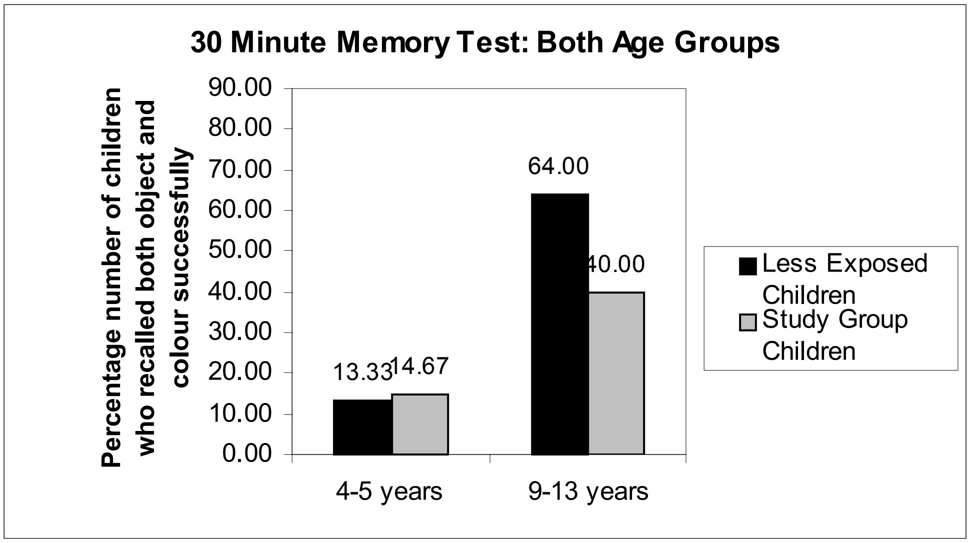
Expectably, the contrast between the study and control group abilities is more apparent in the 9-13 year old children given these time brackets for classifying the abilities that the two sample groups have displayed. In both the age groups, however, there are more percentage number of children from the control locations falling into the longer time categories than the study group children. It is this bracket which is pushing up the overall results of the samples when calculated as average number of seconds that a group can do jumping jacks.

TESTS FOR CONCENTRATION AND MEMORY:

In the case of both age groups, when it comes to the test for concentration / immediate recall, the less-exposed children are significantly better than the exposed group of children (with a difference of 0.42 average points in the case of 4-5 year old children, and a difference of 0.32 points for 9-13 year olds, with the p values for statistical significance for the differential abilities being 0.03 and 0.05 respectively against their corresponding exposed groups).



When it comes to the 30-minute memory test however, in the younger age group, the study groups performed somewhat better than the control location children (by around 1.35 percentage points). The p value of statistical significance in this case is 0.73, and therefore does not say anything definitively about the study group either.



In the case of 9-13 year old children though, the study group did worse than the less-exposed children (the difference here being 24 percentage points).

Overall, out of the 23 tests administered to the two samples in the age group of 4-5 years in Gujarat, on two tests there were equal results; on two tests the study group did better but without significance, while in the remaining 19 tests, the less-exposed children did better. They did so with conclusive statistical significance in the case of 13 tests.

When it comes to 9-13 year old children, 20 tests were administered, out of which less exposed children were better in all the 20 tests, with four tests being without statistically significant results.

KARNATAKA

Karnataka was represented in this study by the district of Raichur, known for its seed cotton production business (which is somewhat on the decline in recent times). There have been earlier reports about suicide deaths and child laborers in seed cotton fields reporting some health problems from this area. The control location for the Raichur children who took part in the study was the same as the one for Andhra Pradesh – in Medak district, which borders both Andhra Pradesh and Karnataka. Within this district, a village very close to the Bidar area of Karnataka was chosen with similar social structures to the Raichur villages selected for the exposed group of children. Therefore, the results from Raichur are being compared with the results already shown in the earlier section against the control location of Andhra Pradesh.

First, we present the profile of the children in both samples, including physical growth measurements as proxies for diet and income. The first table is for 4-5 year old children and the next for 9-13 year old children.

Location (sample size)	**Mean age**	**Gender distribution**[34]	**Boys: 4-5 years**			**Girls: 4-5 years**		
			Height	**Weight**	**H.C.**	**Height**	**Weight**	**H.C.**
Karnataka Study (n=75)	4.77 ± 0.42	40 B + 35 G	100.4 ± 5.94	13.0 ± 1.78	48.9 ± 1.69	98.1 ± 6.21	12.9 ± 1.84	48.5 ± 1.54
Karnataka Control (n=74)	4.77 ± 0.42	32 B + 42 G	99.6 ± 4.61	13.73 ± 1.43	48.9 ± 1.21	99.14 ± 6.14	14.1 ± 1.56	48.1 ± 1.62

As mentioned already, wherever the control group's physical growth parameters were better than the study group's, we used a statistical t-test to compare the similarity between the groups and found that the p values indicate great similarity between the samples (p values ranged from 0.10 to 1, for various measurements between samples of boys and samples of girls). This was done for both age groups, including 9-13 year old children, whose details are presented below:

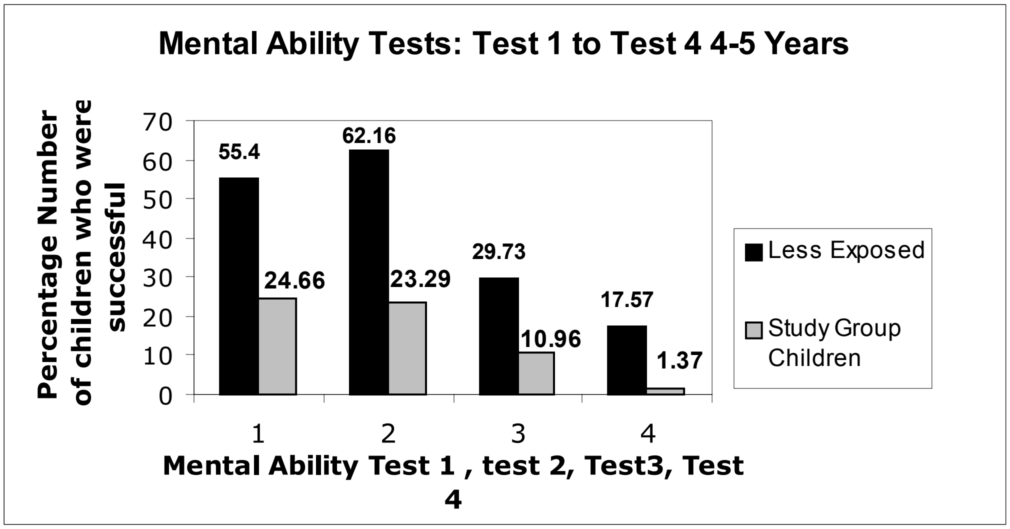
Location (sample size)	**Mean age**	**Gender distribution**	**Boys: 9-13 years**			**Girls: 9-13 years**		
			Height	**Weight**	**H.C.**	**Height**	**Weight**	**H.C.**
Karnataka Study (n=77)	11.27 ± 1.3	40 B + 37 G	135.0 ± 6.7	25.8 ± 4.9	51.4 ± 1.4	131.5 ± 8.6	24.3 ± 4.2	50.7 ± 1.6
Karnataka Control (n=75)	10.48 ± 1.4	42 B + 33 G	127.27 ± 6.04	23.01 ± 2.63	50.4 ± 1.5	126.65 ± 6.72	23.3 ± 3.9	50.9 ± 1.47

Results from Karnataka:

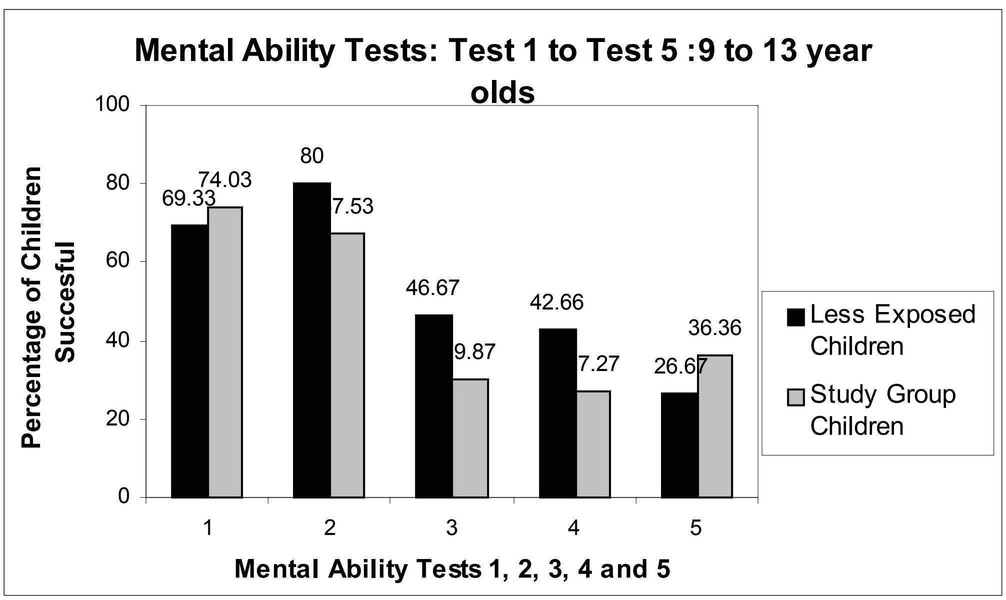
ANALYTICAL TESTS: <u>Mental Ability tests:</u>

In the case of 4-5 years, on all the mental ability tests administered, the control group children performed consistently better than the exposed children. This was with statistical significance. The difference in ability was not along any particular pattern and kept increasing and decreasing as the level of the test increased.

[34] Here, B indicates Boys and G indicates Girls

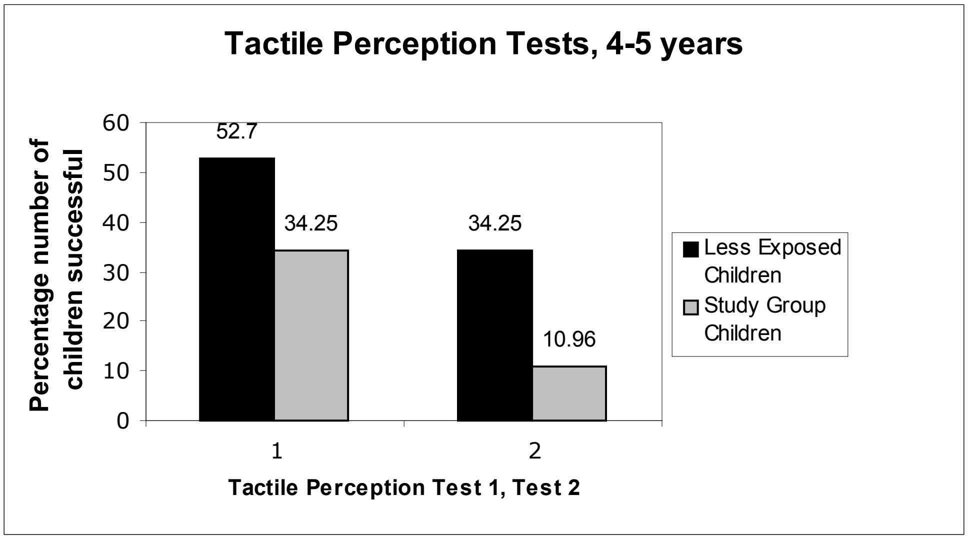


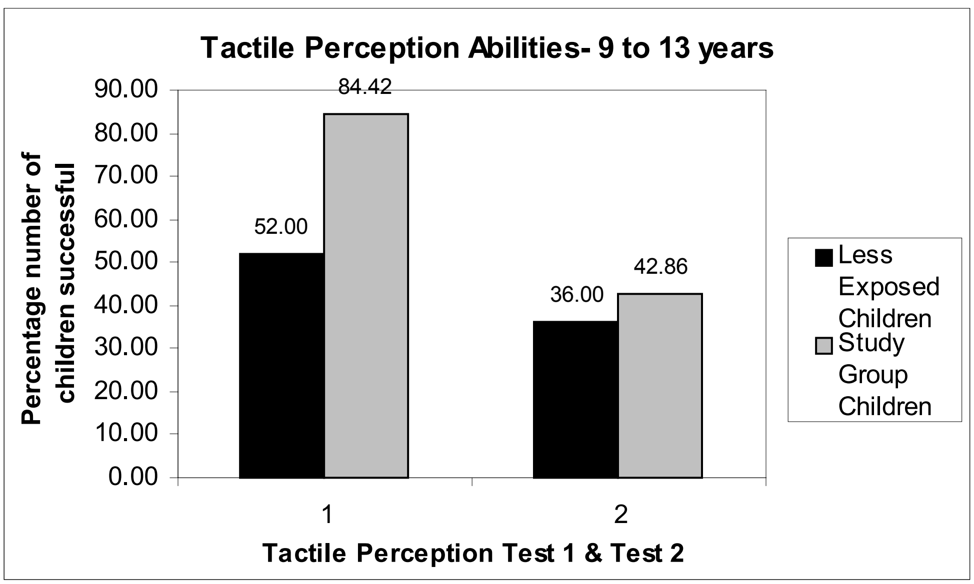
In the case of 9-13 year old children, the first and last tests in this set of five tests were performed better by the study group children. In the first test however, there was no statistical significance to the better performance of the study location children. Even here, there is no increasing or decreasing trend to the differential ability as the tests move to more complicated levels.



Tactile Perception tests:

In the case of 4-5 year old children, in both the tactile perception tests, the control location children performed significantly better than the study location children ($p=<0.0001$ in Test 1 and $p=0.03$ in Test 2). Here, the margin of difference in the ability to perform increased from Test 1 to Test 2. The results from 9-13 age group are very different however. Here, the study group performed better than the control location in both the tests (with a difference of about 32 percentage points in the first test and around 7 percentage points in the second test). The results from the second test are not statistically significant and therefore, do not indicate anything definitively in favor of the Study group either.



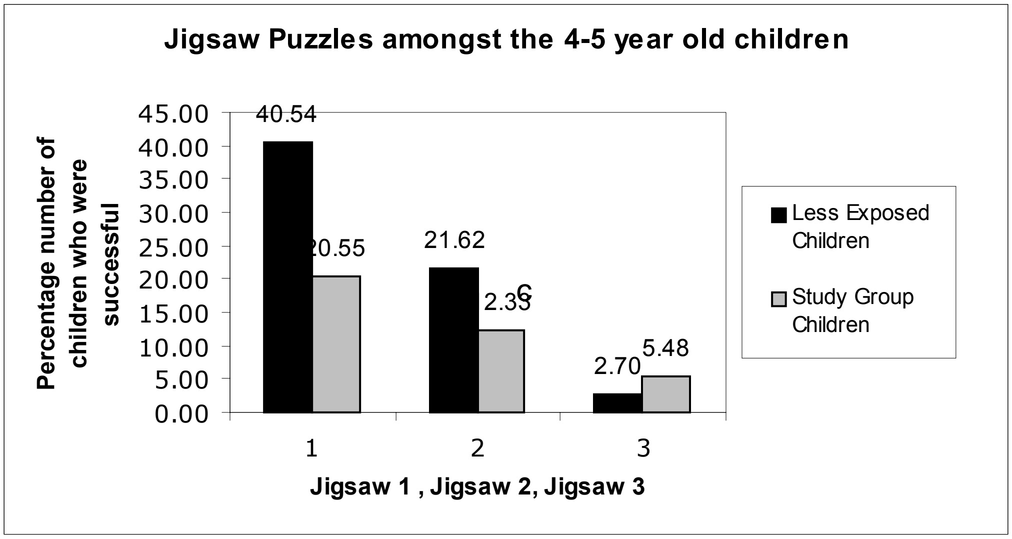


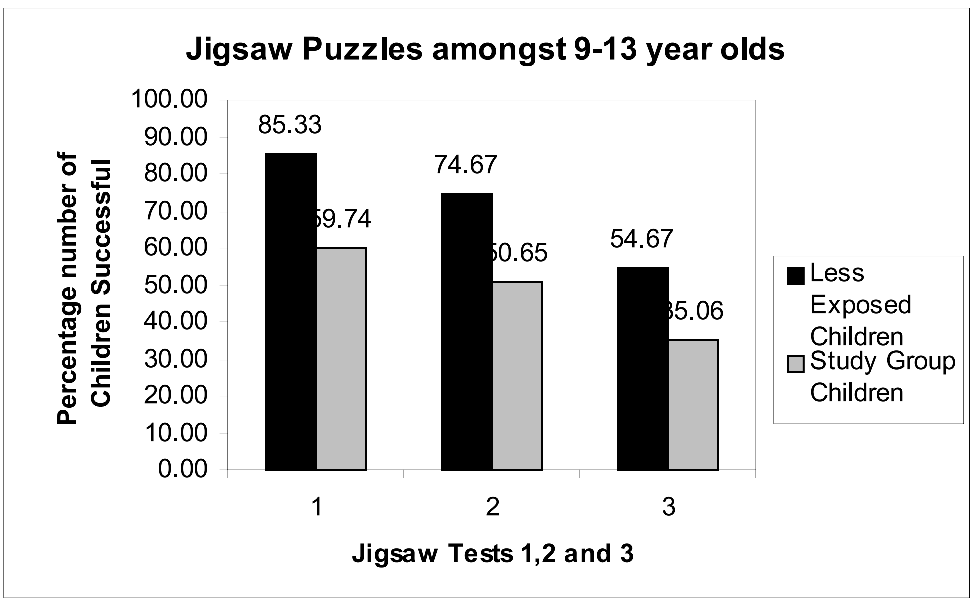
Jigsaw puzzles:

There were two jigsaw puzzles administered in the case of Karnataka for the 4-5 year old children, referred to as Jigsaw 1 and Jigsaw 2. In the case of the 9-13 year old children, there were three jigsaw tests.

When it comes to 4-5 year old children, both tests saw the less-exposed children perform better in a significant manner. The difference in the ability between study and control group narrowed between the first test and the second test, however.

In the case of 9-13 year old children too, the less-exposed children did considerably better than the study location children. Once again, the difference in ability kept decreasing from Test 1 to Test 3, but not in such a stark fashion as in the case of 4-5 year old age group.





Non-verbal Cognitive Abilities:

This is a test for 4-5 year old children, as already mentioned. Here, the control group children performed better by 1.97 average points over the exposed group children, out of a total of 5 average points. The p value is <0.001.

Overall, when it came to analytical abilities, 9 tests were administered to the 4-5 age group, out of which all the 9 tests showed better results by the less-exposed group of children, all of them being statistically significant.

When it came to the 9-13 year old children, out of the ten tests administered, in six tests, control group children performed better, all with statistical significance. In the remaining four tests, the study group performed better, with significance in two tests.

MOTOR ABILITIES:

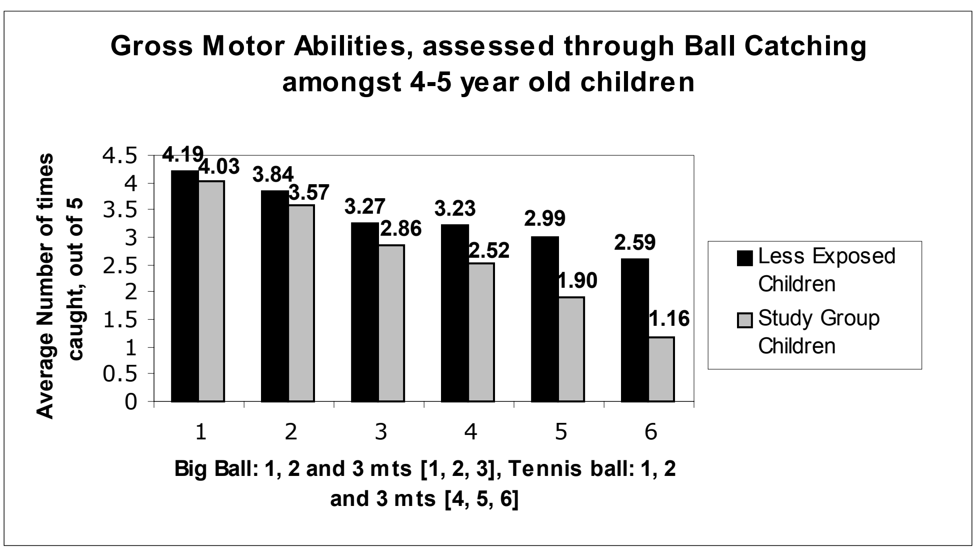
Eye-Hand Coordination with Large Ball:

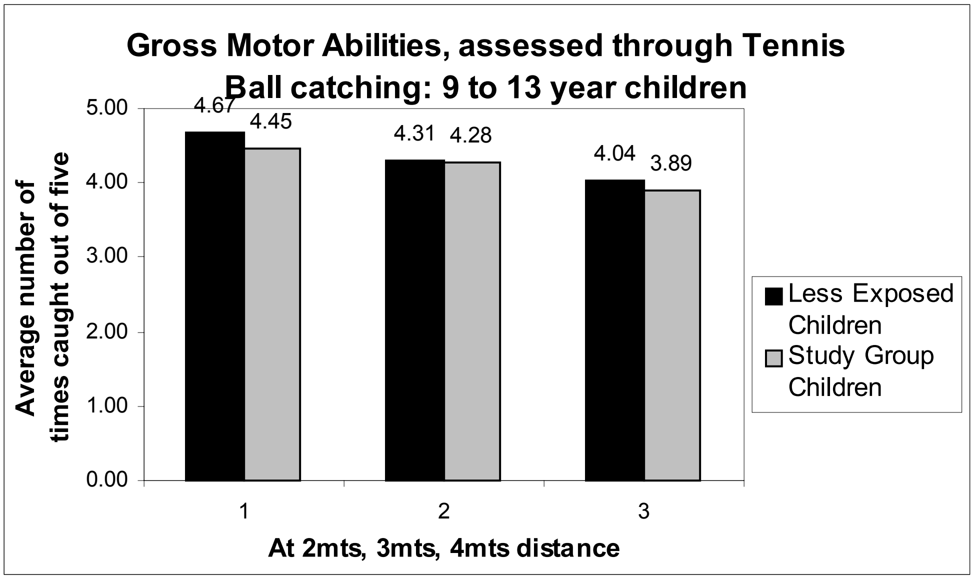
This was for 4-5 year old children. In the three tests administered here, at the first distance, the control group children performed better. At the second distance, both groups performed equally well (3.84 average points out of 5, each) while at the third distance, the study group performed better. Apart from the performance reflected in the group averages, none of the three results showed statistical significance.

