The "Canary Effect"; Evidence Suggesting Worldwide Intelligence Decline Secondary to Air Pollution.

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Abstract. Three studies are presented. I.Q. test data from two time periods 2006-8 and 2009-August of 2015 are compared and then correlated separately with World Health Organization (WHO) air pollution data from 2014. The I.Q. test used is the Kids I.Q. Test, developed by the author and modeled after the WISC-III Verbal test, with five section scores and a total score. The test scores are as reliable as those of the WISC-III. Data was gathered via the Internet on worldwide samples of approximately 113,000 children in the 2006-8 sample and 170,000 children in the 2009-15 sample. Raw scores for the second period are lower than for the first period across all five section scores and the total score across all age groups from 6 through 16. The rate of drop is .60 I.Q. points per year worldwide. Literature review of numerous studies suggested that international air pollution might be the most likely cause of the I.Q score drop seen. The I.Q. scores are then correlated with international air pollution data from the World Health Organization collected in 2014. The correlations are all negative and significant for every age group, with the exception of 6-year-olds in the first cohort, and generally increase from one year to the next, consistent with the notion that the longer one is exposed to polluted air the more the brain is compromised.

Study #1: Evidence of I.Q. score declines between 2006 and 2015.

In the opinion of many, the history of human intelligence over the past eight decades shows a gain of about 3 I.Q. points per decade since 1932, a phenomenon referred to as the "Flynn Effect" (Flynn, 1984, 1987, Neisser, 1998). This effect has been noted across 20 nations, including ones in Europe and in northern and southern hemispheres. The rate of gain for selected groups and tests has been even steeper, for example a 25-point gain between 1952 and 1988 (36 years, or 6.9 points per decade) for Dutch males on the Ravens Progressive Matrices test (Neisser, p. 14).

Also, there has been variation by nation and type of intelligence measured, with Japanese children gaining twice as fast as American children but adults in both countries gaining at the same rate. Gains on the Ravens test, a measure of spatial intelligence, have consistently outperformed those on measures of verbal intelligence. There are examples of I.Q. <u>losses</u>, such as on arithmetic reasoning on the Wechsler tests (Neisser, p. 28) and for certain time periods for Swedish 13-year-olds (Emanuelsson, Reuterberg and Svensson, 1993). There is also data on a leveling off of gains (e.g. Sundet, Barlaung & Torjussen, 2004).

One of many complications in comparing I.Q. scores over decades is the fact that one of the most widely used tests, the Wechsler test, has been changed in content when updated periodically. This test battery consists of ten sections, only two of which have remained essentially the same over the life of the product. These are the Digit Span and Coding tests. Digit Span is basically an immediate memory test in which the subject must remember and repeat back a cluster of numbers, such as 5, 3, 9 and then 7, 2, 8, until both pairs of numbers are failed. Number pairs must be recalled forwards, then another set backwards. The Coding Test requires writing symbols, one for each of ten digits, 1 through 10, in boxes beneath numbers within a two-minute time limit.

Comparison by the present author of the mean scores for the 200 norm boys and girls for each age, 6 through 16, for all five versions of this test, WISC through WISC-V, shows mixed results, another example of the complexities of estimating gains or losses in intelligence over time. The Wechsler tests are normed on samples of 200 boys and 200 girls at each age level. One can argue that these sample sizes are insufficient, but they have been considered adequate by the United States government and by many school districts for decades.

So, assuming for the moment that these are sufficient sample sizes, consider the following information. Specifically, for the Digit Span subtest: For the 25 years between 1949 (WISC) and 1974 (WISC-R) the average raw score change for the 11 age groups was a gain of 1 percent per year. For the 17 years between 1974 (WISC-R) and 1991 (WISC-III) the gain was only .02% per year. For the next 13 years between 1991 (WISC-III) and 2004 (WISC-IV) the average gain was .17% per year. For the next 10 years between 2004 (WISC-IV) and 2014 (WISC-V) the average gain was .6% per year.

For the Coding subtest: For the 25 years between 1949 (WISC) and 1974 (WISC-R) the average gain was .6% per year. For the 17 years between 1974 (WISC-R) and 1991 (WISC-III) the gain was .45% per year. For the next 13 years between 1991 (WISC-III) and 2004 (WISC-IV) the average gain was 0% per year. For the next 10 years between 2004 (WISC-IV) and 2014 (WISC-V) the average change was minus .04% per year.