Eye-Hand Coordination with Tennis Ball: This test was administered to 4-5 year old children at distances of 1 metres, 2 metres and 3 metres, and for 9-13 year old children at distances of 2 metres, 3 metres and 4 metres.

The pattern seen for the large ball-catching exercise got reflected to an extent in the case of the tennis ball too, when it comes to the 4-5 years age group. The first test at 1 meter distance was performed better by the study group children, but without statistical significance. The next two tests were performed better by the less-exposed children, but again without any statistical significance. Also, there was no discernible pattern about the abilities of either group as the distance increases.

In the case of 9-13 year old children, all the three tests (at 2 mts, 3 mts and 4 mts' distance) were played better by the control group children in terms of simple averages. But like in the case of the younger group children, these results were not statistically significant. P values varied from 0.22 (at the last distance) to 0.46 (at the first distance).





Sense of Balance:

This ability was assessed through three tests for 4-5 year old children, and two tests for 9-13 year old children. In the case of the 4-5 year old children, in all the three tests (two tests of standing on one foot, once with the child's eyes open and the next with the eyes closed, and the last test is a balance walk on a plank) the less-exposed children performed better. While in the case of Test 1 this result was statistically significant (<0.0001), in the case of next one with eyes closed, it was not significant (p=0.11).

In the case of 9-13 age group, there were somewhat mixed results. In the Balance test on one foot, with eyes closed, the control group performed better than the study group children by a difference of around 7.24 seconds on an average, with the p value being 0.0008. In the case of the plank walk test, though the study group did better, the result was not significant statistically.

As mentioned already, the tests where the child was encouraged to balance itself on one foot with eyes closed or open did not have a time limit set by the researchers, and we came across children who could do it for very long periods of time, much longer than the rest of their counterparts. Therefore, results from these tests are also being presented here as percentage number of children in particular time brackets of performance.

State: Karnataka Particular time brackets in seconds	**4-5 year old children**				**9-13 years**	
	Eyes Open, %age number of children		**Eyes Closed, %age number of children**		**Eyes Closed, %age number of children**	
	Study	**Control**	**Study**	**Control**	**Study**	**Control**
0 – 30 seconds	97.3	87.7	100	100	93.4	80.1
31 – 60 seconds	2.7	9.6	0	0	5.3	17.3
61 – 90 seconds	0	0	0	0	1.3	1.3
91 – 120 seconds	0	0	0	0	0	1.3
> 120 seconds	0	2.7	0	0	0	0

As the above table shows, except for the test of standing on one foot with eyes closed for 4-5 year old children where both the sample and control are in the same time bracket, the children in the control locations are more spread out into the upper time brackets of performance. This is similar to the results emerging out of other states too.

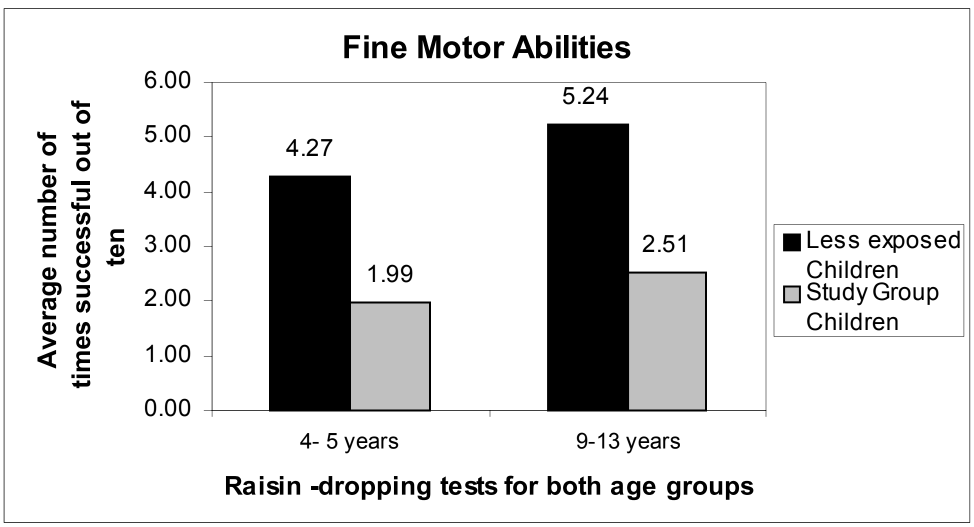
Fine Motor Abilities:

For the 4-5 year old children, fine motor abilities were tested through one test - eye-hand coordination test with raisins. This test was done by the 9-13 year old children too.

In both the age groups, the less-exposed children did significantly better than the study location children, with similar kind of differential abilities demonstrated in both the age groups.

In the 4-5 age group, the results were: 4.27 average points ± 1.97 for the control and 1.99 ± 1.53 for study group children, with the p value being less than 0.0001. In the case of 9-13 year old children, the results were: 5.24 average points ± 1.69 for the control and 2.51 ± 1.77 for study group children. Here also, the p value of significance is less than 0.0001.

In the case of 9-13 year old children, another test in the form of nose-tapping assessed the fine motor abilities. Once again, the control location children were better, with the statistical significance being $p < 0.0001$. The results, recorded in terms of the number of times out of 25 times that a child misses the tip of the nose are: 12.15 ± 5.52 for control location and 18.42 ± 4.5 for the study location. Note that greater the number of such misses, lesser the fine motor ability being assessed.



Stamina:

Stamina, part of the set of tests to assess motor skills in this research, was assessed through the length of time that a child could do jumping jacks without being tired out.

In both the age groups, the less-exposed children performed this test for significantly longer periods of time than the exposed children, with the difference in the ability, expressed as an average being quite stark. The p values are also low (<0.0001 for both the younger and older age groups). The results are: in 4-5 years, 25.74 ± 14.6 seconds for the control on an average, and 10.14 ± 6.65 for the study; in the case of 9-13 years, it is 87.9 ± 49.3 for the control and 24.34 ± 14.8 seconds on an average for the exposed group of children.

However, based on the standard deviation values received for these tests, realising that some children might be performing for much longer periods than the rest of the group (in both samples) we have analysed the data as per percentage number of children in specific time brackets, the results of which are given below.

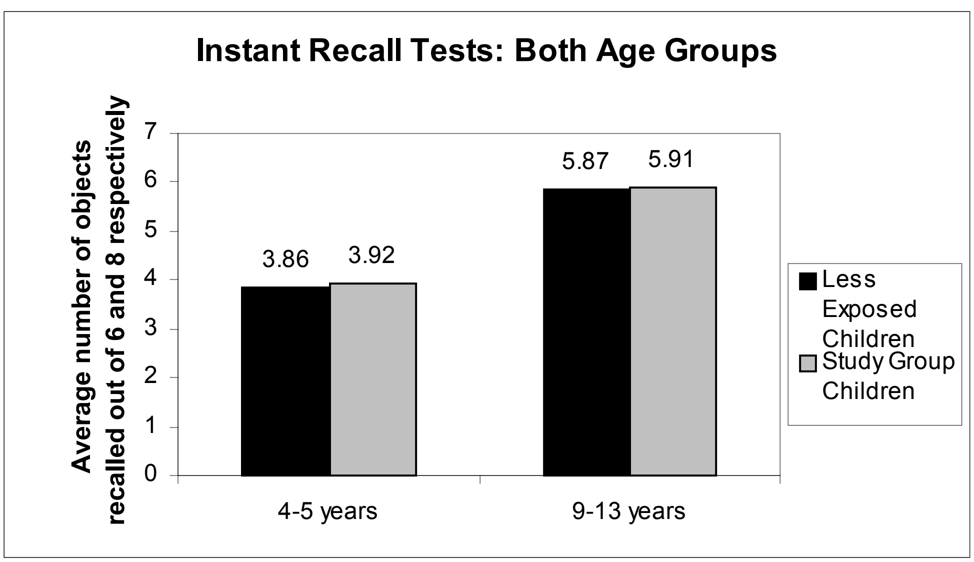
Time brackets, in seconds	4-5 year old children: K'taka		9-13 year old children: K'taka	
	Study	Control	Study	Control
0 – 50 seconds	98.6	94.3	93.5	29.3
51 – 100 seconds	1.4	5.7	6.5	36.0
101 – 150 seconds	0	0	0	22.7
151 – 200 seconds	0	0	0	9.3
> 200 seconds	0	0	0	2.7

Expectably, the contrast between the study and control group abilities is more apparent in the 9-13 year old children given these time brackets for classifying the abilities that the two sample groups have displayed. In both the age groups, however, there are more percentage number of children from the control locations falling into the longer time categories than the study group children. It is this bracket which is pushing up the overall results of the samples when calculated as average number of seconds that a group can do jumping jacks. This is more so in the case of 9-13 age group and the difference with the study group distribution is very apparent.

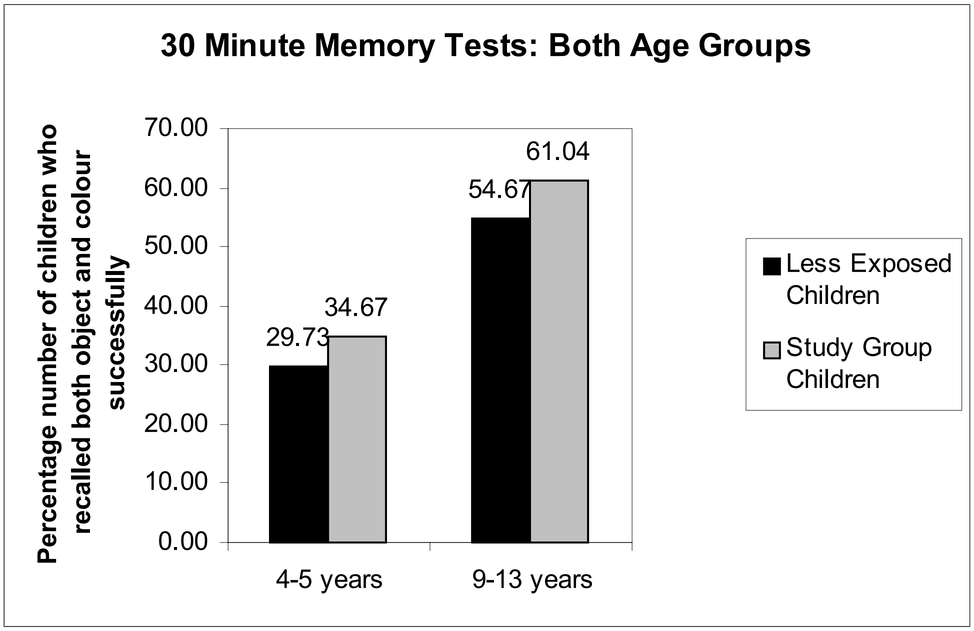
TESTS FOR CONCENTRATION AND MEMORY:

When it comes to tests for Concentration and Memory, both the age groups show very similar trends in Karnataka.

In the case of instant recall tests, in both the younger and older age groups, the study groups are marginally better than the less-exposed children but without any statistical significance. The results are: 3.86 ± 1.15 for control and 3.92 ± 1.11 for the exposed group in the younger age group [p value = 0.383]; 5.87 ± 1.00 for control and 5.91 ± 1.17 for exposed, in the 9-13 age group [p value being 0.41].



In the case of 30-minute memory tests too, this trend persists, where the study group children are better than the less-exposed children, but without any statistical significance.



Overall, out of the 22 tests administered to the two samples in the age group of 4-5 years in Karnataka, on 18 tests, the less-exposed children performed better, and with a statistical significance in the case of 13 of those tests. On all the four tests that the study performed better in, there was no statistical significance to draw inferences about the better abilities of this group conclusively.

When it comes to 9-13 year old children, 20 tests were administered, out of which less exposed children were better in 13 tests. Out of these 13, 10 tests showed statistical significance. While seven other tests saw the study group perform better, 5 of these tests had no statistical significance.

MAHARASHTRA

Maharashtra is one of the most important cotton-growing states of the country. This is also the region where farmers have faced the ecological disaster of pesticides much earlier than the other locations and have by themselves switched over to, experimented and pioneered work on organic ways of cultivating cotton. This is acknowledged as yielding better results by even CICR, Nagpur [Central Institute for Cotton Research, an ICAR set up]. Here, two different tehsils of Yavatmal district were chosen as the study and control locations.

The following table presents the profile of the children in both samples, including physical growth measurements as proxies for diet and income. The first table is for 4-5 year old children and the next for 9-13 year old children.

Location (sample size)	**Mean age**	**Gender distribution**[35]	**Boys: 4-5 years**			**Girls: 4-5 years**		
			Height	**Weight**	**H.C.**	**Height**	**Weight**	**H.C.**
Maharashtra Study (n=75)	4.6 ± 0.49	37 B + 38 G	97.81 ± 6.94	12.92 ± 1.82	48.35 ± 1.58	98.55 ± 6.02	13.18 ± 1.41	47.3 ± 1.86
Maharashtra Control (n=75)	4.4 ± 0.88	41 B + 34 G	92.83 ± 11.23	12.05 ± 1.41	46.0 ± 1.79	92.65 ± 7.13	11.94 ± 1.10	46.03 ± 1.71

Location (sample size)	**Mean age**	**Gender distribution**	**Boys: 9-13 years**			**Girls: 9-13 years**		
			Height	**Weight**	**H.C.**	**Height**	**Weight**	**H.C.**
Maharashtra Study (n=75)	11.25 +/- 1.22	37 B + 38 G	135.5 ± 6.8	24.2 ± 3.6	50.7 ± 1.3	136.3 ± 11.2	26.7 ± 4.91	51.9 ± 3.3
Maharashtra Control (n=75)	11.90 +/- 1.10	45 B + 30 G	133.4 ± 7.6	24.9 ± 3.75	51.9 ± 3.3	132.3 ± 13.1	25.1 ± 5.0	51.4 ± 5.3

To check on the similarity between the study and control samples in terms of the physical parameters mentioned above, T tests were taken up which showed high degrees of similarity except in the case of the Head Circumference measurements in the case of Boys.

Results from Maharashtra:

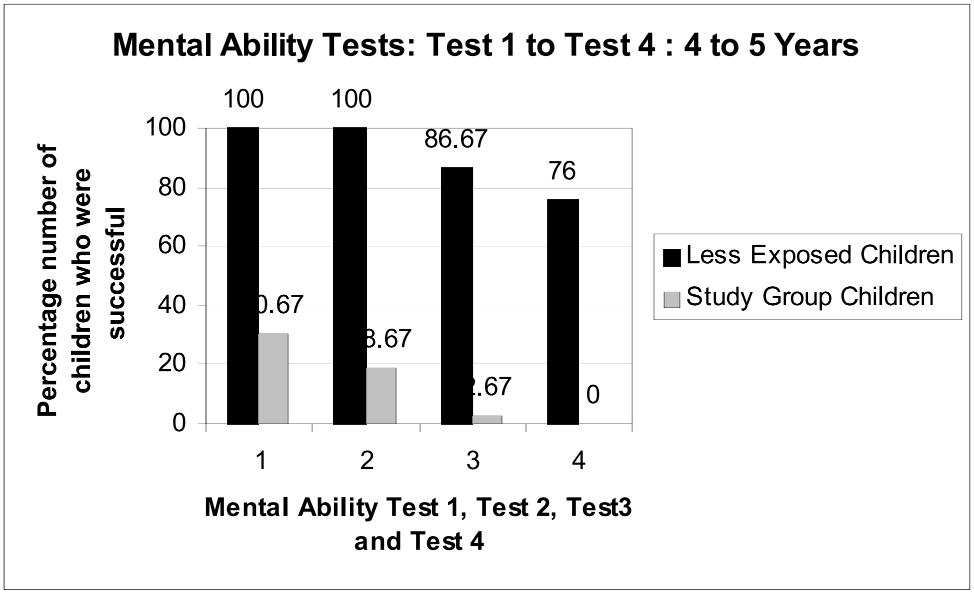
ANALYTICAL TESTS: <u>Mental Ability tests:</u>

As in the case of other states, there were four tests under Mental Ability tests administered to the younger group of children in both samples and five tests for the 9-13 year old children.

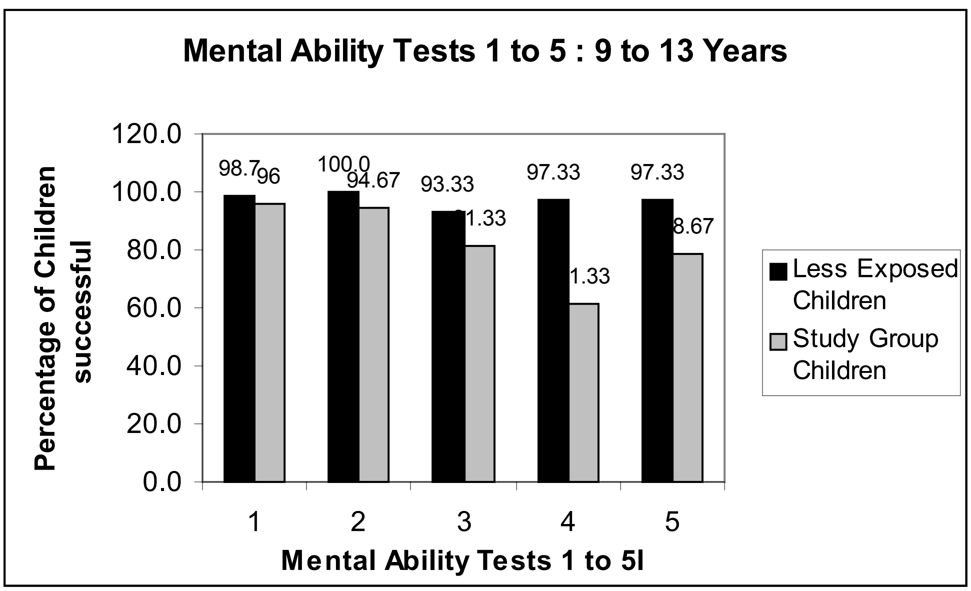
In Maharashtra, the contrast between the study and reference samples was extremely stark when it came to the younger age group, and was not that much when it came to 9-13 year old children. In all the nine tests however (both age groups put together), the results in favor of the control location were statistically significant. This contrast in the 4-5 age group is evident from the fact that just in the first test, in the control location, three times more the number of children than the study location were able to do the test successfully. The margin of difference only

[35] Here, B indicates Boys and G indicates Girls

became starker as the level of test increased to the extent that in the fourth test no child from the exposed group was able to do the test successfully.

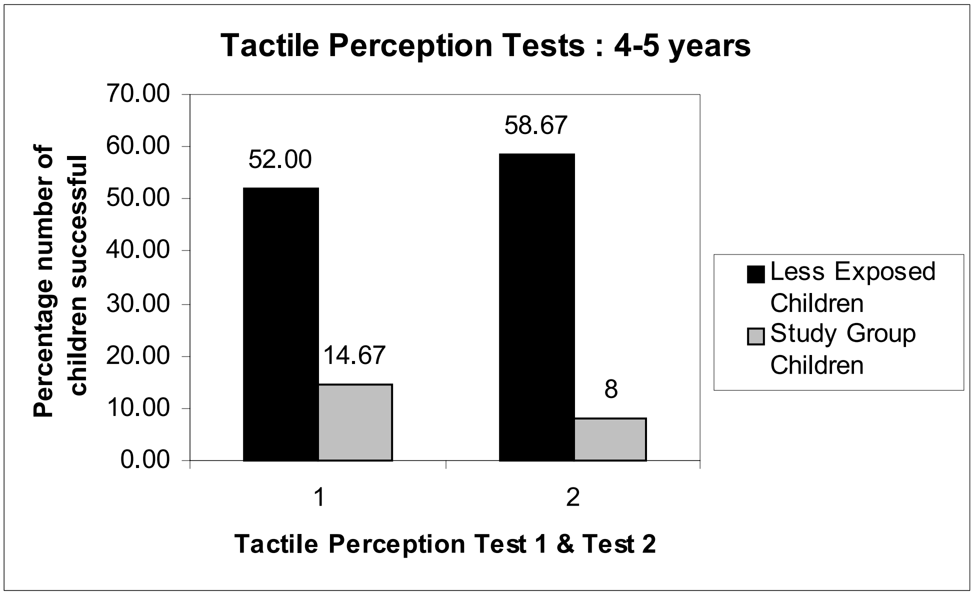


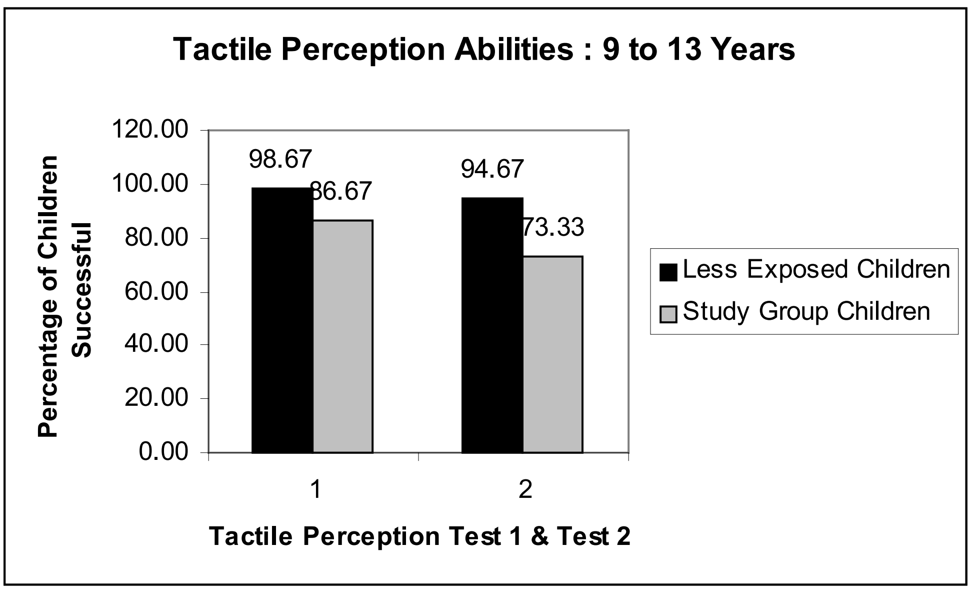
Though not as dramatic as the 4-5 year age group, the difference in the ability also increased in the older age group as the tests moved from the first to the fourth.



Tactile Perception tests:

These tests were once again went in favor of the control location children for both tests and for both age groups. Also, in both age groups, the margin of difference increased when the tests moved from the first to the second (37.3% more children could do the test in the control location, compared to their study location counterparts in the first test – for the second test, the margin shot up to 52%, for instance).

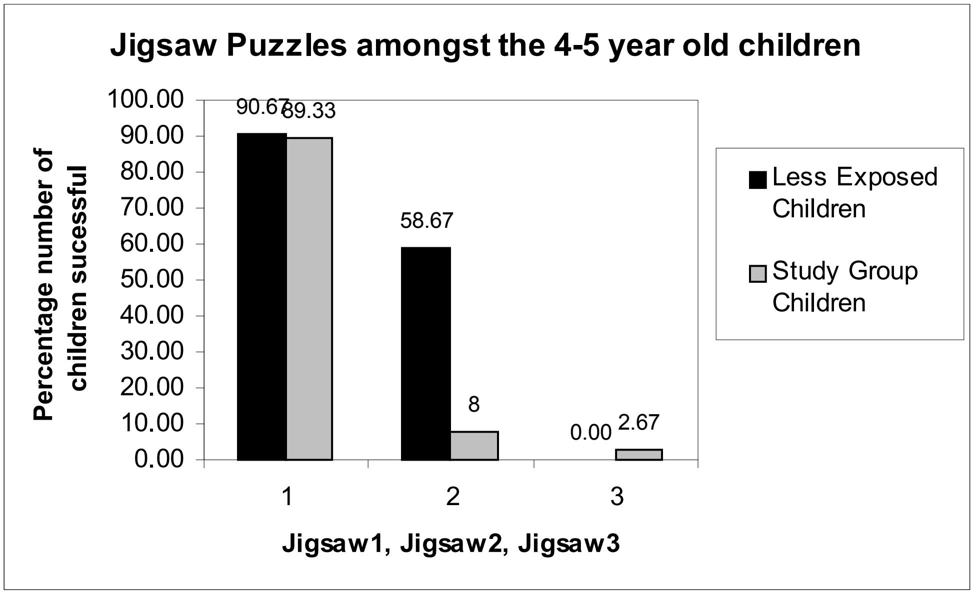




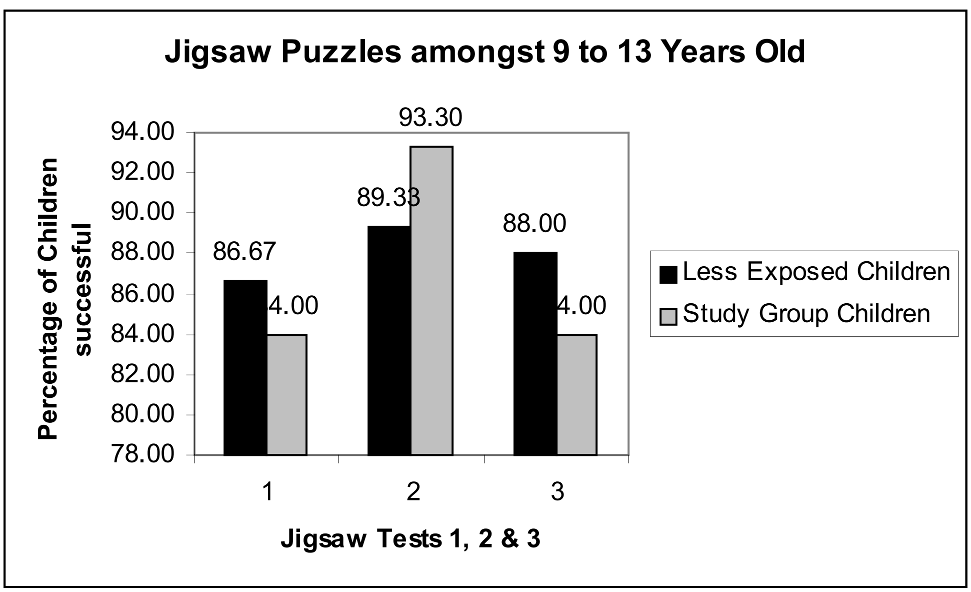
The result for all the four tests (in both age groups together) were statistically significant, with the p values being less than 0.0001 in all cases.

Jigsaw puzzles:

There were three jigsaw puzzles each administered to each age group of children in both samples. In these tests, there were somewhat mixed results in both age groups.
In the case of 4-5 year old children, while Jigsaw 1 and Jigsaw 3 saw control location children perform better, Jigsaw 2 was solved by more number of study group children. However, for Test 1 that went in favor of the control location by 4 percentage points, and for Test 2 which went in favor of the Study location children by around 3 percentage points, there was no statistical significance (p=0.30818 and 0.45438 respectively). For the third test, the control performed significantly better, with the p value at 0.033.



In the case of 9-13 year old children too, the results are mixed and unexpected. The first two tests, from a 2-piece puzzle to 3-piece puzzle saw many control group children being successful in the tests. For instance, in Test 2 nearly eight times the number of exposed group children (expressed in percentage terms) were able to do the test successfully in the control location. While the first test went in favor of the control location without any statistical significance attached to it [p=0.69], the second test had a p value of less than 0.0001. It is the third test that is interesting to note. None of the control group children were able to solve the 4-piece puzzle given to them, while one child in the study location was able to.



Non-verbal Cognitive Abilities:

This is a test for 4-5 year old children, as already mentioned. Here, the control group children performed vastly better by 4.34 average points over the exposed group children, out of a total of

5 average points (control = 4.63 ± 0.61, and study = 0.29 ± 0.96). The p value is <0.001. This, like the last result in the jigsaw puzzles was very different from the other states. Children in the study location could only draw indecipherable circles and lines whereas the control location children were able to draw the human figure in a more recognizable form even if parts of the body were missing in many of such drawings.

Overall, when it came to analytical abilities, 10 tests were administered to the 4-5 age group, out of which 9 tests showed better results by the less-exposed group of children, with only eight of them having statistical significance. One other test was performed better by the study group children, with significance.

When it came to the 9-13 year old children, out of the ten tests administered, in 9 tests the control group children performed better, with eight of these results having statistical significance. In the remaining test, where the study group performed better, there was no statistical significance.

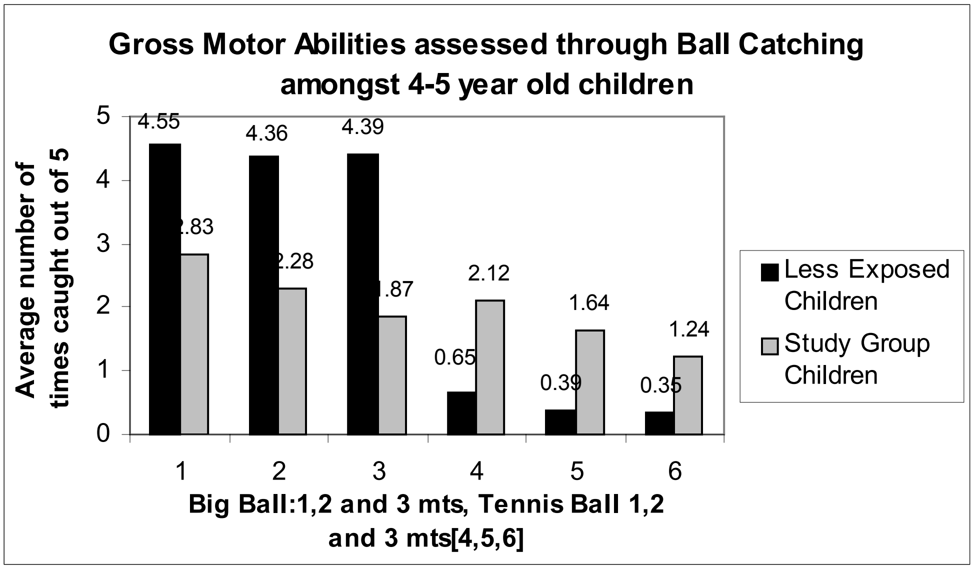
MOTOR ABILITIES:

Eye-Hand Coordination with Large Ball:

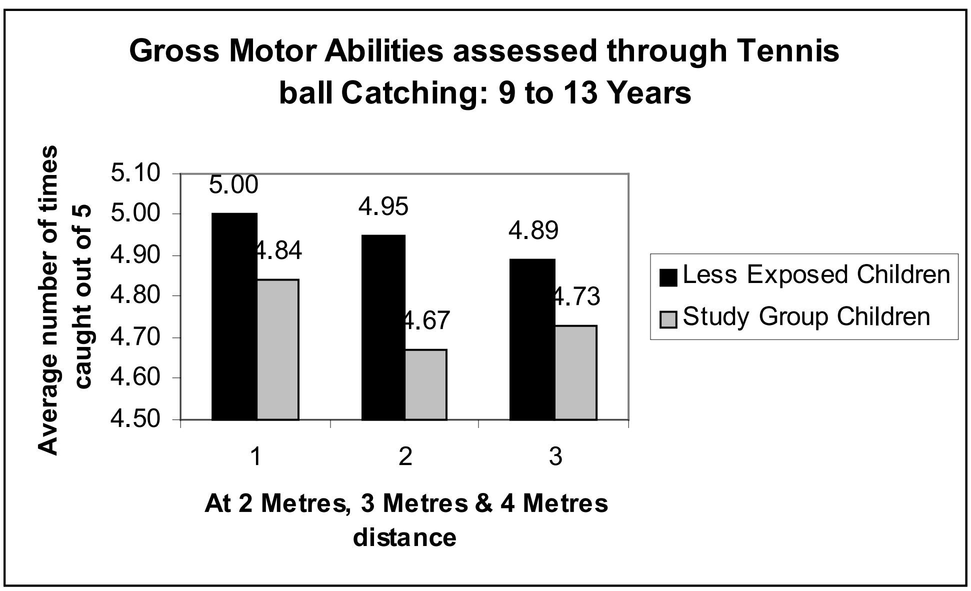
This was for 4-5 year old children. In the three tests administered here, at all the three distances, the control was better. The results were also statistically significant. There was no clear trend of increasing or decreasing abilities as the distance increased. The p values of significance at the three distances were <0.0001, 0.00092 and 0.0132, with the control being able to perform by 1.72, 2.08 and 2.06 average points better than the study location children at the three distances respectively.

Eye-Hand Coordination with Tennis Ball: This test was administered to 4-5 year old children at distances of 1 metres, 2 metres and 3 metres, and for 9-13 year old children at distances of 2 metres, 3 metres and 4 metres.

In the case of 4-5 year old children, at all the three distances the study group children performed vastly better than the less-exposed group of children. This is surprising given the results from the earlier tests with the large ball. The statistical significance to these better results by the study group was highly significant, with the p-value being less than 0.0001.



In the older age group however, the results are somewhat more consistent with the other tests. At all three distances, the control group performed better, and that too with statistical significance to the results [p values were 0.00199, 0.00017 and 0.00431 for the three distances respectively, with the control being better by 0.21, 0.40 and 0.29 average points more than the study group children.



Sense of Balance:

This ability was assessed through three tests for 4-5 year old children, and two tests for 9-13 year old children.

In the case of the 4-5 year old children, there were mixed results in these tests too. When it came to standing on one foot with the child's eyes open, the study did better (for around seven seconds longer on an average as a group, than the less-exposed children, with the p value being 0.0036). However, when it came to standing on one foot with eyes closed, the control group children could stand for three seconds longer on an average. This difference in ability did not have any statistical significance (p=0.18). The third test, of walking on a plank toe-to-heel, turning around and walking back without stepping off the plank, saw the study group perform better again, by a high margin of around 40 percentage points.

In the older age group of 9-13 years too, the study group could stand on one foot, with their eyes closed, for nearly twenty seconds longer on an average than the reference group. This trend is not visible with the plank test, though – more children from the less-exposed group could do this test successfully, with the p value of significance being less than 0.0001.

As mentioned already, the tests where the child was encouraged to balance itself on one foot with eyes closed or open did not have a time limit set by the researchers, and we came across children who could do it for very long periods of time, much longer than the rest of their counterparts. Therefore, results from these tests are also being presented here as percentage number of children in particular time brackets of performance.

State: Maharashtra Particular time brackets in seconds	**4-5 year old children**				**9-13 years**	
	Eyes Open, %age number of children		**Eyes Closed, %age number of children**		**Eyes Closed, %age number of children**	
	Study	**Control**	**Study**	**Control**	**Study**	**Control**
0 – 30 seconds	93.3	100	100	96	48.0	90.7
31 – 60 seconds	5.4	0		0	34.7	4.0
61 – 90 seconds	0	0		0	4.0	0
91 – 120 seconds	0	0		2.7	6.7	2.7
> 120 seconds	1.3	0		1.3	6.7	2.7

As the above table shows, in the case of 4-5 year old children, on the second test of standing on one foot with eyes closed, all the study group children are in the same time bracket of less than 30 seconds. Other than this, in both age groups, the other tests show a greater distribution of study group children in the higher time brackets. This is quite different from the trends obtained in five other states.

Fine Motor Abilities:

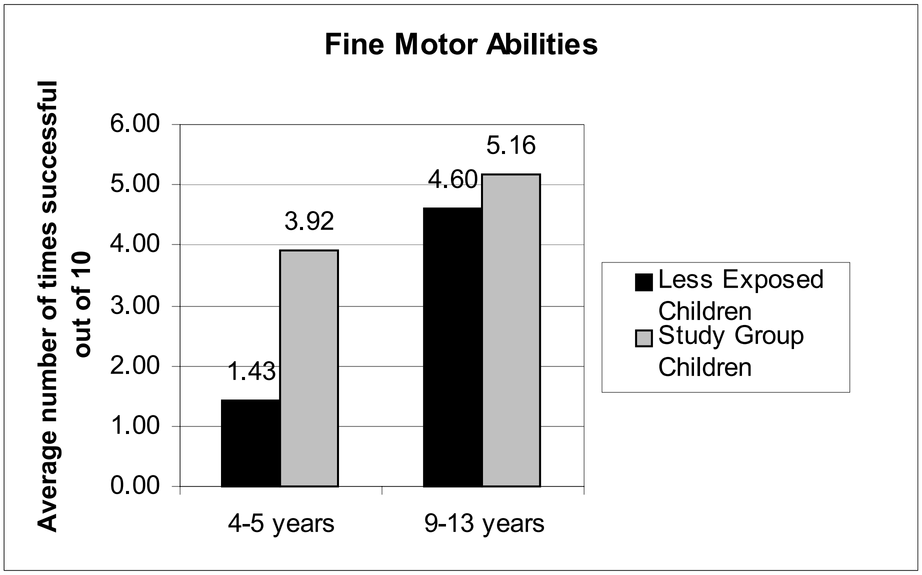
For the 4-5 year old children, fine motor abilities were tested through one test - eye-hand coordination test with raisins. This test was done by the 9-13 year old children too.

In the younger age group, the children from the study location exhibited better fine motor abilities in this test, by a margin of nearly 2.5 average points out of ten. The results are statistically significant too.

In this age group, the results were: 1.43 average points ± 1.21 for the control and 3.92 ± 1.99 for study group children, with the p value being less than 0.0001.

In the case of 9-13 year old children also, this trend persisted with the study group children performing better by around 0.60 average points. The results here were: 4.60 average points ± 1.33 for the control and 5.16 ± 2.12 for study group children. Here, the p value of significance is 0.02779.

In the case of 9-13 year old children, another test in the form of nose-tapping assessed the fine motor abilities. In this test, like in the other states, the control location children were better, with the statistical significance being $p < 0.0001$. The results, recorded in terms of the number of times out of 25 times that a child misses the tip of the nose are: 8.11 ± 2.90 for control location and 18.31 ± 5.77 for the study location. Note that greater the number of such misses, lesser the fine motor ability being assessed.



Stamina:

Stamina, part of the set of tests to assess motor skills in this research, was assessed through the length of time that a child could do jumping jacks without being tired out.

In Maharashtra, in both the age groups, the study group children performed this test significantly better than the control location. The difference in the ability, expressed as an average was quite striking [16.24 seconds longer in the 4-5 year age group and 18.13 seconds longer in the 9-13 age group, on an average]. The p values are also low (0.0002 for the younger age group and 0.02911 in the older group). However, based on the standard deviation values received for these tests, realising that some children might be performing for much longer periods than the rest of the group (in both samples) we have analysed the data as per percentage number of children in specific time brackets, the results of which are given below.

Time brackets, in seconds	4-5 year old children: Maharashtra		9-13 year old children: Maharashtra	
	Study	Control	Study	Control
0 – 50 seconds	97.3	100	62.7	80.0
51 – 100 seconds	2.7	0	26.7	13.3
101 – 150 seconds	0	0	2.7	2.7
151 – 200 seconds	0	0	5.2	2.7
> 200 seconds	0	0	2.7	1.3

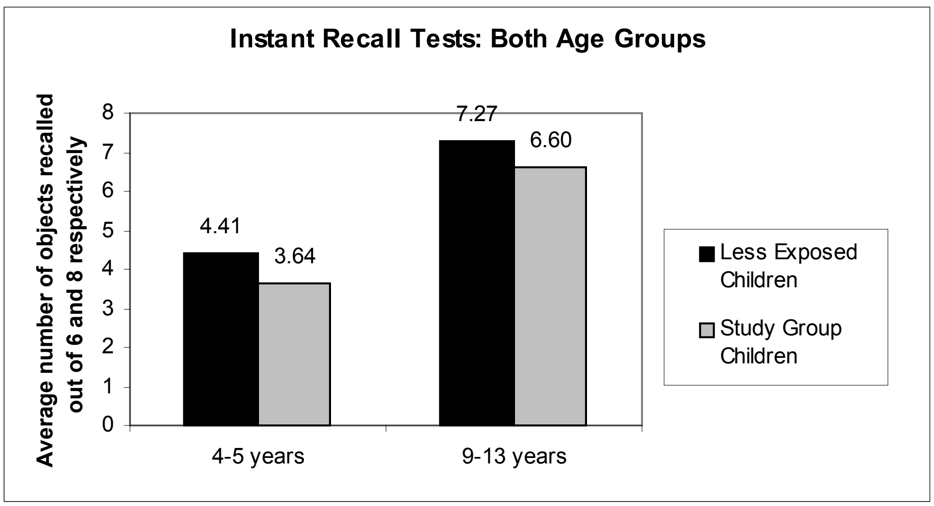
The above results follow the trends shown by the balance tests earlier within Maharashtra. Unlike other states, the study location children are more spread out into the upper time brackets here.

TESTS FOR CONCENTRATION AND MEMORY:

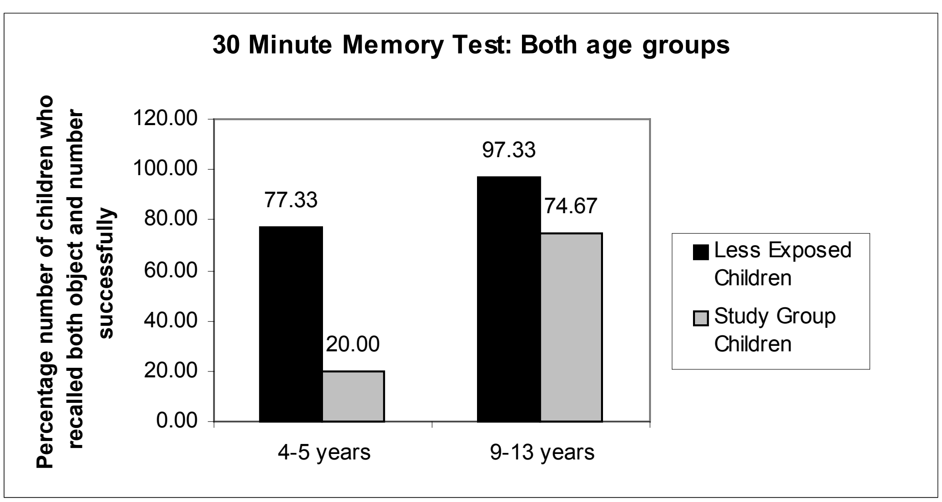
When it comes to tests for Concentration and Memory, both age groups show very similar trends in Maharashtra, with the control group performing better in these tests.

In the case of instant recall tests, in both the younger and older age groups, the less-exposed children are significantly better than the study group children. The difference in ability is higher when it comes to the younger children, calculated in terms of average number of objects recalled [0.77 average points more out of 6 in the case of 4-5 age group, in favor of the control and 0.67 average points out of 8 when it comes to the older age group].

The results are: 4.4 ± 1.25 for control and 3.64 ± 1.37 for the exposed group in the younger age group [p value = 0.00021]; 7.3 ± 1.29 for control and 6.6 ± 0.99 for exposed, in the 9-13 age group [p value being 0.0003].



In the case of 30-minute memory tests too, this trend persists, where the control group children are way ahead of the study group children (57 percentage points higher in 4-5 and 23 percentage points higher in the case of the 9-13 age group).



Overall, out of the 23 tests administered to the two samples in the age group of 4-5 years in Punjab, in 15 tests the less-exposed children performed better, and with a statistical significance in the case of 13 of those tests. When it comes to the remaining eight results which saw the study group performing better, all these results bear statistical significance.

When it comes to 9-13 year old children, 20 tests were administered out of which less exposed children were better in 16 tests. Out of these 16, 15 tests showed statistical significance. In the remaining 4 tests, the study group fared better but without statistical significance in one of the tests.

PUNJAB

Punjab is easily the longest pesticide using location in our study where like our other locations, pesticides related problems are reported in terms of NGO reports on various problems like suicides, disabilities, infertility, cancer incidence and so on.

Bhatinda as an important cotton-growing area of the state has been chosen as the study location, while the control locations was drawn from Ropar district. As could be expected from a state like Punjab, Ropar was not fully free of pesticides either in its agriculture but because of the main crops being wheat and rice here, the quantum of use of pesticides here is starkly less.

Given that overall female literacy rate in Ropar is higher than Bhatinda, it was difficult to control for this factor completely. However, we took the precaution to do a sub-sample analysis for the children of uneducated mothers in the control location and compared them with the group average. The data showed better performance by these children, against the whole group's results. This leads us to conclude that this is not a major influencing variable in this case, probably because the education levels even for the ones who have attended shcools are not very high.

The following table presents the profile of the children in both samples, including physical growth measurements as proxies for diet and income. The first table is for 4-5 year old children and the next for 9-13 year old children.