Thus, this data does not seem consistent with the Flynn Effect argument that human intelligence has been consistently rising over the years. The inconsistency of these results across the two test sections and across the various time periods suggests that the samples of 200 children at each age level used for this norming process may have been less than perfectly representative of children of the United States as a whole, or that the factors responsible for I.Q. gains or losses varied from decade to decade. Or that different aspects or facets of intelligence may change at different rates. If the samples are not perfectly representative, then drawing conclusions from this data about human intelligence changes over the decades in question would be on uncertain grounds. And, if various facets of intelligence change independently of other facets, then generalizations about intelligence as a whole would be even more difficult to make.

This is not meant to imply that the data selection process for the various versions of the Wechsler tests was careless but merely to suggest that the selection process, while conducted in line with current best practices, may have been less than adequate for providing reliable enough data upon which to base firm conclusions about whole population changes in intelligence over decades. If one argues that the samples were random and of sufficient size, then we are still challenged to explain the several different rates and directions of change for different intelligence contents (Digit Span versus Coding) and different sequential time periods.

Given the fact that many other sources of intelligence data have been interpreted to reflect gradual and significant intelligence test gains for humans around the world over the past 8 decades (e.g. Flynn, 1987, p. 185), one is tempted to assume that intelligence gains in general have been real.

Many hypotheses have been offered to explain such gains, including improvements in nutrition, educational systems, information experiences via television and other electronic devices (including games and entertainment systems) and even changes in family structures and economics (Neisser).

A leveling off and even a decrease of intelligence scores in recent decades has been noted by some researchers (e.g. Emanuelsson, p. 260). An especially interesting example is presented by Norwegian researchers (Sundet, Barlaug & Torjussen, 2004). Their data is for three measures of intelligence (“Arithmetic”, “Figures” and “Word Similarities”) used for decades (1954 – 2002) to assess all recruits to the Norwegian military, a very comprehensive and consistent sample of persons. These tests in sum correlate .70 with the Wechsler tests, indicating respectable validity as a measure of general intelligence.

This data shows a distinctly different pattern of scores over time for each of the three types of intelligence (p. 355), further complicating the challenge of explanation. Scores on the Figures test rose steadily until 1994 then leveled off through 2002. Word Similarities scores rose until 1974, leveled off until 1994 and then declined slowly. Arithmetic rose between 1954 and 1962, leveled off until 1969 and then dropped until 1980. Then it rose slightly until 1994 and then dropped rather sharply to 2002, at which point it was only slightly higher than its original level in 1954.

Explanations for rises in I.Q. scores over the decades appear to have been only hypotheses, ranging from improved nutrition and educational systems to the influences of movies, television and video games, changes in family life and culture. “Ceiling effects” have been offered to explain leveling off of scores as a maximum possible physiological benefit from improved nutrition, for example. Explanations for dropping Norwegian math scores have included possible changes in the Norwegian school program for that subject. A similar decrease in I.Q. test scores has been noted in Sweden (Emanuelsson). Future neuropsychological research has been suggested as a possible aid in detecting mechanisms for changes in intelligence scores.

Flynn provided a detailed discussion of the great complications in interpreting the evidence for I.Q. gains between 1932 and 1981, citing in particular the very clear evidence of corresponding *drops* from 500 to 424 points in mean Scholastic Aptitude Verbal Test scores in the United States between 1941 and 1981 (Flynn, 1984).

His arguments imply the possibility that what have been interpreted as higher I.Q. scores for populations may have resulted from norm samples of gradually higher socio-economic status (SES) (and thus improved genetic assets, nutrition, child care and test sophistication). It would seem that one could similarly question whether drop in the Scholastic Aptitude Verbal Test scores in the United States might have been due to an increasing proportion of lower-intelligence students taking the test in the hopes of getting into college when unskilled laboring jobs have been harder to find.

This is the context in which the present author provided intelligence testing services to the general public via his Kids I.Q. test. The data is relevant to the discussion of possible human I.Q. score changes because it is on very large samples of children of wide age range (from 6 through 16) and from around the world. The tests include several dimensions of commonly accepted notions of verbal intelligence. They were directly modeled after the five Wechsler III verbal tests and have obvious face validity. The data provides information about intelligence change over a several-year time span. It is based on exactly the same test over this span, and involves no researcher bias in population sample selection, as the children came to the web site via self-selection.

The Kids I.Q. test data has yielded a particularly provocative finding with some very serious implications. The unusual finding is evidence for a comprehensive, universal *drop* in intelligence as measured via the five tests of different content, worldwide and across children of all ages, especially younger children. While the children tested during the earlier and later time periods were not selected to be similar in all respects relevant to intellectual aptitude, their very large sample sizes are assumed to cancel out possible factors unique to small samples within the whole.