Location (sample size)	Mean age	Gender distribution[36]	Boys: 4-5 years			Girls: 4-5 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Punjab Study (n=75)	4.57 ± 0.49	40 B + 35 G	103.17 ± 6.28	13.96 ± 2.62	50.1 ± 1.51	100.91 ± 4.30	13.06 ± 1.88	48.8 ± 1.63
Punjab Control (n=75)	4.52 ± 0.50	43 B + 32 G	99.79 ± 4.37	13.65 ± 1.93	49.7 ± 1.52	99.53 ± 4.96	13.47 ± 2.10	48.6 ± 1.21

Location (sample size)	Mean age	Gender distribution	Boys: 9-13 years			Girls: 9-13 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Punjab Study (n=75)	11.89 ± 1.2	36 B + 39 G	142.6 ± 12.7	30.2 ± 7.1	52.8 ± 1.6	145.4 ± 10.0	32.0 ± 7.1	52.7 ± 1.7
Punjab Control (n=75)	11.25 ± 1.1	37 B + 38 G	136.9 ± 5.77	28.2 ± 4.47	52.6 ± 1.03	140.8 ± 8.0	29.5 ± 6.5	52.3 ± 1.5

Results from Punjab:

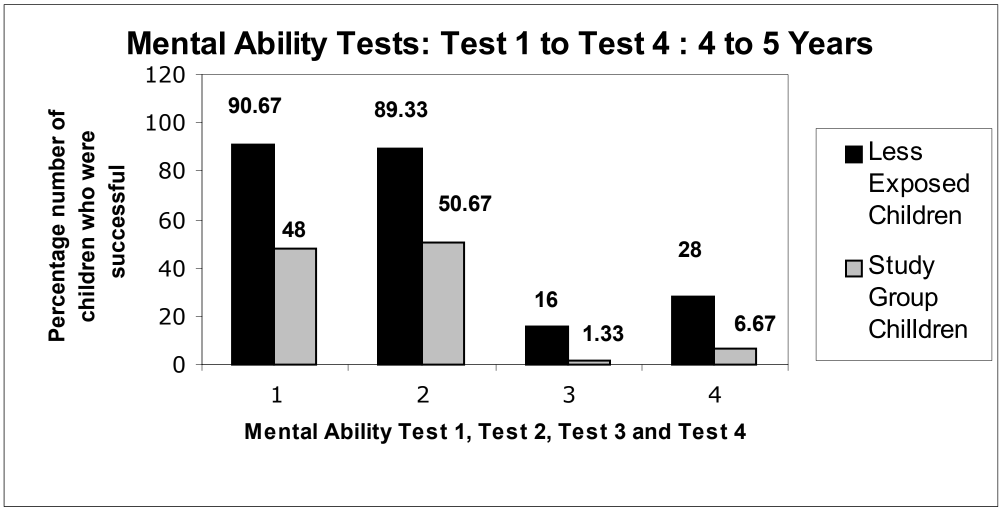
ANALYTICAL TESTS: <u>Mental Ability tests:</u>

As in the case of other states, there were four tests under Mental Ability tests administered to the younger group of children in both samples and five tests for the 9-13 year old children.

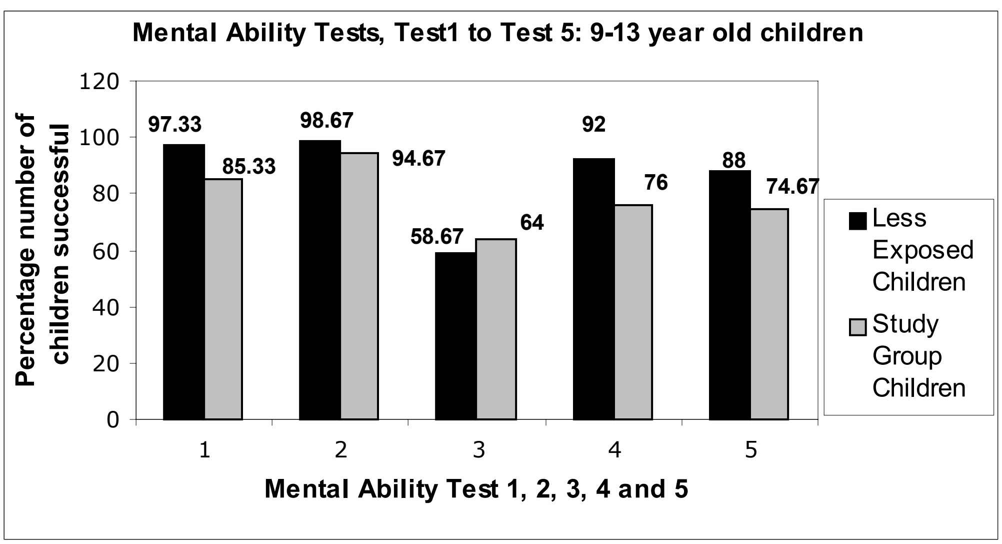
In Punjab, in the case of 4-5 year old children, all the four mental ability test results were in favor of the control location children, with statistical significance in all four cases. It is interesting to note that there was a drastic drop in the percentage number of children who could do Test 3, after Test 2, since the picture shown interpreted differently, and interpreted so in both the study

[36] Here, B indicates Boys and G indicates Girls

and control locations! Therefore, there was no discernible trend to increasing or decreasing difference in abilities as the tests moved from one level to the next.

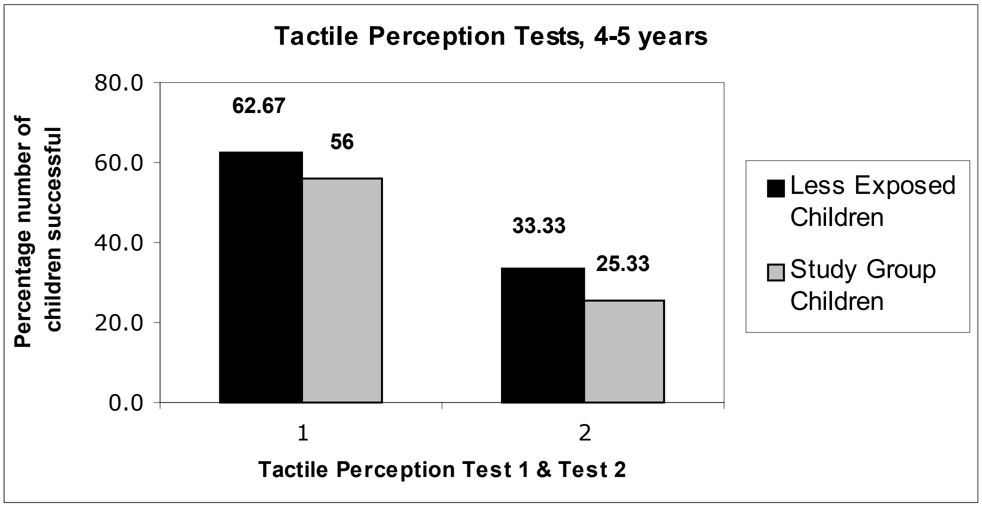


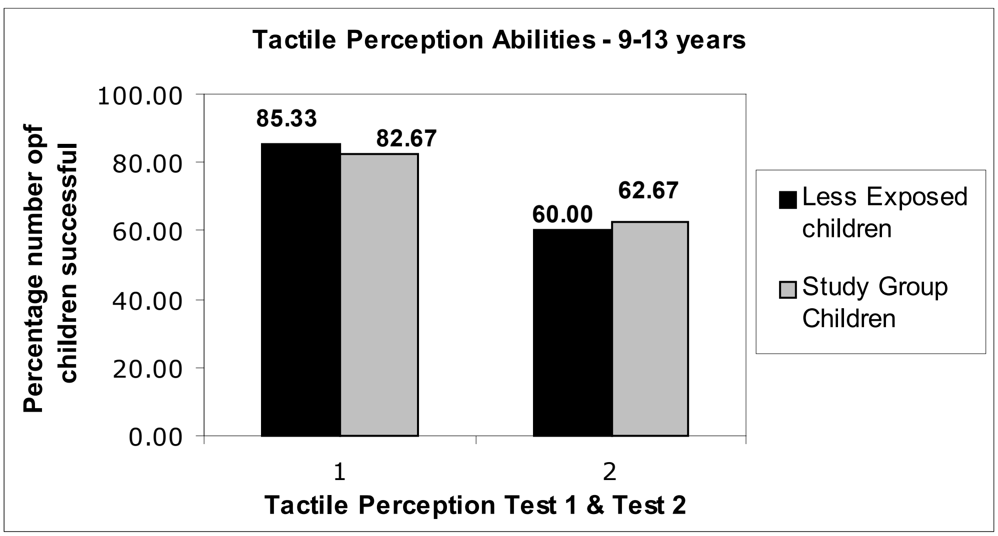
In the case of 9-13 year old children, the same test seemed to have confused the children here too – in this case, in addition to a drastic fall in percentage number of children from Test 2 to Test 3 in both samples, the results went in favor of the exposed group of children. However, there was no statistical significance to this result (p=0.348). The other four tests were in favor of the less-exposed children. Like in the case of 4-5 year old children, there was no discernible pattern of increasing or decreasing abilities.



Tactile Perception tests:

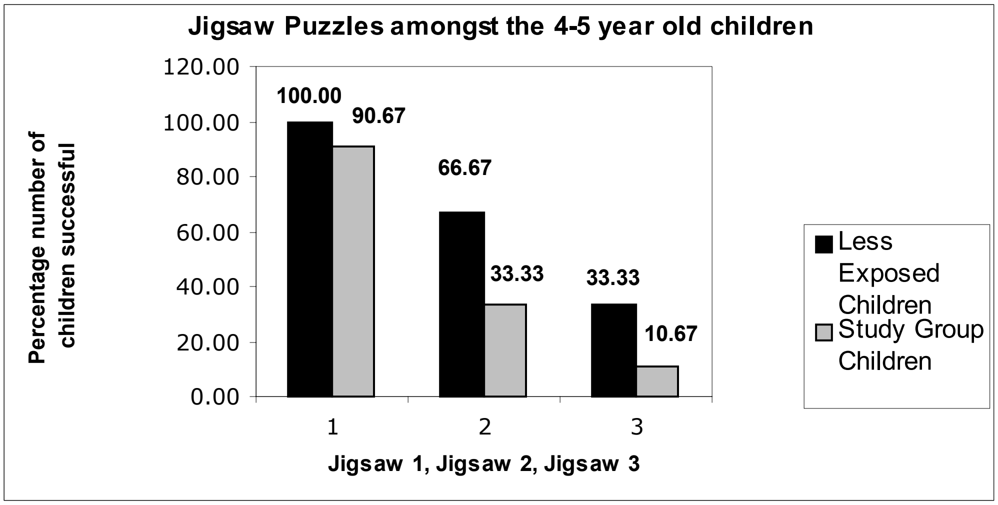
In the case of 4-5 year old children, in both the tactile perception tests, the control location children performed better than the study location children but without any statistical significance. Here, the margin of difference in the ability to perform increased from Test 1 to Test 2. The results from 9-13 age group are very different however. Here, the control group performed better than the study group in Test 1, and the result was reversed in Test 2 where the exposed group of children performed better than their reference counterparts. Interestingly, both the results lack statistical significance. Therefore, one could say that in these tests, in both the age groups, results are inconclusive.



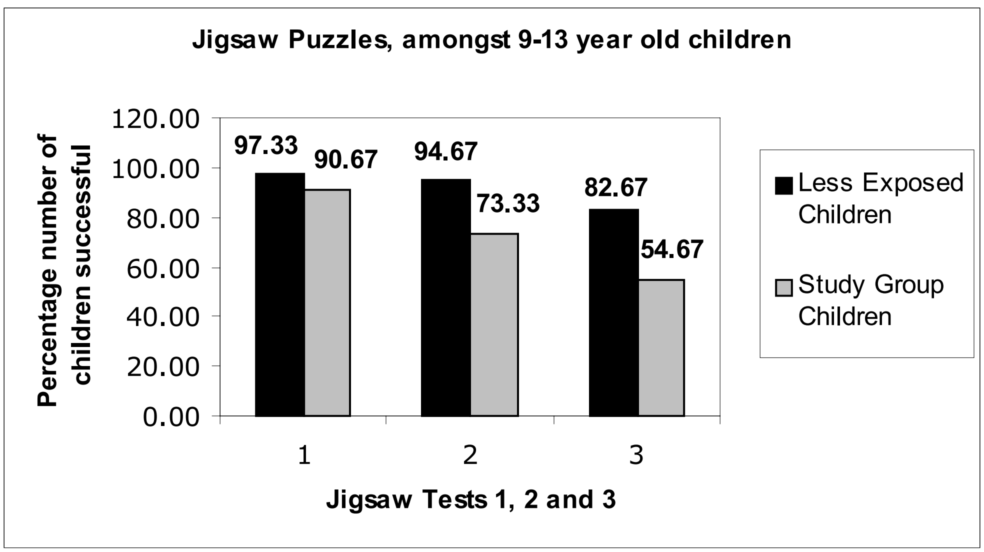


Jigsaw puzzles:

There were three jigsaw puzzles each administered to each age group of children in both samples.



In the case of both age groups, the control children performed better than the study location children. In the case of 9-13 age group, Jigsaw Test 1 saw Control group children perform with a relatively narrow margin of better ability over the study group children.



<u>Non-verbal Cognitive Abilities:</u>

This is a test for 4-5 year old children, as already mentioned. Here, the control group children performed better by 1.33 average points over the exposed group children, out of a total of 5 average points (control = 3.48 ± 1.91, and study = 2.15 ± 2.03). The p value is <0.001.

Overall, when it came to analytical abilities, 10 tests were administered to the 4-5 age group, out of which all the 10 tests showed better results by the less-exposed group of children, with only eight of them having statistical significance.

When it came to the 9-13 year old children, out of the ten tests administered, in eight tests, control group children performed better, with seven of these results having statistical significance. In the remaining one test where the study group performed better, there was no statistical significance either.

MOTOR ABILITIES:

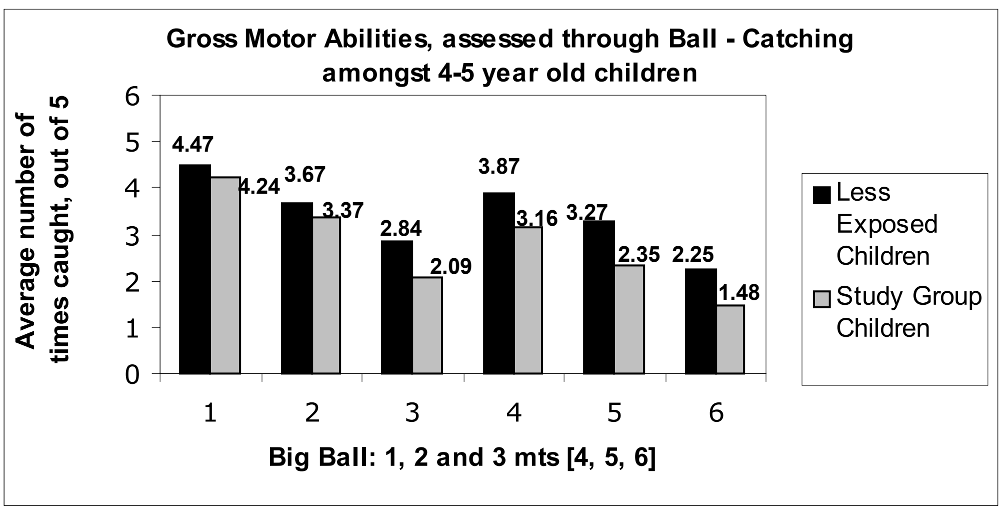
Eye-Hand Coordination with Large Ball:

This was for 4-5 year old children. In the three tests administered here, at all the three distances, the control was better. As the distance increased, the difference in ability also increased between the less-exposed and exposed group of children. Statistical significance with *alpha* fixed at 0.05 levels was missed narrowly in the first test (p=0.07), with the difference being 0.23 average points out of 5. At the second distance, p value was 0.056, and at the third distance, p value was 0.0006.

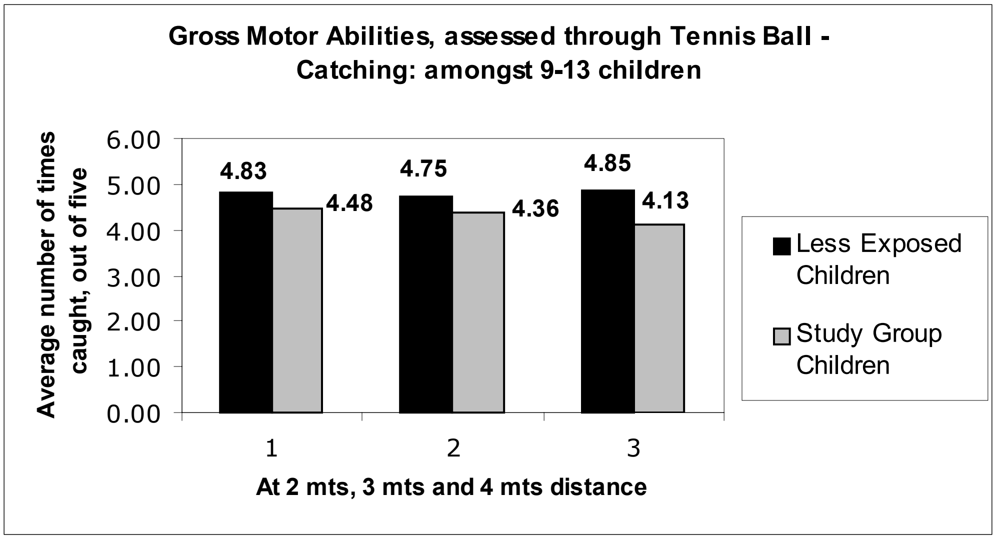
Eye-Hand Coordination with Tennis Ball: This test was administered to 4-5 year old children at distances of 1 metres, 2 metres and 3 metres, and for 9-13 year old children at distances of 2 metres, 3 metres and 4 metres.

In all these tests, for both age groups, the less-exposed children performed better than the study group children. The results were of high statistical significance.

In the case of 4-5 year old children, there was no clear trend regarding the ability to perform better, as the distance increases (the difference was 0.71, 0.92 and 0.77 average points out of five, for distances of 1 mt, 2 mts and 3 mts). The corresponding p values are 0.00035, <0.0001 and 0.00033.



In the case of 9-13 year old children, the difference in ability increased as the distance increased, with better performance by the less-exposed children. The difference in ability at 2 mts, 3 mts and 4 mts was 0.35, 0.39 and 0.72 respectively. The p values in these three cases were: <0.0001, 0.001 and <0.0001.



Sense of Balance:

This ability was assessed through three tests for 4-5 year old children, and two tests for 9-13 year old children.

In the case of the 4-5 year old children, in all the three tests (two tests of standing on one foot, once with the child's eyes open and the next with the eyes closed, and the last test being a balance walk on a plank) the less-exposed children performed significantly better. In the case of standing on one foot, in the first test, they stood for 6.62 seconds longer than their study counterparts on an average, and on the second test, for 2.27 seconds longer on an average. In the case of the plank test, 30% more children could do the test successfully in the less-exposed group, compared to the study group.

In the older age group of 9-13 years, the less-exposed group could stand on one foot, with their eyes closed, for nearly 11 seconds longer on an average, than the exposed group. Similarly, 40% more number of children could do the plank test successfully in the reference group.

As mentioned already, the tests where the child was encouraged to balance itself on one foot with eyes closed or open did not have a time limit set by the researchers, and we came across children who could do it for very long periods of time, much longer than the rest of their counterparts. Therefore, results from these tests are also being presented here as percentage number of children in particular time brackets of performance.

State: Punjab Particular time brackets in seconds	4-5 year old children				9-13 years	
	Eyes Open, %age number of children		Eyes Closed, %age number of children		Eyes Closed, %age number of children	
	Study	Control	Study	Control	Study	Control
0 – 30 seconds	96	92	100	100	81.3	69.3
31 – 60 seconds	4	4	0	0	10.7	14.7
61 – 90 seconds	0	1.3	0	0	5.3	9.3
91 – 120 seconds	0	1.3	0	0	1.3	2.7
> 120 seconds	0	1.4	0	0	1.3	4.0

As the above table shows, in the case of 4-5 year old children, on the second test of standing on one foot with eyes closed, all the study and control group children are in the same time bracket of less than 30 seconds. In the case of this test done with the child's eyes open, as in the case of other states, there are some children in the control location who fall in the top brackets (of even in the "more than 120 seconds" category). The study group children are all distributed into the first two time brackets.

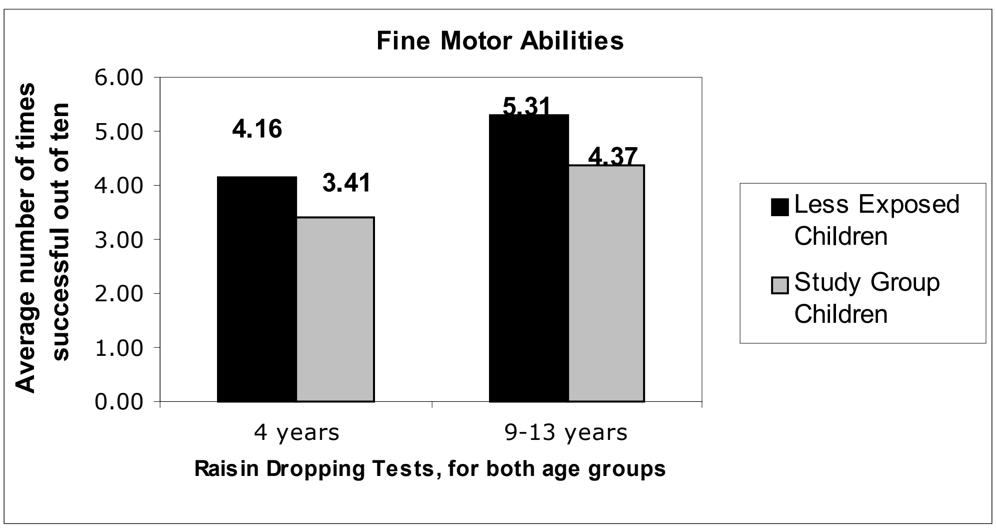
In the case of 9-13 year old children, compared to other states, one finds many study group children moving beyond the first three time brackets. However, even here, it is apparent that there are more number of children from the less-exposed locations who fall in the upper time brackets than from the study locations.

Fine Motor Abilities:

For the 4-5 year old children, fine motor abilities were tested through one test - eye-hand coordination test with raisins. This test was done by the 9-13 year old children too.

In both the age groups, the less-exposed children did significantly better than the study location children, with similar kind of differential abilities demonstrated in both the age groups.

In the 4-5 age group, the results were: 4.16 average points ± 2.05 for the control and 3.41 ± 2.06 for study group children, with the p value being 0.014. The difference is 0.75 average points out of 10 attempts. In the case of 9-13 year old children, the results were: 5.31 average points ± 2.24 for the control and 4.37 ± 2.08 for study group children, with the difference being 0.94 average points. Here, the p value of significance is 0.005.



In the case of 9-13 year old children, another test in the form of nose-tapping assessed the fine motor abilities. Once again, the control location children were better, with the statistical significance being $p < 0.0001$. The results, recorded in terms of the number of times out of 25 times that a child misses the tip of the nose are: 8.0 ± 6.16 for control location and 17.73 ± 6.37 for the study location. Note that greater the number of such misses, lesser the fine motor ability being assessed.

Stamina:

Stamina, part of the set of tests to assess motor skills in this research, was assessed through the length of time that a child could do jumping jacks without being tired out. In Punjab, in both the age groups, the less-exposed children performed this test for significantly longer periods of time than the exposed children, with the difference in the ability, expressed as an average being quite stark [29.72 seconds longer in the 4-5 year age group and 37.33 seconds longer in the 9-13 age group, on an average]. The p values are also low (<0.0001 for both the younger and older age groups). However, based on the standard deviation values received for these tests, realising that some children might be performing for much longer periods than the rest of the group (in both samples) we have analysed the data as per percentage number of children in specific time brackets, the results of which are given below.

Time brackets, in seconds	**4-5 year old children: Punjab**		**9-13 year old children: Punjab**	
	Study	**Control**	**Study**	**Control**
0 – 50 seconds	80	37.3	61.3	16.0
51 – 100 seconds	18.7	49.3	28	53.3
101 – 150 seconds	1.3	12.0	6.7	22.7
151 – 200 seconds	0	1.3	0	2.7
> 200 seconds	0	0	4	5.3

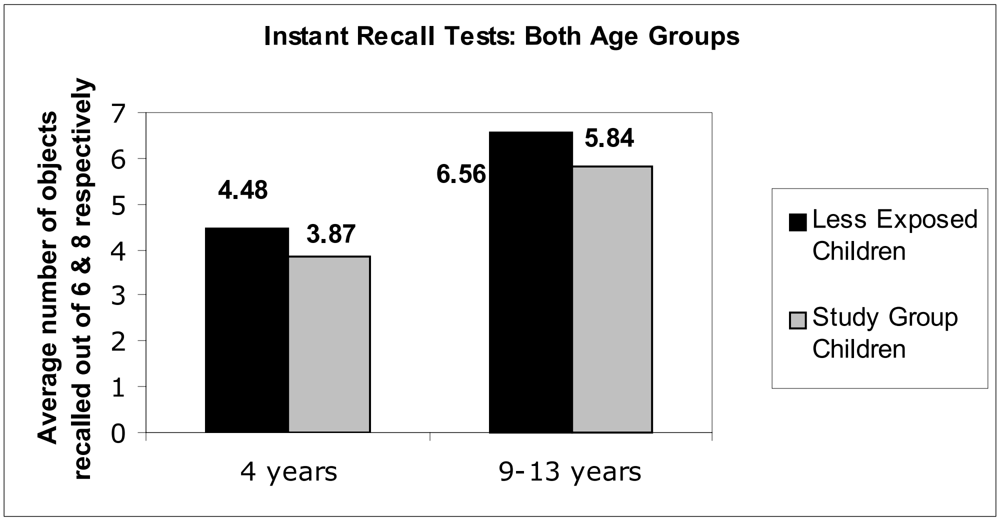
The above results where there are many children distributed across the upper time brackets also are expectable from Punjab. However, the difference between study and control locations is also quite apparent in both age groups. In the case of the 9-13 years, while a majority of the children in the study location could do the jumping jacks for less than 50 seconds, a majority of the control location children could do it for upto 100 seconds. This, in spite of the better physical growth parameters observed in the study location children here.

TESTS FOR CONCENTRATION AND MEMORY:

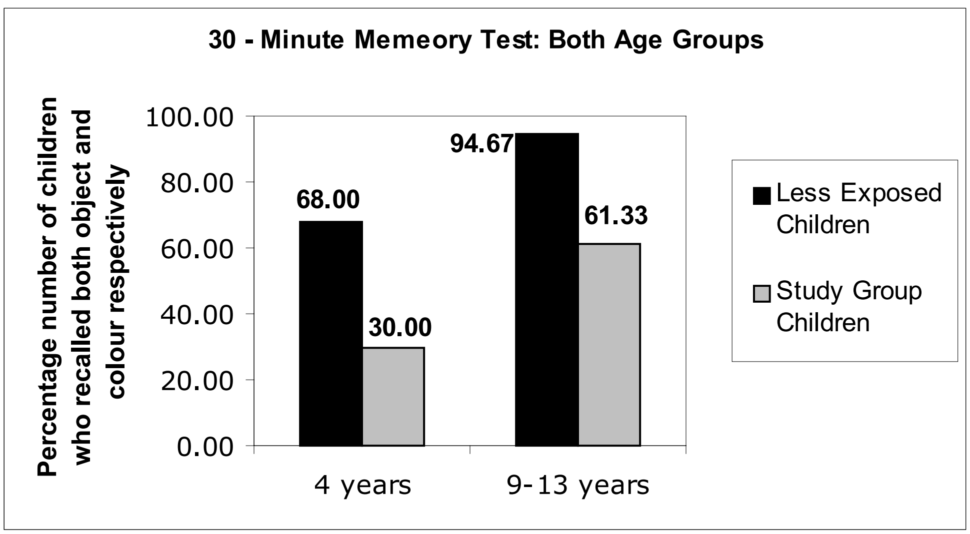
When it comes to tests for Concentration and Memory, both age groups show very similar trends in Punjab, consistent with results from other tests.

In the case of instant recall tests, in both the younger and older age groups, the less-exposed children are significantly better than the study group children. The difference in ability is higher when it comes to the older children, calculated in terms of average number of objects recalled [0.72 average points out of 8 in the case of 9-13 age group, in favor of the control and 0.61 average points out of 6 when it comes to the younger age group].

The results are: 4.5 ± 1.00 for control and 3.87 ± 0.98 for the exposed group in the younger age group [p value = 0.0001]; 6.6 ± 1.03 for control and 5.84 ± 1.04 for exposed, in the 9-13 age group [p value being <0.0001].



In the case of 30-minute memory tests too, this trend persists, where the control group children are way ahead of the study group children (38 percentage points higher in 4-5 and 33 percentage points higher in the case of the 9-13 age group).



Overall, out of the 23 tests administered to the two samples in the age group of 4-5 years in Punjab, in all the tests, the less-exposed children performed better, and with a statistical significance in the case of 20 of those tests.

When it comes to 9-13 year old children, 20 tests were administered, out of which less exposed children were better in 18 tests. Out of these 18, 17 tests showed statistical significance. In the remaining 2 tests, the study group fared better but without statistical significance.

TAMIL NADU

Tamil Nadu is the sixth location in this research project, taken up in the second phase of the study. Here, Theni was the location chosen for the selection of exposed group of children, based on its cumulative cotton production and pesticide use over the past five years. The control location was in the neighboring Madurai district (Theni itself was part of the larger Madurai district earlier).

The following table presents the profile of the children in both samples, including physical growth measurements as proxies for diet and income. The first table is for 4-5 year old children and the next for 9-13 year old children.

Location (sample size)	Mean age	Gender distribution[37]	Boys: 4-5 years			Girls: 4-5 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Tamil Nadu Study (n=75)	4.31 ± 0.46	35 B + 40 G	99.88 ± 8.12	13.30 ± 2.29	49.5 ± 1.61	97.09 ± 7.81	12.3 ± 1.56	47.8 ± 1.44
Tamil Nadu Control (n=75)	4.44 ± 0.50	35 B + 40 G	102.13 ± 4.71	13.83 ± 1.46	49.4 ± 1.81	99.52 ± 6.49	13.34 ± 1.49	48.7 ± 1.81

Like in a few other instances where the control location's physical growth parameters seem to be better (and therefore, an assumption that their nutritional status and developmental abilities would be higher), we sought to assess whether the groups were similar by running t-tests on the samples. We found that the groups were quite similar, especially when it came to boys, and in the case of the girls when it came to height and head circumference.

Location (sample size)	Mean age	Gender distribution	Boys: 9-13 years			Girls: 9-13 years		
			Height	Weight	H.C.	Height	Weight	H.C.
Tamil Nadu Study (n=75)	10.73 ± 1.5	43 B + 32 G	130.34 ± 19.8	24.14 ± 3.0	49.6 ± 4.9	132.6 ± 10.5	23.5 ± 5.6	49.1 ± 6.7
Tamil Nadu Control (n=75)	11.37 ± 1.3	47 B + 28 G	131.3 ± 10.2	24.9 ± 4.6	51.0 ± 1.8	127.0 ± 6.6	23.0 ± 3.2	49.1 ± 1.9

Even for this age group, T-tests were relied upon to assess the similarity of the two samples and these tests show that on two parameters out of three, for both boys and girls, the groups are very similar.

Results from Tamil Nadu:

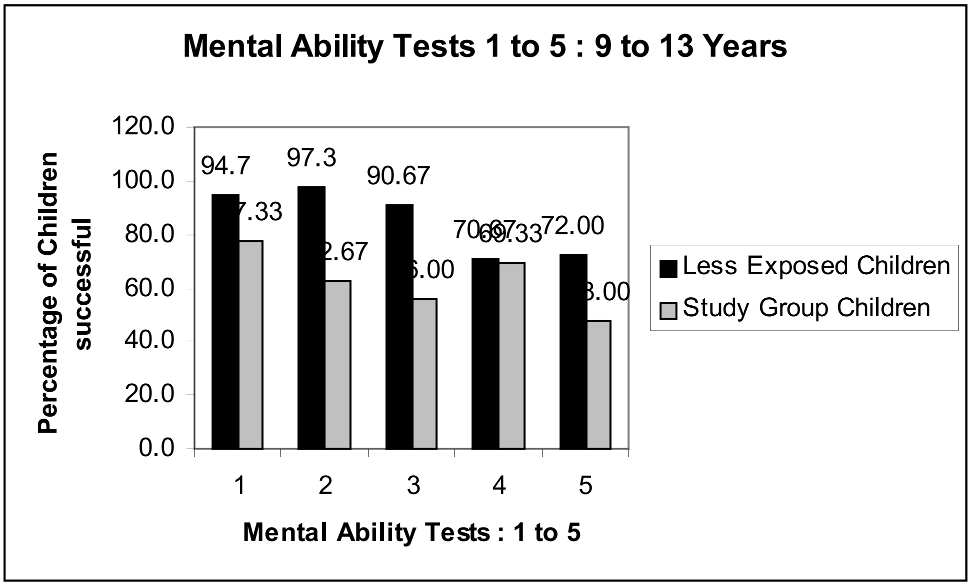
ANALYTICAL TESTS: <u>Mental Ability tests:</u>

As in the case of other states, there were four tests administered to the younger group of children in both samples and five tests for the 9-13 year old children under Mental Ability tests.

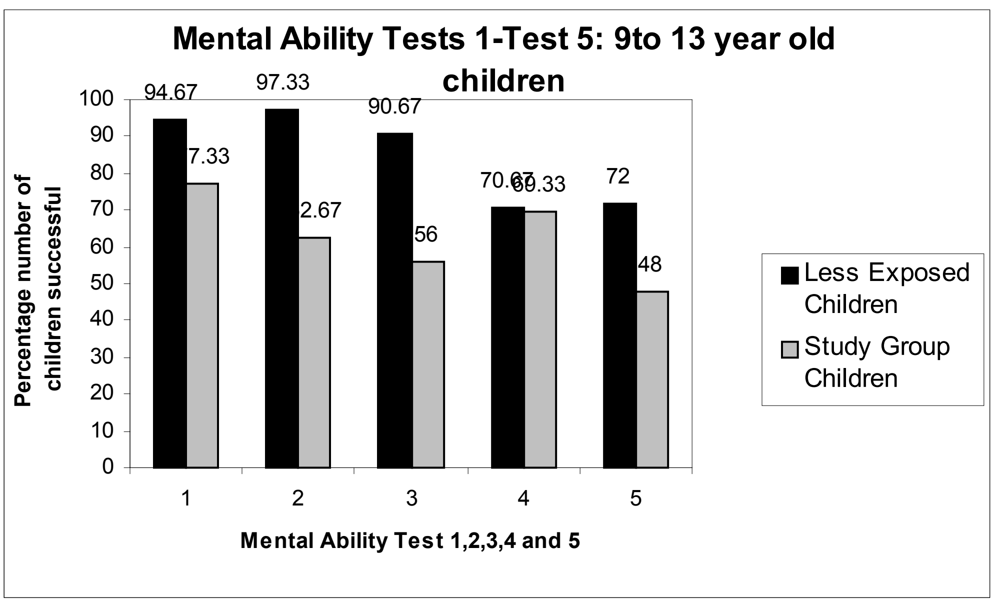
In the younger age group, the control group performed consistently better in all the four mental ability tests and all results show high levels of statistical significance. As in the case of Gujarat, the difference in the ability between the less-exposed and study group children kept decreasing as the level of the test increased – from a difference of 62.67 percentage points in Mental Ability Test 1, to 56% in Test 2, 25.3% in Test 3 and 18.7% in the last test. This meant that the p value

[37] Here, B indicates Boys and G indicates Girls

also changed correspondingly, from <0.0001 in the first test to 0.0035 in the last test. As already mentioned, in this age group, all the four results with better abilities of the control group had statistical significance.



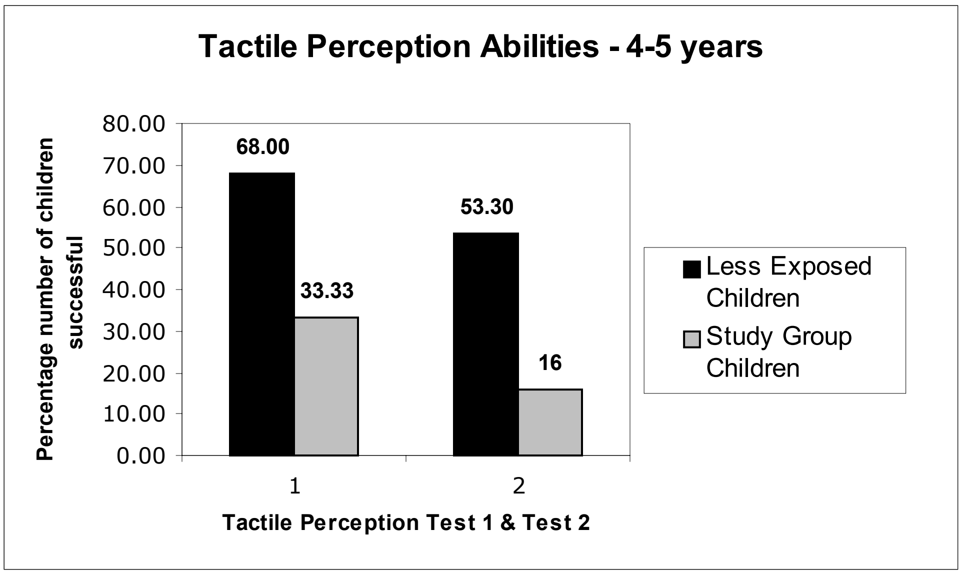
In the case of 9-13 year old children too, the less-exposed children performed better in all the five tests calculated as percentage number of children who could do the test successfully. However, there is no trend of increasing or decreasing abilities as the tests increase in levels, as in the case of the younger age group. In the case of Mental Ability Test 4, there is no statistical significance to the result, even though the control group continued to perform better than the study group.

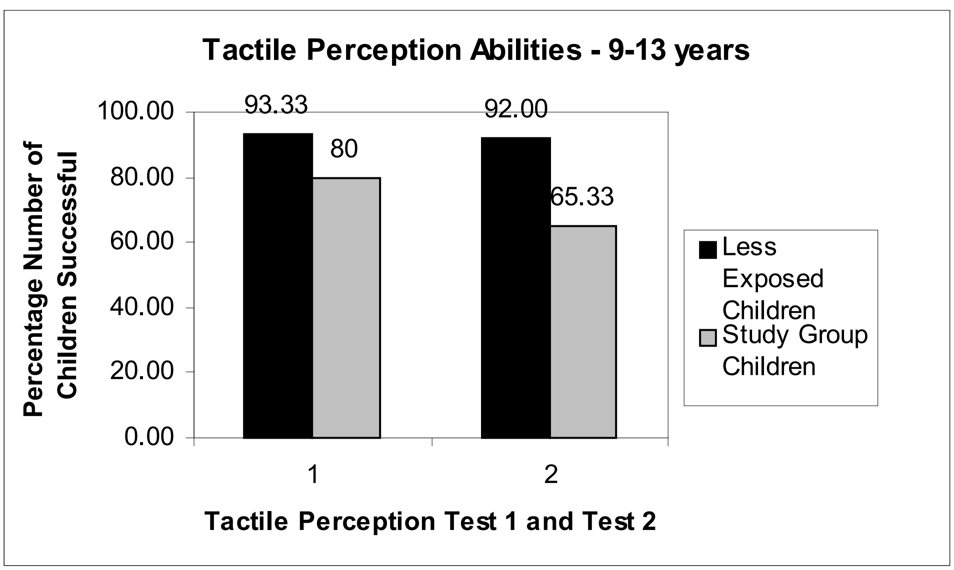


Tactile Perception tests:

Both the tactile perception tests saw the less-exposed children perform significantly better in Tamil Nadu. Here, the results show that more than double the number of children from the control location were able to perform the test successfully, compared to their counterparts in the study locations. The p values for this differential abilities are less than 0.0001 for both tests. The margin of difference in favor of the control group children increased marginally from Test 1 to Test 2.

In the case of 9-13 year age group also, the control group performed better on both tests, with statistical significance attached to the results. The margin of difference, like in the case of the 4-5 year age group, increased from Test 1 to Test 2, in favor of the control group children.

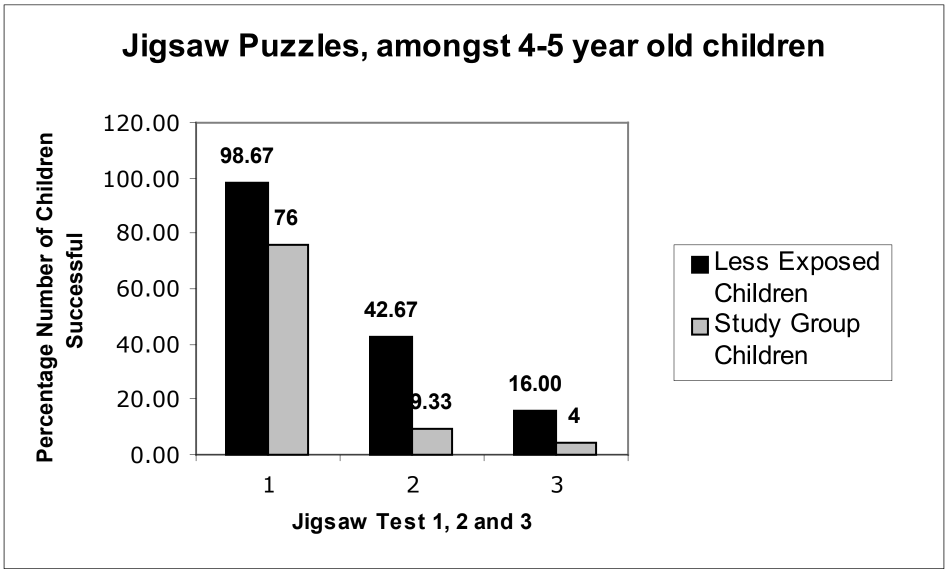




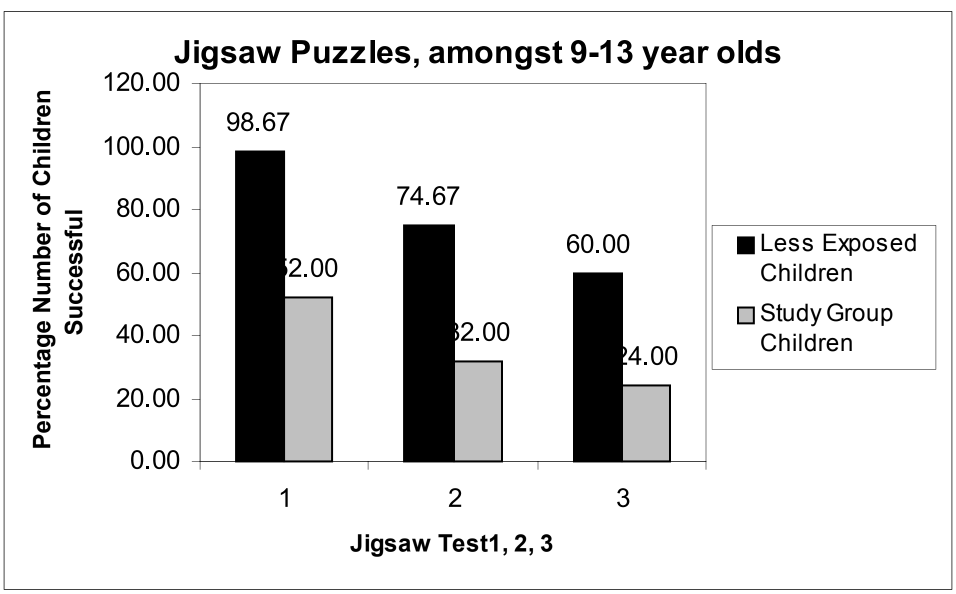
Jigsaw puzzles:

There were three jigsaw puzzles each administered to each age group of children in both samples.

In both age groups together, all the six tests were solved successfully by more number of children in the control locations than in the study locations, expressed in percentage terms. In the case of 4-5 year old children, the three tests showed statistically significant results in favor of the control group children with p values being less than 0.0001 in the first two tests, and p=0.01174 in the last test. There was a dramatic fall in the percentage number of children who could do the test successfully from Jigsaw 1 to Jigsaw 2, and similarly from Jigsaw 2 to Jigsaw 3 – this happened in both the study and control samples.



There was no such dramatic trend in the case of the 9-13 year old children. The margin of difference in the ability to solve the jigsaws was however higher than in the younger age group, with the difference being 46.7%, 42.7% and 36% for Jigsaw 1, Jigsaw 2 and Jigsaw 3 in this age group. All the three results in this age group are also statistically significant, in favor of the less-exposed group of children.



<u>Non-verbal Cognitive Abilities:</u>

This is a test for 4-5 year old children, as already mentioned. This is the only location where this test for non-verbal cognitive abilities in the form of human figure drawings shows a narrow margin between the abilities of the less-exposed children and those of the exposed group. Where in other states, it had even reached a difference of nearly 2 average points out of a total score of 5, the difference here was only 0.32 average points.
Therefore, even though the control group children performed better than their counterparts in the exposed location, the p value is 0.15. The results from the test are: control = 3.36 ± 1.92, and study = 3.04 ± 1.80.

Overall, when it came to analytical abilities, 10 tests were administered to the 4-5 age group, out of which all the 10 tests showed better results by the less-exposed group of children, with nine of the results having statistical significance.