Method:

In 2001 the present author was contacted by FunEducation.com, an Internet-based company in San Diego specializing in delivering testing services to public school systems and to the general public, such as practice tests made available to high school children. There was a market by parents for an I.Q. test that their children could take over the Internet. The author was asked to develop tests to measure verbal and spatial intelligence. He had used standard intelligence tests for years as a clinical psychologist, particularly the Wechsler tests, and had extensive experience in developing tests for applied use in clinical and industrial applications. He developed a battery of five verbal and five spatial tests, both modeled after the Wechsler Intelligence Test for Children, Third Edition (Wechsler, 1991).

The verbal test has been marketed on the FunEducation.Com web site as the *Kids I.Q. Test.* It provides five section scores (Vocabulary, Comprehension, Arithmetic, Similarities and Information) and a total I.Q. score. The section scores have about 40 items each which range in difficulty from easy for 6-year-olds up to difficult for 16-year-olds. The tests have high reliability, virtually identical to that of the Wechsler tests, for all section and total scores for both children and adults, ages 6 on up.

For example, the reliability coefficients for the Kids I.Q. test compared to the WISC-III for 14-year-olds are Information .77 versus .87 for the WISC, Similarities .89 versus .84, Arithmetic .94 versus .77, Comprehension .92 versus .76, Vocabulary .93 versus .91 and Total score .97 for the Kids. I.Q. test versus .95 for the WISC-III. And for 11-year-olds in the 2009-15 cohort for females they are Information .82, Similarities .88, Arithmetic .94, Comprehension .77, Vocabulary .78 and Total score .94, computed by the Kuder-Richardson formula 21. They have obvious content validity, which can be seen by taking the test on the FunEducation web site. Concurrent validity is available in a study by the author and available from him (Research Report: Validity of the McConochie Internet Intelligence Tests, Kids and Adults Verbal and Spatial Tests). This report includes the following data from various studies by the author: The Kids verbal test correlated .69** with latitude and the spatial test .65** with latitude, compared to I.Q. data correlations with latitude from Lynn and Vanhanan (.37**). The Kids verbal test total score correlates .65** with the Wonderlic Personnel Test (verbal intelligence), compared to the WISC Vocabulary correlation with the Wonderlic (.65**). The Kids verbal test total score correlates .46** with the Bennett Mechanical Comprehension Test compared to the WISC Vocabulary subtest with the Bennett (.51**). The Kids verbal test total score correlated .71** with the WISC vocabulary subtest. The Kids verbal and spatial test total scores correlate .63** with each other.

The tests are made available to visitors to the web site, with a brief report provided for free and a more detailed report for a slight fee. The Kids I.Q. Test has been quite popular, attracting children and adults from scores of nations. Test scores do not vary as a function of paid versus free reports. For example, reliability has been the same for both groups.

Norms have been based on those taking the tests over the Internet, first on a sample of a few hundred and then on samples of thousands per age level. The norms were updated in 2008 for

113,000 children and additional adults. The proportion of children of various ethnic groups in this sample was similar to that in the United States. Score analysis was undertaken again in the fall of 2015 for over 170,000 children who had taken the tests since 2008. The statistics for this second cohort were in most respects consistent with those from the first, showing no substantial differences by gender and standard deviations very similar to those of the first cohort. Mean raw scores by age group showed a gradual increase up to about age 16, then a leveling off through about age 40 or 50 and then a gradual decline. This is similar to the score pattern across ages for the Adult Wechsler Intelligence Test, Fourth Edition. Thus, the similarity of the present tests with the Wechsler tests in content, raw scores over age ranges and reliability characteristics is consistent with the intention that the Kids I.Q. test serve as a dependable measure of verbal intelligence.

The spatial test also has five sections of about 40 items each which have reliability similar to that of the Wechsler spatial I.Q. tests. Sample sizes for the spatial test have been lower, as the test has been less popular. Thus, this test was omitted from the present study.

Results:

A peculiar and unexpected characteristic of the 2009-15 cohort was that all of the mean raw scores for all of the tests, the 5 section tests for Information, Similarities, Arithmetic, Comprehension and Vocabulary, and the Total Score, were slightly lower than for the 2006-2008 cohort, as presented in Table 1.

[Insert Table 1 about here.]

This drop in scores seemed strange, especially in light of the evidence that human intelligence test scores, for the most part, had been *increasing* gradually since 1932, as discussed above. Note in particular that the drop seems most prominent for the youngest age groups (ages 6-8).

Neither the FunEducation staff nor the present author could think of any reasons why the latter cohort should be significantly different in general makeup from the earlier cohort, as both cohorts were presented essentially the same opportunity to take the tests over the FunEducation.com web site and the site had not been changed substantially. Nor was there any reason to expect anything but perhaps a mild increase in raw scores secondary to the increasing availability of knowledge, good nutrition and intellectual stimulation for children during the first years of the 21st Century, as via improved educational systems and the Internet, conditions that had been offered by other researchers to explain the gains in I.Q. during prior decades. The children who took the test had access to the Internet, as that is the medium by which it is offered to the public. By implication, they also had access to other societal benefits, such as good nutrition and educational opportunities. Contrarily, one could argue that it is possible that the second cohort could have included many more children from lower socioeconomic groups, who, by attending public school, had access to the Internet more easily than did such children from the first cohort. If these children have lower intelligence than children from higher socioeconomic groups, who have computers in their homes, this could account for the slightly lower scores in the second cohort.

Finally, the mean score for all 163,000 children in the second cohort was 100.05 with a standard deviation of 15.00, meaning that this group was virtually the same, overall, as the first, in verbal intelligence.

Out of curiosity, data for three age groups were analyzed for the United States, the largest sample in the study, as presented in Table 2.

[Insert Table 2 about here.]

For 6-year-olds, the total test raw score dropped 3.9 percentage points, the equivalent of 3.9 I.Q. points. For the 11 and 16-year-old children the total score rose slightly. There was no apparent reason for this pattern.

The mean Total Score decrease worldwide as presented in Table 1 is 2.9% for males and 2.3% for females. The average is 2.6%. This is a drop in the total raw score from which I.Q. scores are computed. This is a drop over 4.33 years on average, from the middle of the first data cohort for the years 2006-2008 to the middle of the second cohort for the years 2009-August of 2015. 2.6% divided by 4.33 yields a .60 percent drop per year in the average raw scores. This yields a similar .60 percent per year drop in average I.Q. scores.

Discussion of study #1.

A .60 percent per year average I.Q. drop over 50 years would result in an intelligence loss of 30 points (.6 x 50 = 30). The current "average I.Q." range is, by definition, between 90 and 110, with a mean of 100. 100 minus 30 = 70, which is the upper end of the mild intellectual disability (retardation) range. With the average I.Q. at the equivalent of 70, fully half of a nation's population would then have I.Q.s *below* 70. These adults would be generally unemployable for most jobs.

In this scenario, persons who otherwise would have I.Q. scores currently equal to 130, in the superior range, at the 98th percentile, in 50 years would have intellectual functioning equivalent to a current I.Q. of 100. This is the middle of the current average range, which is probably too low to succeed in a robust current 4-year college curriculum. In essence, there would be virtually no new college graduates 50 years from now, worldwide. While that might mean no clever dictators or investment scam artists, it would also mean only marginally effective government leaders, business managers and school teachers at best. And there would be only a small proportion of the population (perhaps 2 to 5 percent) with the current equivalent of only average intellectual aptitude to fill all careers requiring management and related skills, including business executives, attorneys, physicians, nurses, school teachers, engineers and research scientists. In short, society and culture as we currently know it could not exist.

The SAT data cited above had a mean score of 500 and standard deviation of 100 in 1941. By 1981, 40 years later, the mean had dropped 75 points to 424. 75 is ¾ of 100. Transposing this to I.Q. data expressed in terms of a mean of 100 and standard deviation of 15, the common statistics for I.Q. tests, we would have a drop of ¾ times 15 = 11.25 I.Q. points over 40 years, or a drop of .28 points per year or 2.8 points per decade. But, as summarized in the introductory section above, we have seen evidence of I.Q. scores *increasing* about 3 points per decade (or .30 points per year) during this same time period.

What possible combination of forces could have been acting on American children during the past 80 years to result in an initial *gain* of .30 I.Q. points per year between 1932 and 1981, a simultaneous *drop* of .28 points per year in SAT scores between 1941 and 1981, and a *drop* of .60 I.Q. points per year between 2006 and 2015 on the Kids I.Q. test, and score drops on some tests used in Denmark with all Army recruits in recent decades? Of special concern, what could be causing the drops in I.Q. test scores?

This question inspired the second study.

Study # 2: Air pollution explored as a possible cause of intelligence decline.

While intelligence increases (the “Flynn Effect”) over many prior decades have suggested *beneficial* effects from improved diet, educational systems, etc., the above decreases in SAT test and intelligence test scores suggest possible universal *detrimental* effects. It seems possible that many different factors have been influencing human brain functioning, some beneficially (improved nutrition, education, etc.) and some detrimentally.