When it came to the 9-13 year old children, out of the ten tests administered for analytical abilities, in all the ten tests the control group children performed better, with nine of these results having statistical significance.

MOTOR ABILITIES:

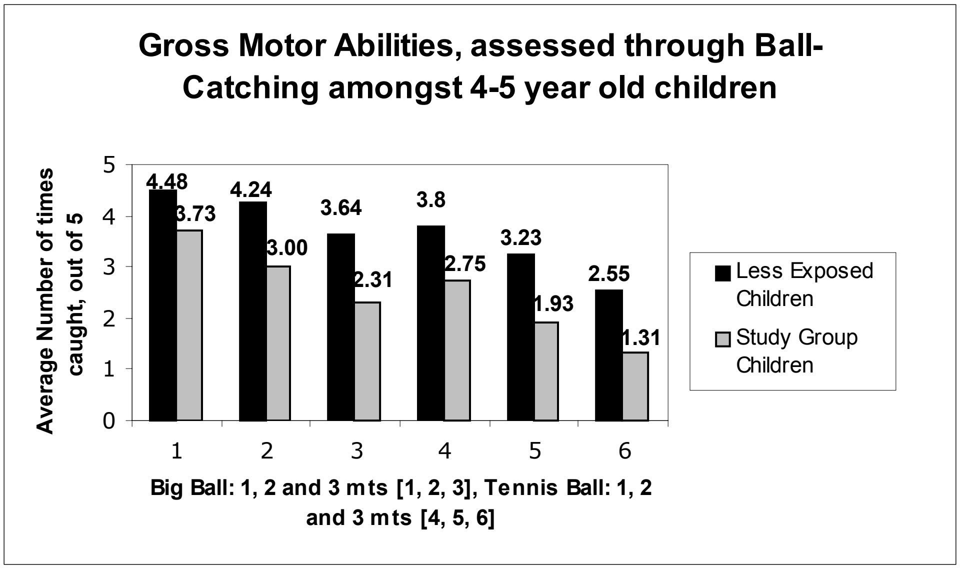
<u>Eye-Hand Coordination with Large Ball:</u>

This was for 4-5 year old children. In the three tests administered here, at all the three distances, the control was better. As the distance increased, the difference in ability also increased between the less-exposed and exposed group of children (0.75 average points out of 5 at 1 metre distance, 1.24 at 2 metres and 1.33 at 3 metres' distance). Statistical significance was high, with the p value being less than 0.0001 in all the three tests.

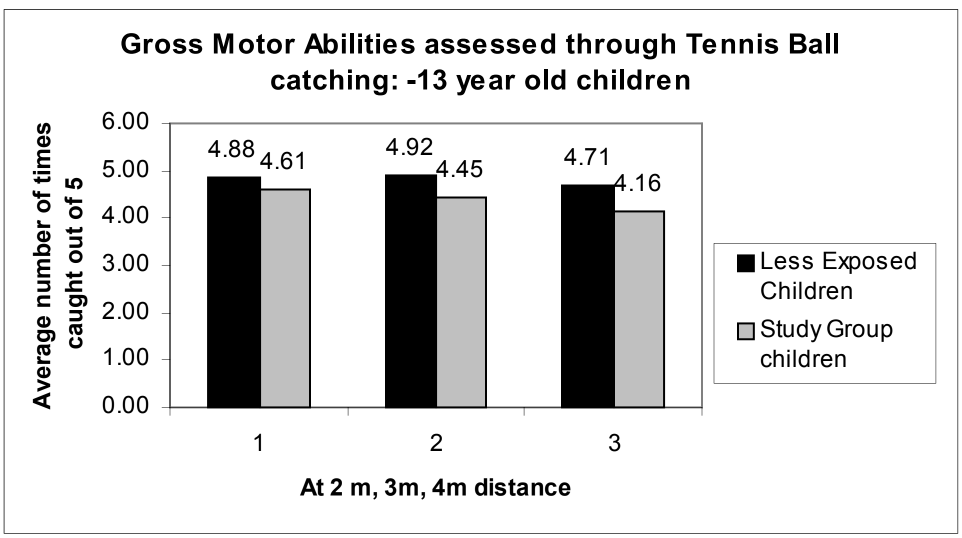
<u>Eye-Hand Coordination with Tennis Ball:</u> This test was administered to 4-5 year old children at distances of 1 metres, 2 metres and 3 metres, and for 9-13 year old children at distances of 2 metres, 3 metres and 4 metres.

In all these tests, for both age groups, the less-exposed children performed better than the study group children. The results were of high statistical significance.

In the case of 4-5 year old children, there was no clear trend regarding the ability to perform better, as the distance increases (the difference was 1.05, 1.30 and 1.24 average points out of five, for distances of 1 mt, 2 mts and 3 mts). Though there was no trend so to speak of, the difference remained high consistently and the high statistical significance is reflected in p values being less than 0.0001 in all three cases.



In the case of 9-13 year old children, even as the mean scores of the control group children fluctuated up and down as the distance increased, the difference in ability increased as the distance increased. The difference in ability at 2 mts, 3 mts and 4 mts was 0.27, 0.47 and 0.55 respectively. The p values for the results at the first distance was 0.003, while for the other two distances it was less than 0.0001.



Sense of Balance:

This ability was assessed through three tests for 4-5 year old children, and two tests for 9-13 year old children.

In the case of the 4-5 year old children, in all the three tests (two tests of standing on one foot, once with the child's eyes open and the next with the eyes closed, and the last test being a balance walk on a plank) the less-exposed children performed significantly better. In the case of standing on one foot, in the first test, they stood for 11.77 seconds longer than their study counterparts on an average at 15.56 seconds, and on the second test, for 3.8 seconds longer on

an average, with the group average being 5.52 seconds. These results have high statistical significance.
In the case of the plank test, around 37% more children could do the test successfully in the less-exposed group, compared to the study group.

In the older age group of 9-13 years, the less-exposed group could stand on one foot, with their eyes closed, for nearly 22 seconds longer at an average of 30.57 seconds for the group. However, on the plank test, 7% more number of children from the study group could do the test successfully compared to the less-exposed children. This result does not have statistical significance though since the p value is placed at 0.229.

As mentioned already, the tests where the child was encouraged to balance itself on one foot with eyes closed or open did not have a time limit set by the researchers, and we came across children who could do it for very long periods of time, much longer than the rest of their counterparts. Therefore, results from these tests are also being presented here as percentage number of children in particular time brackets of performance.

Particular time brackets in seconds	**4-5 year old children [TN]**				**9-13 years [TN]**	
	Eyes Open, %age number of children		**Eyes Closed, %age number of children**		**Eyes Closed, %age number of children**	
	Study	**Control**	**Study**	**Control**	**Study**	**Control**
0 – 30 seconds	100	96	100	100	94.7	64.0
31 – 60 seconds	0	2.7	0	0	5.3	33.3
61 – 90 seconds	0	0	0	0	0	2.7
91 – 120 seconds	0	0	0	0	0	0
> 120 seconds	0	1.3	0	0	0	0

As the above table shows, in the case of 4-5 year old children, on the second test of standing on one foot with eyes closed, all the study and control group children are in the same time bracket of less than or equal to 30 seconds.

In the case of this test done with the child's eyes open, as in the case of other states, there are some children in the control location who fall in the top brackets (of even in the "more than 120 seconds" category) – one child from the sample as the case happens to be here. Contrast this with the study group where all the children are distributed into just the first time brackets.

In the case of 9-13 year old children too, there are more number of children in the second and third time brackets from the control location compared to the study location. This is a trend that has been observed across all the six states in the study.

<u>Fine Motor Abilities:</u>

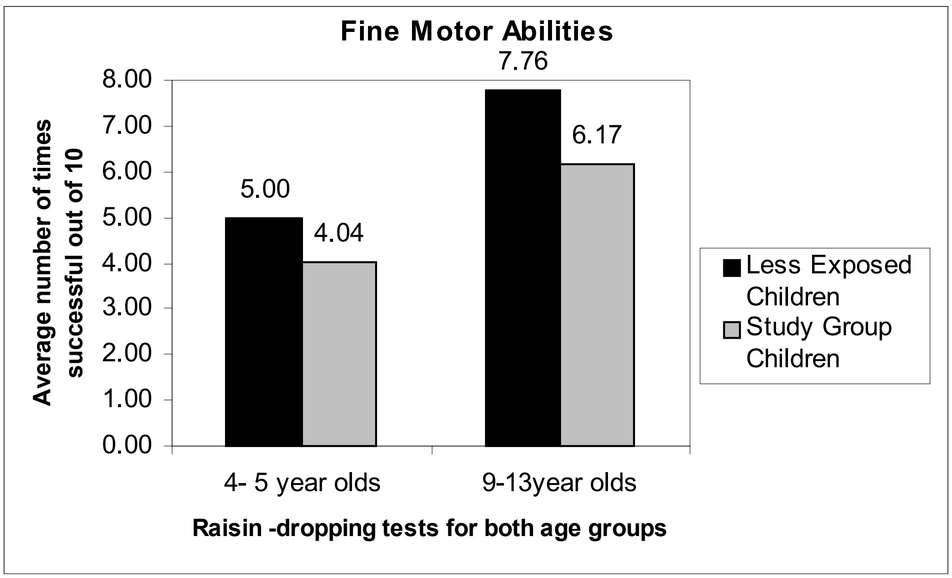
For the 4-5 year old children, fine motor abilities were tested through only one test - eye-hand coordination test with raisins. This test was done by the 9-13 year old children too.

In both the age groups, the less-exposed children did significantly better than the study location children, with similar kind of differential abilities demonstrated in both the age groups.

In the 4-5 age group, the results were: 5.0 average points ± 2.00 for the control and 4.04 ± 1.87 for study group children, with the p value being 0.001. The difference is 0.96 average points out of 10 attempts.

In the case of 9-13 year old children, the results were one of the highest across the various states, with the better abilities of the less-exposed children being demonstrated here too, as in the case of the other states: 7.76 ± 1.75 for control and 6.17 ± 2.10 for study, with the p value being less than 0.0001.

In the case of 9-13 year old children, another test in the form of nose-tapping assessed the fine motor abilities. Once again, the control location children were better, with the statistical significance being $p < 0.0001$. The results, recorded in terms of the number of times out of 25 times that a child misses the tip of the nose are: 9.79 ± 4.41 for control location and 18.73 ± 4.11 for the study location. Note that greater the number of such misses, lesser the fine motor ability being assessed.



Stamina:

Stamina, part of the set of tests to assess motor skills in this research, was assessed through the length of time that a child could do jumping jacks without being tired out.

In Tamil Nadu, in both the age groups, the less-exposed children performed this test for longer periods of time than the exposed children. In the case of 4-5 year old children, however, the result did not carry any statistical significance with the p value being 0.21, even though the less-exposed children were able to do the test for 4.82 seconds longer on an average over the study location children. In the case of the 9-13 age group, the difference in the ability was starker, with the control group children able to do the exercise for around 12.7 seconds longer on an average, with their (control group) group average placed at 45.16 seconds. The result here is highly significant, with the p value being 0.003.

However, based on the standard deviation values received for these tests, realising that some children might be performing for much longer periods than the rest of the group (in both samples) we have analysed the data as per percentage number of children in specific time brackets, the results of which are given below.

Time brackets, in seconds	4-5 year old children: Tamil Nadu		9-13 year old children: Tamil Nadu	
	Study	Control	Study	Control
0 – 50 seconds	96.0	96.0	89.3	70.7
51 – 100 seconds	1.3	1.3	6.7	22.7
101 – 150 seconds	0	2.7	2.7	6.7
151 – 200 seconds	0	0	0	0
> 200 seconds	2.7	0	1.3	0

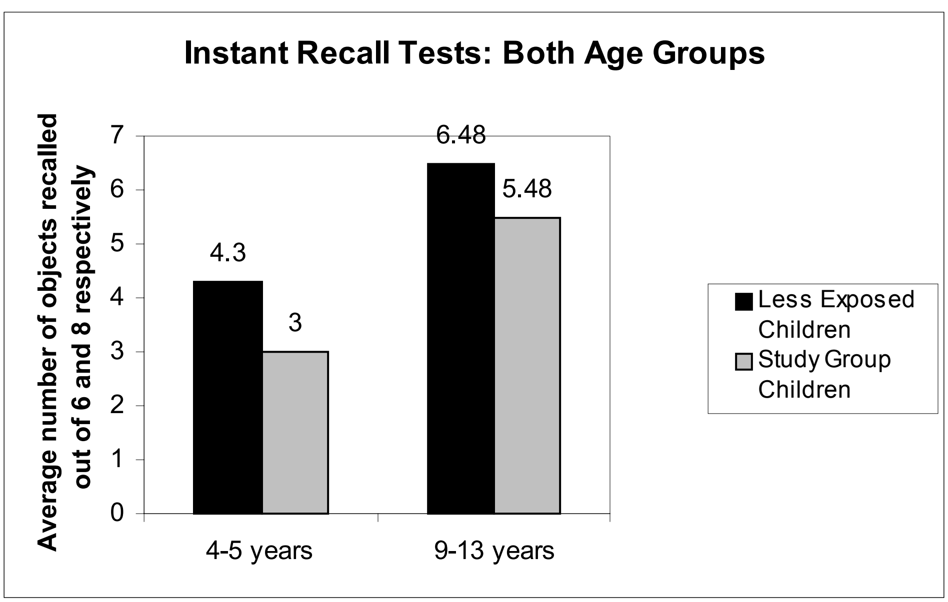
The above results from Tamil Nadu are slightly different from other states, where the children from the higher brackets of more than 150 seconds would usually be drawn from the control locations. While there are two children in the 4-5 age bracket and one child in the 9-13 age group who performed far better than the rest of the study group, the rest of the distribution shows the trend observed in other locations too. The control group children are distributed more into the longer time brackets than the study group children, borne out here by the data from the 9-13 age group.

TESTS FOR CONCENTRATION AND MEMORY:

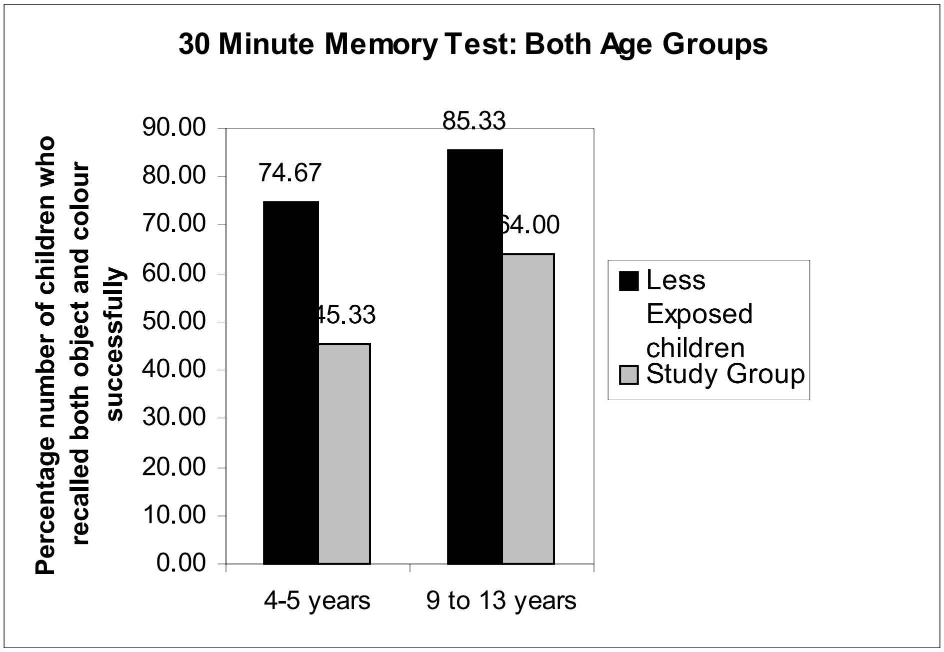
When it comes to tests for Concentration and Memory, both age groups show very similar trends in favor of the control location, consistent with results from other tests in the state.

In the case of instant recall tests, in both the younger and older age groups, the less-exposed children are significantly better than the study group children. The difference in ability is higher when it comes to the younger children, calculated in terms of average number of objects recalled [1.00 average point out of 8 in the case of 9-13 age group, in favor of the control and 1.31 average points out of 6 when it comes to the younger age group].

The results are: 4.3 ± 1.37 for control and 3.0 ± 1.44 for the exposed group in the younger age group [p value < 0.0001]; 6.5 ± 1.13 for control and 5.48 ± 1.12 for exposed, in the 9-13 age group [p value being <0.0001 once again].



In the case of 30-minute memory tests too, this trend persists, where the control group children are better than the study group children (nearly 30 percentage points higher in 4-5 and 21 percentage points higher in the case of the 9-13 age group).



Overall, out of the 23 tests administered to the two samples in the age group of 4-5 years in Tamil Nadu, in all the tests, the less-exposed children performed better, and with a statistical significance in the case of 21 of those tests.

When it comes to 9-13 year old children, 20 tests were administered, out of which less exposed children were better in 19 tests. Out of these 19, 18 tests showed statistical significance. The one test that went in favor of the study group did not have any statistically significant results.

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

This study by Greenpeace India is the first study of its kind in India – there have been no large scale, multi-locational studies done on the chronic impact of pesticides on children. Since the chronic effects concern long-term exposure to low doses of pesticides, and since many children in this country face such a situation in real life all the time, the findings are of great significance to all such situations, and are actually a matter of public health concern.

The significance of this study stems from another fact too - it looks at the issue of pesticides and human health impacts from a farming community's perspective. This is a neglected area when it comes to most studies in India, since they usually look at the issue of pesticides from the urban consumers' perspective (residues in food, water and so on).

The fact that the study focuses on children, a particularly vulnerable community when it comes to pesticide impacts, is also important. It is known and established that children are more vulnerable to the adverse health impacts of pesticides because of the particular way their bodies are built, and function as well as their unique behaviours.

The study also brings out findings from important cotton farming areas of the country – cotton exhibits high levels of pesticide abuse, even as the intensity of use on the crop is high. There is an irony hidden here. It is popularly made out that pesticides are a necessary evil to have stable food production levels in the country, whereas 55% of the pesticides are being used on a non-food crop [cotton], grown on just 5% of the country's land.

This is also a cocktail situation – the real life situation sees the victims exposed to hundreds of different formulations of pesticides, in innumerable and unimaginable combinations. It is significant to note here that cotton, more than many other crops, has well-established and successful alternatives for non-chemical farming.

In India, 147 pesticides have been registered as active ingredients and the tolerance limits of only 50 have been evaluated. There is much unknown about the potential effects of these chemicals, even the ones that have been evaluated. On top of this are the "formulants", which are added to the active ingredients. They are not necessarily inactive and could cause their own effects. No tests are done for such possible effects. Many such pesticides are used in large volumes and in an intensive fashion on the cotton crop grown in this country.

The ecological and farming disaster this causes (which led to farmer suicides in large numbers) has been more or less acknowledged - the disaster on the public health front goes unrecorded and unacknowledged. And the question of remediation therefore has not even risen.

Organophosphates (OPs), the most widely used insecticide type, are designed to be neurotoxic to living organisms. OPs and Carbamates interfere and inhibit the activity of cholinesterase which in turns works with neurotransmitters. As a result there is over-stimulation of nerve endings causing acute poisoning symptoms such as, serious sensory and behavioural disturbances, impaired coordination, muscle twitching, weakness, reduced heart rate, depressed cognition and coma. Organophosphates have also been shown to cross the placenta and therefore, cause potential [adverse] developmental effects in humans. Similar is the case with Synthetic Pyrethroids. Though these pesticides have been brought in as replacements and solutions to OPs, Carbamates and Organochlorine compounds, they too attack the nervous system. Some pyrethroids have been associated with neurologic and respiratory reactivity as well as potential hormonal effects.

It is believed that the nature of the health effects from pesticides depends on the type of pesticide, the dose, timing and duration of exposure, as well as the particular susceptibility of the exposed individual. But farming community members apparently have no control over several or all of these factors, given a cocktail exposure situation.

The study population in this project is getting exposed to all these pesticides, in unimaginable combinations and doses and mixtures in a variety of ways.

The exposure routes for the adults could be more direct (since many of them work in the agricultural fields), but for the children, the possible routes are many, both direct and indirect. It could be *in utero*, or for a foetus, even before its creation, a malformed sperm because of the impact of pesticides. It could be because of the toxic residues present in the mothers' milk. It could be because of residues in food and water, or contaminants left in the soil and air. In the case of many study villages, it could also be from the fact that the cooking fuel is dry stalks from the cotton crop on which pesticides have been sprayed aplenty during the season. And then, the children also sometimes get directly exposed to the sprays of pesticides given the extensive cotton cultivation in these areas.

While this is the context, the study and its findings rest strongly on the following:

- Compared to the less-pesticides-exposed group, the study group children in two different age groups, have displayed lower abilities in cognition, memory, stamina, motor skills and concentration – significantly lower in some abilities, and marginally so in some others, but consistently lower abilities nonetheless, analysed as number of tests where results went in the favor of one group.

- The above results are not surprising but reiterate findings from other such studies. The methodology adopted is a scientifically accepted approach, as borne by the earlier study.

- Though there have been some variations in the "study and control environments" between the states, the results displayed the above pattern more or less consistently across states, irrespective of other possible confounders. Usual confounders such as maternal education did not seem to play a part since data was analysed separately for children with uneducated mothers in the control location as in the case of Punjab. Child psychologists during our discussions with them also pointed out that certain tests like stamina, fine eye-hand coordination, nose-tapping for body awareness, sense of balance tests etc., may not be influenced by many external confounders in any case (like media exposure, or maternal education).

- The findings also conform to expectable results given the known effects of certain kinds of pesticides – organophosphorus compounds, which are used some eight to nine times more than other kinds of pesticides in these locations, are known to be neurotoxic. There are other similar pesticides too.

Epidemiological studies such as this are observational since they cannot be experimental. It is obvious that it is very difficult to adequately address all the potential confounding variables and establish a cause and effect correlation definitively. However, observational studies are the best possible evidence and the clear complement to animal studies for increasing information on human health effects from pesticides.

The validity of the findings and their correlation to pesticides comes mainly from three or four sources:

- That there are strongly similar trends across different locations of the country where the research was taken up, and similar trends across age groups

- that the design and methodology used have been used earlier in a similar scientific study (in Mexico) and have been adapted in consultation with Indian experts

- that the sample size is much larger than the earlier study (50:1648, in terms of number of children studied, between the earlier study and the current one)

- that it is a multi-locational study, across six different states of the country, with common trends between them – wherever needed, sub-sample analysis was taken up for further validation

- that the study has been closely guided by a group of international advisors, who are all specialists in relevant fields

- that the findings from the study re-iterate expectable and known patterns (from animal studies and from earlier observational studies).