Regarding possible worldwide detrimental effects, humans all consume food and water, but from many different sources. The one item that all humans consume from the same general source is air. Air circulates worldwide as wind. Thus, air of roughly similar quality is what most humans ingest in common.

What brain toxins might all humans worldwide be consuming from air? The author knew from personal experience that air toxins can be consumed directly by breathing. Benzene is released in gaseous form from gasoline and is especially concentrated in the Northwest U.S. Benzene can cause large B-cell non-Hodgkin’s lymphoma, a type of cancer. Carbon monoxide is a component of exhaust from gasoline combustion, which can kill people who elect suicide by leaving their vehicle running in a closed garage. We all breathe air containing these vehicle exhausts, especially if we live in traffic-congested communities.

Toxins also can be consumed indirectly from the air when airborne toxins are deposited on oceans and crops. Coal burning releases mercury into the atmosphere, some of which is absorbed by the ocean and then enters the food chain and is more highly concentrated in larger fish, such as tuna. Humans eat these fish. Citizens in Oregon, the author’s state, are warned to restrict their ingestion of fresh water fish from certain bodies of water in the state known to be contaminated with toxins from mining operations.

To further explore atmospheric toxins, the author reviewed scientific publications and web site information from health organizations, finding a plethora of information consistent with the hypothesis that air pollution could be causing worldwide human cognitive decline. An article in the American Psychological Association Monitor magazine (Weir, 2012) was particularly revealing. This article reports: “Researchers have known since the 1970’s that high levels of air pollution can harm both cardiovascular and respiratory health, increasing the risk of early death from heart and lung diseases. The effect of air pollution on cognition and mental well-being, however, has been less well understood. Now…researchers have found that high levels of air pollution may damage children’s cognitive abilities….”

Weir then cites several studies that document relationships between air pollution and cognitive decline. A study in the Boston area followed more than 200 children, documenting a relationship between greater levels of black carbon (soot) exposure and lower memory and verbal intelligence test scores (Suglia, et al 2008). A study in Michigan documents lower graduation rates for children in schools located closer to industrial pollution sites when controlling for other possible confounding factors, such as socioeconomic level (Mohai, et al 2011).

Studies in smog-troubled Mexico City are cited (Calderon-Garcinduenas, et al, 2008). Children in Mexico City were compared to children in a less polluted suburban community via MRI brain scans and tests of memory, cognition and intelligence. The city children had more signs of brain pathology and lower test scores. Autopsies of city dogs there showed greater toxin-related brain changes associated with Alzheimer’s disease.

Also cited by Weir is a study at Ohio State University (Fonken, L.K. et al 2011). Research mice exposed for months to doses of air pollution typical of what human commuters in and out of cities experience had more trouble learning and avoiding mistakes in completing tasks. Autopsies of the mice brains showed signs of inflammation and damage to areas involved in spatial memory.

A study in Barcelona, Spain examined the effect of air pollution on 2,715 children aged 7 to 10 (Lilley, 2015). Higher levels of vehicle traffic exhaust pollution were associated with a 4% difference in working memory and two other areas of cognitive functioning over 12 months between children in low pollution versus high pollution areas. The toxic effects of diesel exhaust on rat brains have been studied (Levesque, Surace, McDonald and Block, 2011). Neuroinflammation and neuropathology were consequences of 6 months of inhalation of exhaust gasses in 344 rats. The findings were interpreted as having implications for Alzheimer’s and Parkinson’s disease.

A study in El Paso, TX documented the toxic effect of air pollutants on children's school grade point averages, with special reference to the impact of diesel fuel exhaust (Clark-Reyna, et al 2016). The authors opine: "Thus, the effects appear insidious, since they are mild, unlikely to be perceived, and, hence, unlikely to be addressed in any way. It would be important to note that seemingly trivial effects on children's development may translate into substantial impacts throughout the life course, in terms of physical and mental health and personal success (e.g., lifetime earnings)."

The international spread of air pollution in the form of ozone, aerosols and nitrogen oxide is documented by Akimoto (Akimoto, 2003). The MAPS (Measurement of Air Pollution from Satellite) instrument has measured air pollution globally, documenting that air pollution from industrial sources, and from fuel and biomass (wood, etc.) combustion travels worldwide, affecting residents everywhere. The atmospheric lifetime of pollutants harmful to human health, such as ozone and carbon monoxide, is long enough for these gases to be transported by winds for thousands of miles and from continent to continent.