The findings therefore lead us to conclude that pesticides could be strongest and foremost reason for the lower abilities being displayed by the study group children.

The findings therefore, demonstrate to us that basic child rights of survival, growth and development are being violated and denied by technologies such as pesticides.

It is also obvious that the situation has been allowed to continue as well as grow, by the government as well as the industry, with the chronic effects slowly building up. It is quite apparent from the study that environmental standard setting is not done as per the vulnerabilities of children or the poor. This calls into question the current regulatory and policy frameworks with regard to pesticides.

The very approach of risk assessment and risk management that is adopted in the case of pesticides is primitive and untenable. As mentioned earlier, humankind does not even know what are the various risks to be studied. Risk assessment and management approach, though touted as "scientific" does not take into account the real-life situation of synergistic effects of pesticides, along with many other chemicals in our environment. Worst, this approach meant that safer alternatives of non-chemical agriculture never got the attention and support that they deserve.

It is also well known that the entire regulatory system and the industry function in a very opaque and unaccountable manner. Considering that enough information exists on pesticides from various epidemiological and animal studies, the only alternative available is to take a Precautionary approach with regard to this poisonous technology.

In this context, Greenpeace makes the following demands to the Government and the industry:

- **Demands to the State**: 1. The government should adopt a rational pesticides policy (a draft version annexed to the main report), 2. greater support to organic farming (especially on cotton) in terms of resources and mechanisms for more research, extension and crop loan support and infrastructure, 3. a ban on all those pesticides that have been banned in other countries, and 4. regulate the pesticides industry and all its operations, and make it liable for the damage caused
- **To the Pesticides Industry**: 1. pro-actively withdraw Class I a and I b pesticides, 2. stop aggressive marketing and promotion of pesticides, 3. immediate provision by the industry for compensation to and rehabilitation of all the poisoning victims.

The central principles of the Rational Pesticides Policy being advocated for are:

- a precautionary approach, and not a "risk management" approach to be adopted to pesticides
- Pesticides to be looked at not from a chemical perspective, but from a Sustainable Agriculture perspective – this means, pesticides to be registered and used only where there are no safer alternatives (product of last resort)
- Polluter Pays principle to be applied to the industry to make it liable and accountable.

ALTERNATIVES TO PESTICIDES IN COTTON FARMING

Traditionally, cotton cultivation had been chemical-free, especially with the native varieties in rain fed conditions. However, introduction of certain technologies aggressively by the world of agricultural science and the industry changed the scenario for the worst.

However, there are once again many attempts to revive non-chemical agriculture, pioneered both by farmers and non-governmental organizations. This chapter looks cursorily at such efforts, beginning with Non-Pesticidal Management of cotton and comparing with conventional/chemical and IPM (Integrated Pest Management) practices. Towards the end of this chapter are some details on organic cotton cultivation also.

NPM:

There is a new concept of crop and pesticide management that has evolved due to work done mostly by non-governmental organizations, gaining good ground with farmers in several states called Non Pesticidal Management (NPM) of crops. For consumers, this addresses the immediate problem of pesticide residues in food and water since this approach does not use any synthetic pesticides at all during crop cultivation.

NPM as an approach is one step ahead of IPM (Integrated Pest Management) and a couple of steps behind a more holistic sustainable agriculture approach (shunning all chemicals and based on principles of diversity). The following table tries to capture the main differences between IPM, NPM and Organic Farming, as popularly understood and practiced:

	Integrated Pest Management	**Non-Pesticidal Management**	**Organic Farming**
What is the main approach?	IPM advocates rational use of pesticides, and pesticides as a last resort. IPM is based on ecological principles and helps in efficient and sustainable crop production, according to FAO of the United Nations, which had popularized and spread the concept in many developing countries.	In NPM Indigenous Technical Knowledge is fully utilized in a participatory mode (as per its practitioners). The importance of biological control and inputs has made bio-diversity an essential component in this approach; this in turn has further environmental and social benefits.	Organic agriculture prohibits the use of toxic and persistent chemical pesticides and fertilizers, as well as genetically modified organisms.
What crops mostly?	The Government of India has so far come up with IPM packages for nearly 77 crops, including sugarcane, cruciferous vegetables, wheat, maize, potato, groundnut etc., though most IPM programmes concentrate on cotton and paddy, two high-pesticide-consuming crops	NPM programmes have so far not received any governmental attention despite good successes. NGOs have usually focused on crops like cotton, pigeonpea, groundnut and some vegetables	This has been usually taken up on crops like cotton, gram, spices, tea and coffee etc.

Certification requirements	IPM is not usually certified	NPM products also do not go through certification, but have usually been managed at the farmers' end by village level committees overseeing the process	Organic farming is usually understood in a context of certification by an external agency. This certification extends to an entire farm and its production methods and inputs (land preparation, planting materials used and so on) and not just the product; the standards that could be followed are various, sometimes varying at the national level
What stage towards sustainable agriculture?	The first stage, where synthetic pesticides are used only as a last resort for crop protection	The second stage, where synthetic pesticides are completely avoided in cultivation	The third stage, which also prohibits the use of Genetically Engineered materials; however not completely at the stage of ecological agriculture based on principles of diversity
How long in practice?	Approach been around since 1981, but institutionalization in a formal sense from around 1992.	Some of the more popular NPM projects have been around since the early 1990s	International Federation for Organic Agriculture Movements (IFOAM) has been around since 1972 but the 1990s saw the biggest surge in organic production. The recent rate of growth in some European countries has been as high as 30%.
What is the government's position on this?	This is the official strategy of the Government of India, articulated also in the Rio Agenda (Agenda 21 policy statements)	NPM programmes have so far not received any governmental attention despite good successes. NGOs have usually been pioneering this approach	There are only some formal government-led initiatives on this front for crops like tea and spices.

The following box clearly indicates the official stand of the government of India, but in reality the progress on the ground has been unimpressive, given the total cropped area in the country. This is especially so compared with the rapid spread of other approaches like NPM by small NGOs (in comparison to the massive R & D and extension set up that the government possesses). In addition, there is an EU-supported FAO IPM programme on cotton in India. Even here, the penetration of the programme is unimpressive, especially compared to similar IPM programmes in countries like Indonesia.

> To alleviate the ill effects of pesticides, India has officially adopted IPM as its policy and is a prominent feature in recent Five Year Plans. On a broader scale, IPM is defined and explained in terms that encompass the farm families & their environment, and regional food security. The essential element for IPM includes one or more management activities that are carried out by farmers that result in the density of potential pest populations being maintained below levels at which they become pests, without endangering the productivity and profitability of the farming system as a whole, the health of the farm family and its livestock, and the quality of the adjacent and downstream environments.
>
> *Agenda 21 articulations of Government of India, repeated in "Natural Resource Aspects of Sustainable Development in India", India's official report submitted to the 5th Session of the UN Commission on Sustainable Development.*

Non-chemical crop protection approaches whether it is IPM or NPM, are knowledge-intensive systems. The Central and State governments have adopted a 3-tier approach encompassing master trainers, agricultural extension officers and farmers. The institutional mechanism set up to ensure that farmers have sufficient knowledge and understanding of pest management issues is the Farmer Field School (FFS). It is mainly through these FFSs that the dissemination of the knowledge and the increase in outreach happens.

Since 1994-95, only about one thousand master trainers, 27 thousand agricultural extension officers and 1.9 lakh farmers have been trained through establishment of more than six thousand Farmers' Field Schools.

In terms of financial allocations for IPM projects, about 3200 lakhs of rupees has been spent in the year 1999-2000 by 31 states and Union Territories. States like Karnataka, Orissa, Tamil Nadu and AP spend more amounts than others on an average on IPM projects.

Coming to a concrete illustration on the results of IPM as well as NPM in crop cultivation, let us take the case of Cotton under both approaches, and the available data.

In India, some of the deadliest pesticides in the largest volumes get used in cotton. Though it is not a food crop *per se*, the pesticide drift from cotton to the end-consumer's food or water cannot be ruled out. Cotton occupies only 5% of the cropped area in India, pesticide consumption on cotton is 54% of the total pesticide consumption in the country. Given this situation, it becomes very important to change the situation with regard to cotton.

The following table gives details of the **Cost and returns under IPM and non-IPM situations**.

Item	**Non IPM (Rs per hectare)**	**IPM (Rs per hectare)**
A. Costs		
Pest control inputs	2408.00	2096.80
Manure & Fertilisers Farm yard manure NPK	 342.40 940.30	 377.80 1076.20
Seed	797.10	565.60
Bullock Labour	350.00	288.40
Human Labour	3185.30	3662.00

Total variable cost	8023.20	8066.70
B. Returns		
Gross returns	17600.80	21792.80
Net returns	9577.60	13726.1
Crop Yield	8.80 qtls/hectare	10.90 qtls/hectare
Pesticide use	3.16 kgs/hectare	0.014 kgs/hectare

Source: "Economics of IPM: Evidences and Issues", Indian Journal of Agricultural Economics, Vol. 55, No. 4, Oct.-Dec. 2000

Another table, presented below, gives the economics of NPM and non-NPM situations with regard to cotton, coordinated by Hyderabad-based Centre for World Solidarity. Here, they work through partner organizations from different districts of AP as well as neighboring states.

Comparison of Yields & Cost of Plant Protection (2000-01)						
	Yield (Q/ha)		**Cost of Pest Management (Rupees)**		**Income (Rs./ha)**	
Organisation	**NPM**	**Conventional**	**NPM**	**Conventional**	**NPM**	**Conventional**
CROPS	10.98	8.9	950	7615	14112	770
MARI *	18.76	20	1177	4790	28115	19065
Nvajyothi	12.02	9.1	1982	5322	13622	3952
SWARD	13.62	9.5	1826	9815	16056	1358
KVK-MSSM *	12.53	7.5	2864	4168	14915	1317
KVK-PIRENS *	21.29	17.5	2011	3602	23072	16547
Average	**14.9**	**12.1**	**1801.7**	**5885.3**	**18315.3**	**7168.2**

* irrigated & black cotton soils; compiled from data provided by CWS

A comparison of the two methods (NPM and non-NPM) shows that for a difference of 3.6% in yield (higher yields usually for NPM) the cost of pest management is lesser by 341% and net income is more by 11.1% for NPM. The yields are much more than the national average of 300kgs/ha and are comparable to the best yields in the world, the experience so far shows.

The biggest commercial advantage of NPM to conventional cotton farming lies in the lower cost of plant protection, where this leads to more net profits. With 70% of the farmers being small or marginal, low-input cost becomes a core competency. Added to this is the benefit of being able to get away from pesticide dealers and high interest loans.

Unfortunately however, NPM has not received any attention from government research and extension agencies and therefore, no agricultural university has so far strongly supported this approach. If we acknowledge that the path towards sustainable agriculture could be a three-staged one, with IPM followed by NPM, leading to organic farming, it is high time that the scientists started looking closer at NPM experiences in different states, as well as supporting organic farming efforts.

Organic farming, as practiced by some cotton farmers of Maharashtra, received some attention from the Central Institute for Cotton Research (CICR, Nagpur), but the farmers' organisations do not receive any governmental support for their pioneering work, nor do extension agencies promote this with other farmers. Some data about organic cotton farming, in Maharashtra and Gujarat, is presented below. The encouraging results are apparent and clear when it comes to economics of these practices. The positive environmental implications need not be over-stressed.

Economics of organic raw cotton for different years						
Year	**Yield (Q/ha)**	**Gross Income (Rs.)**	**Premium (20%)**	**Total (Rs.)**	**Net Income (Rs.)**	**Surplus/ Deficit**
Conventional	10	20000	0	20000	9000	0
First Year	5	10000	0	10000	750	-8250
Second Year	5.75	11250	0	11250	3750	-5250
Third Year	6.25	12500	2500	15000	7000	-2000
Fourth Year	7.5	15000	3000	18000	10500	1500
Fifth Year	8.75	17500	3500	21000	13500	4500
Sixth Year	10	20000	4000	24000	16500	7500

Details	Chemically grown cotton (Rs)	Organically grown cotton (Rs)
Land preparation	1400	900
Manure	7000	7,250
Chemical fertilizers	1070	
Seed and Seed Treatment	350	350
Irrigation	2000	2000
Weed control	1000	1000
Plant protection	2500	700
Harvest cost	1200	900
Total cost of Cultivation	16520	13100
Production Quintals/Acre	12	10
Sale Price	2250	2430
Total Income	27000	24300
Net Income	10480	11200

Source: Vivekanada Research & Training Institute, Mandavi, Kutch, Gujarat

Given this situation, it is indeed unfortunate that neither the Government of India, nor the state governments come forward to support such endeavours, but continue on the disastrous chemical agriculture path, even as these farmers' groups are exporting certified organic cotton to countries like Japan.

It is time that farmers and consumers alike demand that the situation be changed for everybody's benefit.

EPILOGUE

The pesticide industry in particular and agriculture scientists in general have for long perpetrated this myth that without the poisons called pesticides, agricultural yields cannot be protected or increased. In recent times however, there has been some acknowledgement from the premiere agriculture research institutions of the CGIAR setup itself that pesticides are best used only as a last resort and that there has been much abuse of these chemicals leading to a variety of problems.

A few potential impacts of only some pesticides are known to humankind despite the frenzy to create more molecules, to get them registered with concerned authorities and to make profits out of selling them. In India for instance, out of a total of 147 pesticides registered, the tolerance limits of only 50 have been evaluated[38]. There has been much written about the inadequacy of the current stipulated tests for pesticides registration and regulation even in the developed world. The truth is that we don't even know what to study as impacts, leave alone the reality of incomplete assessments.

In India, farmers in the country are known to use mixtures of pesticides, the possibilities of such mixtures running into thousands. In Punjab, the current study came across farmers using mixtures of up to four pesticides in one spray. Obviously, the impact is unknown and incalculable.

The Precautionary Principle has never been more acutely needed than here, in the case of pesticides[39]. In fact, as is known, pesticides are poisons intended to kill or harm living organisms, and any poison that can kill or harm other living organisms, in the 'right' conditions can kill or harm a human being too.

Almost all the studies available on pesticides in this country relate to the excessive use of pesticides resulting in pesticide residues ending up in food and water beyond 'permissible' limits, and of increased "body burden" with these chemicals – for instance, levels of DDT in human blood and in mother's milk. Much of such research and documentation ironically is from government agencies themselves. There has also been some documentation on the impact of pesticides on wildlife. Another kind of documentation that is present to some extent is that of acute poisoning of pesticide users. Unsafe use of pesticides and resultant deaths and illnesses however do not get recorded or reported accurately or extensively.

There has been extensive reportage of the toll that pesticides have taken of the cotton farming communities in the country – the ecological as well as the economic devastation due to pest resistance and pest resurgence amongst other factors received good media attention too.

However, there have been very few studies that look at the human health impacts of pesticides – studies that make the connection between pesticide use and the health effects caused. One of the reasons for this is the simple fact that experimental research cannot take place on human beings for these effects to be studied. The best approach in such a case is to take up cross-sectional studies. Even such studies and surveys are not being taken up by the regulators and other concerned authorities in any case. The government seems to be hiding behind data that only looks at "negligible levels" of pesticide residues and similar jargon.

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[38] "Pesticides in India: Environment and Health Sourcebook", Toxics Link, November 2000

[39] The Precautionary Principle is intended to be a general rule in situations where there is the potential for serious or irreversible threats to health and the environment and requires action to be taken to avoid such threats even where definite proof of harm does not yet exist. It stops the lack of scientific certainty being used to delay preventive action.

Greenpeace India, with the support of Greenpeace UK, undertook the present study in six high-pesticide use states of India with a variety of objectives in mind. We wanted the pesticide industry to face up to its liabilities – studies on pesticide residues have never focused attention on the industry which brazenly manufactures and profits from the deadliest chemicals. Studies on residues inadvertently make farmers the culprits for the situation when in fact they never invented the product or welcomed it in the first instance. It is time that the industry which projects itself as the one which is feeding the world and its hungry millions even as it is making millions of dollars of profits, and as the one coming up with products that can be safely used in countries like ours is made accountable. It is also time that this industry is shown for all the false promises and myths created around their technology because it is the same companies which are now making similar promises with the Genetic Engineering (GE) technology. The promises and projections are uncannily similar – so are the hazards that both technologies pose. And it is not accidental that it is the same set of companies which make profits out of both technologies.

We know that the use of pesticides did not decline as was prophesied with the advent of GE technology. Since GE is mostly applied to herbicide-resistant crops, the use of herbicides only went up, along with the added hazards from the gene-altered crops.

This study is intended to mobilize farmers and we would like the results to be carried into all those farming communities that use pesticides and use them indiscriminately and to those communities that are now looking towards the GE technology as a possible solution. The study shows what seems to lie in store for the future generations in the farming communities that depend on these technologies.

There are also precious lessons to be learnt from the experiences of successful organic cotton farmers in particular and organic farmers in general that safer and more ecological farming practices are indeed possible and are also viable in a commercial sense. Just the fact that organic cotton is successfully exported from this country by farmers' collectives is testimony to this. This however has never received support from the government, nor have liabilities of compensation and remediation ever been imposed on the industry. We would like to show the farmers that both are parts of their rights.

Doing the study had not been easy. Like most studies, there have been resource and time constraints in addition to logistical difficulties. Some of our researchers unfortunately met with accidents while on the research work and this posed additional problems. However, with the help of many agencies and individuals who assisted us in various ways (hospitality, technical advice, data collection etc.), we were able to complete the study on schedule.

We hope that NGOs and government agencies make full use of this study to disseminate the shocking findings to the farmers that they work with. We also demand that regulatory authorities stop fooling around with people's lives and health and the future of a whole new generation by their current practice of supporting the pesticide technology to the exclusion of safer, ecological alternatives.

We would like to express our gratitude for the sincere and rigorous work put in by all the eight partner organizations associated with this research and all the others who lent their support in numerous ways.

G Ananthapadmanabhan
Executive Director
Greenpeace India

January 2004

Annexure 1

PESTICIDES IN INDIAN COTTON CULTIVATION

Firstly, about Cotton in India:

Cotton is a very important and significant crop in Indian agriculture and economy for various reasons. India is the world's third largest producer of cotton, second largest in terms of consumption and is the first largest when it comes to area under cotton cultivation in the world.

- The area under cotton cultivation in India is the highest in the world (about 19% of the world's cotton area). India ranks third in global cotton production after USA and China (around 12% of global cotton production).
- One third of India's export earnings are from the textile sector and cotton alone constitutes around 60% of the raw material (cotton's share in world textile manufacturing is around 45% whereas in India, its share is around 70%)
- Cotton plays a major role in India's economy in term of employment – both directly and indirectly – as it employs around 60 million people
- India is one of the two centres of origin of cotton (the other being Peru)
- India grows all the four major types of cotton – G arboretum, G hirsutum, G herbaceum and G barbadense
- The first hybrid in the cotton crop was developed in India, in Surat, by Dr C T Patel (H4 intra hirsutum in 1970) – more than 200 varieties and hybrids were evolved in the subsequent five decades
- The crop occupies less than five percent of total area under cultivation in India, but consumes more than 50 percent of the total pesticides used in Indian agriculture. Around 10% of the world's pesticide consumption, and 25% of its insecticide consumption are on cotton, worth $ 2.6 billion an year. On an average, Indian farmers cultivating cotton spend roughly Rs 500 crores on seeds, Rs 500 crores on fertilizers and almost Rs 2500 crores on pesticides every year. [40]
- The yield of cotton in India is one of the lowest, with 300 kilograms per hectare against the world average of 580 kilos per hectare
- More than 60 percent of cotton area in India is under rainfed conditions
- Hybrids occupy around 45% of cotton crop in India, as in 1998
- Important landmarks in the Indian cotton history include the development and release of native hybrids like G cot DH 37, G cot DH 9, DDH 2 and drought tolerant straight varieties like SRT 1, Renuka, LRA 5166, Anjali and Rajat
- Cotton farmers in India are mostly smaller farmers accounting up to 70%.

The crop-wise consumption of pesticides in India presents the following picture:

Crop	Pesticide Share - %	Cropped Area - %
Cotton	52-59	5
Rice/Paddy	17-18	24
Vegetables and Fruits	13-14	3
Plantation Crops	7-8	3

[40] Source: Calculations by T N Prakash, University of Agricultural Sciences, Bangalore, provided by Meena Menon, 2003

Cereals/Oilseeds/Pulses	6-7	58
Sugarcane	2-3	2

Source: IARI data, 1999

The above table points out the intensity of pesticide use in cotton in India. Even in terms of value, cotton consumes the highest amount of pesticides: 44.5% of the total cost spent on pesticide consumption, equivalent to 2462.13 million rupees. Cotton is also supposed to consume 58% of insecticides in India, while consuming the highest share of pesticides.

Cotton suffers attacks from over 40 insect pests of which more than ten are sucking pests. The CICR technical bulletin 1/2000 mentions that cotton, being a long duration crop, is quite vulnerable to many biotic stresses and is a major consumer of nutrient and hormone chemicals. Out of the total agrochemicals that are applied in cotton, 75 per cent are used at peak boll development stage.

However, the crop loss in cotton due to pests is estimated to be 22% while in terms of value, much lower than rice or oilseed crop losses.

Types of pesticides used in cotton cultivation in India:

The product categories of pesticides used on cotton include organophosphorus, organochlorine, carbamate as well as pyrethroids – amongst these, organophosphates and synthetic pyrethroids are most commonly used.

Monocrotophos is widely used and accounts for 22% of the cotton insecticides market, as are endosulfan, chlorpyriphos, quinalphos, cypermethrin, fenvalerate and acephate. Other products introduced in the Indian market include triazophos, profenophos and lamdacyhalothrin[41].

According to Pesticides News of PAN-UK, June 1995, the following were the recommended pesticides for use in cotton in India: aldicarb, carbaryl, carbofuran, chlorpyriphos, cypermethrin, decamethrin, demeton-S-methyl, dicofol, dimethoate, endosulfan, fenvalerate, monocrotophos, phosalone, phosphamidon, quinalphos etc. Many of the above pesticides are part of the very toxic category of organophosphates, some belong to the WHO Class I category or Class II category in terms of their toxicity. Further, Aldicarb and Carbaryl were the pesticides that were being manufactured in the Union Carbide factory in Bhopal.

According to a study conducted in Guntur district of Andhra Pradesh (the state of AP consumes the highest amount of pesticides, and the district of Guntur the highest within the state), farmers were using a range of 22 insecticides, many of which are highly hazardous under the usual conditions of use, and require observation of a number of days before re-entry into the field.