It seems possible that in addition to air pollution directly, virtually all humans could be contaminated in utero if all mothers breathe contaminated air. An article in Scientific American is titled “Tests Find More than 200 Chemicals in Newborn Umbilical Cord Blood” (Goodman, 2009). The senior scientist from the Environmental Working Group, which commissioned the research, was particularly concerned about evidence for 21 new contaminants, including bisphenol A, associated with precancerous growth in animals and erectile malfunction in Chinese adult males. Another umbilical cord blood study found similar chemicals, leading the senior scientist to opine that human exposure to toxic chemicals is ubiquitous. Leo Trasande at the Mount Sinai School of Medicine said the results had alarming implications for the health of children.

This was the 11th study of human blood toxins commissioned by the Environmental Working Group (Cook, 2016). These studies have found 493 foreign, polluting chemicals in human blood from newborns to grandparents, including perchlorate, a solid rocket fuel component and potent thyroid toxin that can disrupt production of hormones essential for brain development.

Literature review suggests that the bulk of the environmental contaminants for human brains seem to be airborne. In another study, 10 volunteer adults were exposed to diesel exhaust fumes in laboratory conditions for one hour (Cruts, 2008). Their brains were then studied by quantitative electroencephalography, which revealed increases in “median power frequency”, a sign of stress on the brain.

The U.S. Department of Labor provides a partial list of toxic chemicals associated with diesel exhaust and other sources (OSHA). These include carbon dioxide, carbon monoxide, nitric oxide, sulfur dioxide, benzene, formaldehyde and numerous polynuclear aromatic hydrocarbons. A fact sheet by the California Environmental Protection Agency and the American Lung Association of California provides detailed information about motor vehicle fuel toxins (Cal/EPA). The sheet states:

"Gasoline and diesel fuels contain toxic substances that can enter the environment and cause adverse health effects in people. Some of these substances, such as benzene, toluene and xylenes, are found in crude oil and occur naturally in fuels and their vapors. Other substances, such as 1,3-butadiene and formaldehyde, are formed in engines during combustion and are only present in exhaust. Other harmful pollutants found in engine exhaust include particulate matter…, nitrogen oxides, carbon monoxide, sulfur dioxide and various hydrocarbons. Ozone, the major component of urban smog, is formed when nitrogen oxides react in sunlight with hydrocarbons….Diesel exhaust also contains over 40 different substances identified by the California Air Resources Board (ARB) as toxic air contaminants that may pose a threat to human health [including] particulate matter that has been linked to cancer." Diesel vehicles constitute only 2 percent of the vehicles in California but emit 60 percent of motor vehicle particulate matter.

This fact sheet continues. "Just breathing the air exposes people to fuel components, especially in urban areas. People are exposed to gasoline and diesel exhaust when they drive or ride in a vehicle, jog or bike along roads or park in a public garage….People who work in or live near freeways, refineries, chemical plants, loading and storage facilities…may be exposed to higher levels of fuel components…and face higher health risks…Breathing gasoline and diesel vapors …[and] lifelong exposure can increase the risk of …cancer." The chemicals in vehicle exhaust that can cause cancer include benzene, 1,3-butadiene, formaldehyde and acetaldehyde.

“Long-term exposure to particles in diesel exhaust poses the highest cancer risk of any toxic air contaminant ….about 70 percent of the cancer risk that the average Californian faces from breathing toxic air pollutants comes from diesel exhaust particles.” This fact sheet reports that California has made progress in reducing toxic emissions from vehicles, but the number of vehicles keeps growing, eroding overall air pollution control efforts.

Numerous reports at the United Nations World Health Organization web site publications page express concern for toxic air pollution (WHO). For example, “An estimated 12.6 million people died as a result of living or working in an unhealthy environment in 2012 – nearly one in 4 of total global deaths, according to new estimates from WHO. Environmental risk factors, such as air, water and soil pollution, chemical exposures, climate change, and ultraviolent radiation, contribute to more than 100 diseases….” "More than 80% of people living in urban areas that monitor air pollution are exposed to air quality that exceeds the World Health Organization (WHO) limits...98% of cities in low- and middle-income countries with more than 100,000 inhabitants do not meet WHO air quality guidelines. However, in high-income countries, that percentage decreases to 56%." Recommendations for prevention include “reducing the use of solid fuels [e.g. wood] for cooking and increasing access to low-carbon energy technologies.”