WHO Classification of pesticides used by surveyed farmers			
Extremely Hazardous Class I a		**Highly hazardous Class Ib**	
Parathion	OP	Demeton-S-methyl	OP
Parathion Methyl	OP	Monocrotophos	OP
Phosphamidon	OP	Triazophos	OP
Moderately Hazardous Class II			
Chlorpyriphos	OP	Cypermethrin	Synthetic Pyrethroid
DDT	Organochlorine	Dimethoate	OP

[41] Current Science, April 2001: Bhagirath Choudhary and Gaurav Laroia

Endosulfan	Organochlorine	Ethion	OP
Fenvalerate	Synthetic Pyrethroid	Lambdacyhalothrin	Synthetic Pyrethroid
Phosalone	OP	Phosmet	OP
Profenofos	OP	Quinalphos	OP

According to a recent FAO internal unpublished paper, pesticide poisonings are reported to be the highest in Maharashtra, Kerala, Haryana, Pondicherry, Rajasthan, Tamil Nadu, Punjab, Andhra Pradesh etc., closely overlapping with the states which grow cotton and consume large amounts of pesticides.

Dependence on chemicals has been so heavy that farmers often resort to a cocktail of several pesticides, and it is not uncommon to spray more than 30 times per season. And as the crop fails because of weather conditions and/or pest resistance, an increasing number of farmers have been known to consume the same chemicals to end their lives and escape the humiliation of mounting debts. More than 2000 cotton farmers in Andhra Pradesh, Karnataka, Maharashtra and Punjab have committed suicide in recent years. (Mae-Wan Ho, Department of Biological Sciences,Open University, Walton Hall, UK).

A fact finding mission's report from Warangal district of Andhra Pradesh estimates that in 2001-2002 cotton season alone, around 500 farmers/agricultural workers could have been fatally poisoned by pesticide exposure and killed and more than 1000 exposed (in the period of August to December 2001)[42].

[42] "The Killing Fields" – Farmer deaths due to exposure to pesticides in Warangal district – Fact Finding Team report, January 2002

Annexure 2

2.A Crop-wise Consumption of Pesticides

Crop	Estimated (in million Rs)	Percentage of total
Paddy	1272.05	22.0
Wheat	354.18	6.4
Jowar	495.40	8.9
Bajra	95.05	1.8
Barley	0.00	0.0
Ragi	24.04	0.4
Maize	63.62	1.1
Arhar	155.20	2.8
Gram	12.20	0.2
Jute	15.38	0.3
Cotton	2462.13	44.5
Sugarcane	38.41	0.7
Groundnut	136.84	2.5
Rapeseed and Mustard	9.10	0.2
Soybean	0.95	0.0
Sunflower	3.04	0.1
Onion	10.92	0.2
Potato	2.45	0.0
Tobacco	3.93	0.1
Tapioca	0.10	0.0
Fruits and vegetables (excluding Onion and Potato)	389.38	7.0
Total	**5556.37**	**100.0**

Source: Pesticides in India: Environmental and Health Source Book, Toxics Link, New Delhi, November 2000.

2.B.1 State-wise Consumption

Sl No	State/Union Territory	Consump-tion (MT)
1.	Andhra Pradesh	9910
2.	Arunachal Pradesh	30
3.	Assam	595
4.	Bihar	1700
5.	Gujarat	5500
6.	Goa	22
7.	Haryana	4500
8.	Himachal Pradesh	718
9.	Jammu& Kashmir	110
10.	Karnataka	3900
11.	Kerala	1100
12.	Madhya Pradesh	4500
13.	Maharashtra	6020
14.	Manipur	50
15.	Meghalaya	45
16.	Mizoram	15
17.	Nagaland	12
18.	Orissa	1800
19.	Punjab	5770
20	Rajasthan	2758
21.	Sikkim	20
22.	Tamil Nadu	12500
23.	Tripura	164
24.	Uttar Pradesh	8480
25.	West Bengal	5000
26.	Andaman & Nicobar	-
27.	Chandigarh	-
28.	Delhi	60
29.	Dadrar & Nagar Haveli	4
30	Daman & Diu	-
31.	Pondicherry	135
32.	Lakshadweep	0.70
	Total	**75,417.70**

2.B.2 Some Major Pesticide-Consuming states of India

Major Pesticide Consuming States (in tonnes)	
States	**Quantity**
Andhra Pradesh	13000
Uttar Pradesh	11000
Tamil Nadu	9500
Maharashtra	6900
Punjab	6400
West Bengal	5800
Haryana	5200
Gujarat	5100
Karnataka	4400
Rajasthan	2900

Source : Agricultural Research Data Book, 2001.

2. C.1 Major Cotton-Growing States of India in 2000-01 (expressed in percentage terms of total crop)

Andhra Pradesh	17.9 percent
Gujarat	17.1 percent
Maharashtra	14.6 percent
Madhya Pradesh	2.5 percent
Haryana & Rajasthan	7.5 percent
Karnataka	5.7 percent
Tamil Nadu	3.9 percent

(Source: Amitabha Sen, India onestop.com)

2. C. 2: Cotton: Statewise production (lakh bales of 170 kg each)								
	1990-91	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-2000**	**2000-01**	**2001-02 E**
Northern region	**38.25**	**41.35**	**43.5**	**27.25**	**23.5**	**31.5**	**30.25**	**20**
Punjab	17.25	15.15	16	7.25	5	7.85	9.5	9
Haryana	11.5	11.6	13.5	9	7	10.65	10	5.25
Rajasthan	9.5	14.6	14	11	11.5	13	10.75	5.75
Central region	**46**	**75.65**	**86**	**86**	**92.75**	**81**	**61.25**	**86.75**
Gujarat	15	32.2	34.25	42	47.5	27.5	23.75	33.5
Maharashtra	15	28.6	33	21.5	26.5	38	18.25	33.5
Madhya Pradesh	16	14.85	18.75	22.5	18.75	15.5	19.25	19.75
Southern region	**31.75**	**45.95**	**41**	**38**	**39.25**	**35**	**38.5**	**40.5**
Andhra Pradesh	18.75	29.5	26.5	25.5	25	22.5	25.25	27.5
Karnataka	8	10.45	9	7.5	8.75	7	7.75	8
Tamil Nadu	5	6	5.5	5	5.5	5.5	5.5	5
Others	1	1.25	1	1	1.25	1.5	1	0.75
Loose cotton	0	6	6.4	5.75	8.25	7	9	10
Total	**117**	**170.2**	**177.9**	**158**	**165**	**156**	**140**	**158**

E: Estimate; Source: CAB

Annexure

9. SELECTION OF DISTRICTS AND BLOCKS IN EACH OF THE SIX STATES

1. Andhra Pradesh

District Wise Consumption of Pesticides, Technical Grade

(from 1994-95 to 2002-03)

Compiled from information provided by Commissionerate of Agri., AP

SL No	District	Consumption
1	Srikakulam	338
2	Vizianagaram	629
3	Visakhapatnam	542
4	East Godavari	2588
5	West Godavari	3636
6	Krishna	2908
7	Guntur	12400
8	Prakasam	2908
9	Nellore	2276
10	Kurnool	3874
11	Anantapur	1155
12	Cuddapah	975
13	Chittoor	1606
14	Rangareddy	2119
15	Nizamabad	2046
16	Medak	707 (Control)
17	Mahbubnagar	1590
18	Nalgonda	2104
19	Warangal	4382 (Study)
20	Khammam	3675
21	Karimnagar	2349
22	Adilabad	1425

Selection of Study Block in Warangal district:

(Based on extent of cotton cultivation in the past four years)

Sl	Mandal	1999-2000	2000-2001	2001-2002	2002-2003	Average
1	Atmakur	6731	7190	7437	7508	7217
2	Parkal	6541	6971	7248	7466	7057
3	Geesugonda	4972	5559	5846	NA	5459
4	Chityal	4426	5290	NA	6584	5433
5	Regonda	5607	6566	7325	7990	6872
6	Mugullapalli	4338	4921	5185	NA	4815
7	Mulugu	5162	5255	4883	4693	4998
8	Sangem	4604	5205	NA	6073	5294
9	Duggondi	1868	1780	1963	4873	2621
10	Sayampet	NA	NA	NA	4343	4343
11	Hasanparthi	NA	NA	NA	4439	4439

Source: Data obtained from the JDA (Agri)'s Office, Warangal

Gujarat

Gujarat Cotton Cultivation Area
(4 Years – 1999 to 2002)

S No.	District	Area in hectares
1	Ahmedabad	5017
2	Banaskhantha	536
3	Vadodhara	5138
4	Bharuch	4474
5	Valsad	-
6	Dang	-
7	Gandhinagar	99
8	Kheda	433
9	Mehsana	3056
10	Panchmahals	201
11	Sabarkhantha	146
12	Surat	113
13	Amreli	2509
14	Bhavnagar	6010
15	Jamnagar	1050
16	Junagadh	981
17	Kutchh	1226
18	Rajkot	5322
19	Surendranagar	11775
	Gujarat State	**49046**

Main Crops in Bharuch dist.
Average area in hectares (ten yrs)

S. no	Crop	Avg. area under cultivation (ha)
1.	Paddy (ropan)	2,980
2.	Paddy (oran)	14,490
3.	Bajra – Kharif	6,150
4.	Bajra – summer	620
5.	Jowar – Kharif	21,780
6.	Jowar – Rabi	36,720
7.	Maize	6820
8.	Tuar (red gram)	1,19,610
9.	Moong (green gram)	9,710
10.	Math	670
11.	Urad (black gram)	7,180
12.	Other kathod – kharif	710
13.	Wheat – irrigated	5,570
14.	Wheat – non-irrigated	14,690
15.	Horse gram	2,770
16.	Other kathod – rabi	650
17.	Sugarcane	9,120
18.	Groundnut – Kharif	4,220
19.	Groundnut – summer	720
20.	Sesame	4,170
21.	Castor	170
22.	Mustard	300
23.	Cotton – irrigated	21,660
24.	Cotton- non-irrigated	61,900

Source: Gujarat Agriculture Department, Ahmedabad and Bharuch

Karnataka

Karnataka government, neither at the state-level, nor at the district level had district-wise or pesticide-wise data on consumption. Here, we present the overall consumption information obtained from the Plant Protection Department of the Commissionerate of Agriculture, GoK:

Year	Total Consumption of Pesticides, Technical Grade, in MTs
1997-98	2962
1998-99	2600
1999-00	2480
2000-01	2200
2002-03	1692

When it comes to Raichur, data was available for only two of the preceding years, once again at a total consumption level (source: Deputy Director, Agriculture, Raichur district).

2001-2002: 15,335 lts liquid + 30,390 kgs of dust
2002-2003: 21,035 lts liquid + 6,772 kgs of dust

Selection of Taluka in Raichur district:

Taluka		**1998-99**	**1999-2000**	**2000-01**	**2001-02**		**Total cotton area**
Raichur	Kharif	11452	4423	5723	3449	25047	
	Rabi	2715	2299	3127	2322	10463	35510
Manvi	Kharif	8804	4001	2651	1433	16889	
	Rabi	1464	6374	5753	1850	15441	32330
Devadurga	Kharif	1927	231	196	345	2699	
	Rabi	6800	10503	13418	10970	41691	44390
Lingasugur	Kharif	863	244	521	85	1713	
	Rabi	1529	217	1297	50	3093	4806
Sindhanur	Kharif	8800	6086	1647	676	17209	
	Rabi	5112	8800	6281	3160	23353	40562
		49466	43178	40614	24340		157598

Source: Dept of Agriculture, Raichur District

The selection was based on Irrigated Cotton grown, proximity and follow-up possibilities for partner organizations and consultations with pesticide dealers.

Maharashtra

District-wise Cotton Cultivation - Area in hectares (1995-2001)

Districts	1995- 2001
Nasik	237
Dhule	5462
Jalgaon	20907
Ahmednagar	595
Pune	18
Solapur	290
Satara	283
Sangali	175
Kolhapur	8
Aurangabad	7961
Jalna	9322
Beed	5535
Latur	1825
Osmanabad	159
Nanded	16364
Parbhani	19495
Buldhana	15162
Akola	21457
Amravati	20489
Yavatmal	27120
Wardha	8392
Nagpur	3603
Bhandara	0
Chandrpur	3332
Gadchiroli	4
Maharashtra	**188192**

Taluka-wise Cotton Cultivation Area in Yavatmal (1999-2002)

SL. No	Talukas of Yeotmal	Total Area Under Cultivation	Area Under Cotton Cultivation	% Area Under Cotton Cultivation
1.	Yeotmal	195027	79550	40.80
2.	Kalam	160100	92277	57.64
3.	Babulgaon	141380	69047	49.31
4	Ralegaon	166891	98542	59.07
5	Ghatanji	183183	90063	49.23
6	Pandharkawda	162136	98282	60.61
7	Maregaon	127592	66971	52.48
8	Zarizamni	122877	63347	51.68
9	Wani	192095	94273	49.08
10	Ner	172756	89388	51.79
11	Darvha	188171	82970	44.11
12	Arvi	141535	54103	38.20
13	Digras	110868	56954	51.39
14	Pusad	212171	83157	39.19
15	Umarkhed	192917	60620	31.37
16	Muhagaon	170114	76193	44.94
	Total	**2655014**	**1252536**	**47.17**

Source for Maharashtra data:
http://www.maharashtra.gov.in/english/webRing/webRingDept.php,
http://www.fadinap.org/stat_country/introduction.html
Yeotmal District Agriculture Department.

Punjab

Selection of Block, based on Block-Wise cotton cultivation areas in Bhatinda district

Block	2002-03		2001-02		2000-01		1999-2000		1998-99	
	American	Desi	American	Desi	American	Desi	American	Desi	American	Desi
Bhatinda	24963	2512	31195	3364	25344	4931	25690	4181	38910	4708
Nathana	9374	2068	11773	2793	8852	3502	11161	2259	13182	2221
Sangat	22166	1923	27581	2552	25926	4190	28327	3882	28470	3785
Talwandi Sahbo	**29103**	**3286**	**36208**	**4312**	**30083**	**8722**	**32988**	**6098**	**35572**	**5839**
Mour Mandi	14718	1318	18350	1793	15226	3279	15974	2696	20101	2296
Rampur	5919	1967	8942	2445	6229	3035	6311	2536	7471	3116
Phool	3047	3140	5191	5031	3038	4640	5182	3873	6356	4759

Source: Dept of Agriculture, Bhatinda district

Pesticide Consumption data in Bhatinda district (1996-2001) in MT/Lts
[Sold by pesticide dealers, for some select pesticides]

Chemical Name	Consumption
Monocrotophos	1228768
Dimethoate	69515
Endosulfan	251615
Fenvelerate	246772
Cypermethrin	336535
Quinalphos	500817
Methyl Parathion	21384
Chloropyriphos	553843
Ethion	448237
Phorate	280643
Alphamethrin	71795
Malathion	31193
Phosphamidon	40846
Triazophos	57448
Acephate	47781
Decamethrin	52081
Oxydemeton-Methyl	56423
Anilophos	86264
Butachlor	67351
Isoproturan	219380
2,4-D	37232
Mancozeb	34138
Copper Oxychloride	32287
Aluminium Phosphide	410830
Phosphamidon	163.5

Tamil Nadu

District-wise Cotton Cultivation Area in TN 1999-2000 and Pesticide distribution through Department in TN (in MT/Lts from 1994-2001)

SL. No.	District	Cotton area in Hectares	Dust	Liquid
1.	Kancheepuram	131	40.08	36529
2.	Tiruvallur	1	2	5360
3.	Cuddalore	2277	38.4	47302
4.	Villupuram	6808	20.7	35883
5.	Vellore	3338	34.8	32065
6.	Tiruvannamalai	2638	15.6	35897
7.	Salem	15898	8.4	34080
8.	Namakkal	3430	2.4	8420
9.	Dharmapuri	13304	7.1	30492
10.	Erode	10139	6.9	23807
11.	Coimbatore	9944	22.9	35303
12.	Nilgiris	6	0	0
13.	Tiruchirapalli	11569	7	28974
14.	Karur	643	1.5	5720
15.	Perambalur	26017	1.3	5220
16.	Pudukkottai	428	8.9	27663
17.	Thanjavur	1086	12.7	30715
18.	Nagapattinam	1284	57.8	30860
19.	Tiruvarur	1204	0.9	4790
20.	Madurai	10154	36.9	41031
21.	Theni	6468		
22.	Dindigul	6268	5.6	16400
23.	Ramnathpuram	2504	5.6	22385
24.	Virudhnagar	21891	3.5	16991
25.	Sivagangai	297	3.1	17405
26.	Thirunelveli	7874	6.9	23218
27.	Thoothukudi	12726	6	23517
28.	Kanniyakumari	1	6.3	8963
	State	**178325**	**361.58**	**735981**

Source: Statistical Hand Book of Tamil Nadu

Block selection in Theni district (which was part of Madurai earlier):

Block	Cotton Cultivation Area (Ha) 1996-2002
Theni	4213
Periyakulam	7820
Bodi	7018
Uthamapalaym	1752
Cumbam	2241
Chinnamanur	1067
Andipatti	10252
Kadamali-Mailladumparai	7736

Source: Theni District Agriculture Department

Annexure 4

Advisors to the Research Project:

a. **Dr Elizabeth Guillette,**
Assistant Scientist, Department of Anthropology
PO Box 117305, University of Florida
Gainesville, FL. 32611-7305, USA
(Her methodology for a similar study in Mexico, published in a scientific journal has been adapted for this study – she was also the Principal Trainer for the researchers in the study, in the first phase)

b. **Dr Romeo Quijano,**
Professor, Department of Pharmacology & Toxicology,
College of Medicine, University of the Philippines,
Manila, Philippines
(Worked extensively against the pesticides in the South East Asian region, and is the co-author of many books, including Community-Pesticide Action Kits (C-PAKs), which were adapted for cotton farming in India, in this project)

c. **Dr Vijaya Raman,**
Assistant Professor, Clinical Psychology
Department of Psychiatry, St. John's Medical College & Hospital,
Bangalore, India
(Is a child psychiatrist who advised the study on the appropriateness of the tools being used, and the conclusions to be drawn)

d. **Dr S K Kabra,**
Senior Physician. Presently, Advisor, SDM Hospital, Jaipur and Visiting Faculty, Indian Institute of Health Management Research, Jaipur, India
(Health Activist with interest in Medical Audit and Pesticide Impact on Human Health. Has taken up research projects on health impacts of pesticides and has also initiated many legal battles against pesticides)

e. Friends from **NIMHANS**, Bangalore, mostly clinical psychologists

f. **Dr Ravi Narayan** and **Dr Francis** from Community Health Cell, Bangalore

Annexure 5

Partner organizations in this research project

State	Organisation (and contact details)	Coordinator/Facilitator/Researchers
Andhra Pradesh	Sarvodaya Youth Organisation, 6-1-76/A, Opp Sridevi Theatre, Hanamkonda, Warangal 506 001 Andhra Pradesh Support from: SKS, Hyderabad	Mr P Damoder, Ms Sabitha, Mr Manohar and Mr Srinivas Mr Gokul Krishna, Ms PushpaVani, Ms Suneetha and Ms Vijaya
Gujarat	Yusuf Meherally Centre, Gujarat National House, Apollo Bunder, 6 Tulloch Road, Mumbai-400039	Ms Advaita Marathe, Ms Hetal, Ms Trupti, Mr Hemant and Mr Kalpesh.
Karnataka (3 organisations)	1. ICRA (Institute for Cultural Research & Action), # 22, 5th Cross, Michael Palya II Stage, Bangalore 560075 2. Sewa (Jan Shikshan Sansthan) 12-11-61, Arab Mohalla,Raichur 584 101 3. Jana Chetana, 1-4-1289/440, IDSMT Layout, AIR Road, Raichur 584 101	Mr Srinivas Ms Anita, Mr Thimmappa, Mr Shivappa Ms Geetha
Maharashtra	Dharamitra Bank of India Colony, Nalwadi, Wardha-442001; Maharashtra.	Mr Madukar Kombe, Ms Karuna, Ms. Shughangi, Mr Namdev, Mr Vilas Rao
Punjab	Kheti Virasat, St No 1, Kamla Colony, Patiala Gate, Nabha 147201; Punjab	Mr Rajinder Kumar, Mr Surinder Singh, Ms Anjali Saini, Mr Umendra Dutt, Ms Mandeepinder Kaur
Tamil Nadu	SIRPI Ammapatti, Alagapuri (PO), Vadaputhupatti (Via) Periyakulam (TK), Theni Dt-625523. Tamil Nadu	Mr Chandrasekar, Mr Raman, Mr Raotahiya, Ms Shanti and Ms Chandrlekha

Annexure 6

National Coordinators for the Study

1. Ms Kavitha Kuruganti (overall coordination)

Sustainable Agriculture Campaigner
Greenpeace India
3360, 13th 'B' Main, HAL-2nd Stage
Indira Nagar, Bangalore-560 038
Tel: 080-51154861-66
Email: kavitha_kuruganti@yahoo.com

2. Ms Shalini (field coordinator)
Consultant
H-38/11, Gita Apartments, Appar Street
Kalakshetra Colony, Besant Nagar
Chennai-600 090
Tel: 044-24466385
Email: shaliniarvind@hotmail.com

Industry Players the study came across:

There were a variety of manufacturers and formulators that the study came across, having their markets in these districts. Some were very local, while many were large multinational companies. Interviews with dealers and distributors revealed that Bayer probably has the largest market, especially after the recent acquisition of Aventis Crop Science. Syngenta, Dupont and DeNocil also hold strong markets (though exact information on market shares is not available), in addition to BASF. While some of the farmers the investigators came across kept track of the constant acquisitions, mergers and takeovers within the industry, there were many others who continue to use the old names for pesticides, as well as the companies. They would still refer to the usage of pesticides like "DDT" which is illegal to be used in agriculture in this country or to Sandoz company or Novartis. One of the coordinators came across a farmer asking for "DDT" in a shop in Bhatinda, and indeed being provided by a chemical by the shopkeeper in response!

Some of the brands of these companies have become generic pesticide names now – Metacid and Metasystox or Confidor of Bayer for instance, or Ekalux of Syngenta, or Avaunt of DuPont.

Indian players included Cheminova, Rallis, Excel Industries, Hyderabad Chemical Supplies, Markfed AgroChemicals, Coromandel, Nagarjun Agro-chemicals, Modern Insecticides, Indofil Chemicals, Godrej Agrovet, Insecticides India Ltd, Gujarat Insecticides Limited, Lakshmi Agro-chemicals, Cheminova India, Pioneer Pesticides, Parry Chemical, Sudarshan Chemicals, Mahalaxmi Organics etc.