And, as summarized by the London Guardian: “The World Health Organization has issued a stark new warning about deadly levels of pollution in many of the world’s biggest cities, claiming poor air quality is killing millions and threatening to overwhelm health services across the globe….The latest data, taken from 2,000 cities, will show further deterioration in many places as populations have grown, leaving large areas under clouds of smog created by a mix of transport fumes, construction dust, toxic gases from power generation and wood burning in homes." (Guardian). "In Britain, where latest figures suggest that around 29,000 people a year die prematurely from particulate pollution and thousands more from long-term exposure to nitrogen dioxide gas, emitted largely by diesel engines, the government is being taken to court over its intention to delay addressing pollution for at least 10 years." "Leading economist Lord Stern said air pollution was an important factor in climate change. 'Air pollution is of fundamental importance. We are only just learning about the scale of the toxicity of coal and diesel. We know that in China, 4,000 people a day die of air pollution. In India it is far worse. This is a deep, deep problem,' he said."

The widespread presence of toxins in the United States and their detrimental effects on intelligence are discussed by Lu (Lu, 2015). Toxins are present in food containers, cash register receipts and other ubiquitous sources. I.Q. deficits can be a side-effect of these toxins. For example, from Cincinnati Children's Hospital: "The effects [of such toxins] may be slight in an individual, a difference of an I.Q. point or two or a quirk that veers children off their normal path of development" (p. 64). And "...phthalates are still used in vinyl, plastic wrap and food containers, and in scented products, such as dryer sheets and air fresheners. They're also elements of fragrances used in scented soaps, lotions and shampoo...children exposed during pregnancy to elevated phthalate levels had I.Q. scores more than 6 points lower, on average, than children exposed to lower levels" (p. 65). "PBDEs (polybrominated diphenyl ethers) are chemically similar to thyroid hormones...[and] may tamper with brain development...higher prenatal exposure to PBDEs was correlated with lower I.Q.s of up to five points and higher hyperactivity in 5-year-old children" (p. 66). Some of the toxins cited in this article are airborne, including pesticides in agricultural communities (p. 64). Some of them have differential effects by gender, with BPA (Biphenol A) having a more detrimental effect on boys, with more aggression, rule-breaking and sleep problems (p. 66).

In summary, the above brief literature review reveals the presence of scores of toxins in the environment, many of which appear in gaseous form polluting air. Prominent among these is smog from motor vehicle exhaust, which is especially dense in areas of heavy traffic, such as along freeways and in cities. Children in schools near dense smog areas show cognitive deficits, including lower intelligence test scores. Toxic gasses in some forms remain potent long enough to be transported around the world via winds.

Given the steady increase in worldwide production of fossil fuels, it seems that these air toxin problems are likely to get steadily worse, increasing the rate of health problems and of intelligence decline. The United States Energy Information Administration provides relevant statistics (EIA). For example, oil production increased 6.3 percent worldwide between 2006 and 2012, for an average of about 1 percent per year. Coal production increased 25 percent during this time, or about 4 per cent per year. Natural gas increased 17 percent, 2.8 percent per year. If air toxins increase above previous levels, the time it will take average I.Q. levels to drop from 100 to 70 may be less than the above estimate of 50 years.

This air pollution compromise of human health is consistent with the author's hypothesis that international air toxins might underlie recent world-wide gradual erosion of human intellectual functioning as measured by I.Q. tests. Several of the studies refer to greater pollution damage to young children and elderly adults. The reader is reminded of the apparent greater drop in I.Q. scores for younger children (ages 6-8) in Table 1, above.

German chemist Fritz Haber won a Nobel Prize for inventing a process for extracting nitrogen from air. Nitrogen is used to make fertilizer and gun powder. He also invented the chlorine gas poison used by the German military in World War I. He developed Haber's Rule, a formula, C x t = k, which summarizes the effect of toxic gas. Exposure to toxic gas of low concentration (C) over a longer period of time (t) can have the same lethal effect (k) as exposure in higher concentration over less time.

Method.

To explore the possible relationship between air pollution and cognitive functioning, correlations were run between the Kids I.Q. test scores for the two cohorts (2006-2008, Study #2 and 2009-2015, Study #3) and worldwide air pollution levels as reported by the World Health Organization for 2014 (WHO, 2016). In the introduction to the many tables of data, this WHO report explains that the pollution data was gathered from about 3000 cities in the 194 member states (nations) in 2014. Analysis of the data led to the WHO report statement that "Exposure to air pollutants can affect human health in various ways leading to increased mortality and morbidity. Epidemiological evidence on the health effects of air pollution is growing and evolving quickly. Today, air pollution is the largest environmental risk factor." (p. 19).

The data for the present study was taken from *Annex 1: Modeled population exposure to particulate matter (PM 2.5), by country*. The median figures for rural, and for rural and urban combined measurements were used for the present study, though subsequent analysis revealed these were statistically equivalent, correlating .998 with each other. The figures were described as "Annual median concentration of particulate matter". These figures were entered into the data file such that each child's entries included the two particulate matter measures. Then Pearson Product moment correlations were computed for the 2006-2008 cohort, as presented in Table3.

[Insert Table 3 about here.]

In a prior study (McConochie, Study 25) the present researcher had found significant correlations between I.Q. and latitude, with a tendency for the relationship to be positive and gradually increasing with age. Therefore, the relationships between the total intelligence test scores and latitude were computed, as presented in column 4 of Table 3. The correlations are small and not consistently significant, statistically speaking (column 5). However, because the correlation between the total intelligence score and latitude across all age groups was .021**, significant at the .000 level, correlations between the total intelligence score and latitude were computed, controlling for pollution (column 6). They are generally inconsistent and statistically insignificant.

This suggested that there is no meaningful relationship between intelligence and latitude per se. The next step was to run correlations between intelligence (the total test scores) and the two measures of air pollution, controlling for latitude. The results are presented in columns 8 and 10, with corresponding significance levels in columns 9 and 11 respectively. As the two pollution scores correlate very highly with each other (.998), the results in columns 8 and 10 are virtually identical. Beginning with 7-year-olds there is a significant negative correlation between the intelligence measure and pollution levels: the higher the pollution, the lower the intelligence. And there is a tendency for the effect to rise gradually with age, from .03 at age 7 to .17 for young adults (ages 17-26), consistent with the notion that the longer that persons are exposed to toxic air, the greater their brains are compromised.

Study #3. The robust relationship between intelligence and air pollution.

This study was then replicated for the second cohort, with results as presented in Table 4. In this study, the I.Q. scores rather than total raw scores were used.

[Insert Table 4 about here.]

The results are similar to those in the study #2, though more robust. This may reflect the fact that 162 nations were represented, compared to just the 12 nations used in the first study. The correlations between I.Q. scores and latitude, column 4, are again consistently positive and all statistically significant. And, when controlling for pollution, these correlations again deteriorate noticeably, with many becoming statistically insignificant (columns 6 and 7), just as they did in the first cohort. The correlations between intelligence and pollution are also as found in the first cohort, but are more robust (columns 8-11). They are significant at age 5 and rise more strongly, into the .20 range by age 9. They rise to .29 for the oldest groups, higher than in the first cohort. This steady rise in negative effect size with age is again consistent with the notion that longer exposure to toxic air has greater negative effects on brain function.

Discussion of all three studies.

The present studies are correlation-based. They do not prove cause. However, it is difficult to imagine another explanation for this clear negative relationship between air pollution levels and intelligence test performance. The World Health Organization considers air pollution to be a deadly toxin, as mentioned above. And the plethora of findings from other studies surveyed above has documented the negative effects of air toxins on the brain in the form of brain toxins present on autopsy and differential cognitive scores for groups of children and elderly adults in communities of differing pollution levels.

In essence, we humans may be living in a gas chamber. More to the point, we may be slowly *dying* in a gas chamber. We may be “canaries in the coal mine”, showing early signs of health deterioration secondary to environmental toxins. This appears to include erosion of human intelligence. In contrast to the "Flynn Effect", the steady rise of intelligence assumed by several researchers in the last century, this apparent erosion of human intelligence seems to be an early sign of what may be considered the “Canary Effect”. Our children’s decreasing I.Q. scores may signal a deadly threat to human society as we know it. In as few as 50 years, average human intelligence could fall from 100 to 70, at which point half the world's population would be essentially unemployable and the most intelligent humans will be ill-equipped to manage complex social organizations or conduct meaningful research to understand and solve challenging problems.

The rise and fall of different measures of I.Q. around the world over the past 8 decades may reflect numerous causal factors, including nutrition, education, electronic media, research sample variations and toxins. While increases are more likely the result of improved nutrition and educational systems, decreases are more likely a reflection of toxins. A ceiling effect may have been reached in terms of nutrition and educational benefits. A steadily increasing air toxin level in recent decades may have outstripped the benefits of nutrition, etc. for a net progressive erosion of human intelligence in recent years. The drop in SAT scores may have been due to an increase in the proportion of SAT takers that had lower intelligence as the years passed, as children having less optimism about being able to find unskilled laboring jobs aspired to college degrees instead. Also, the variations in scores for different types of intelligence may be due in part to the differential effects of various environmental toxins on different parts of the brain; and different parts of the brain underlie different types or facets of intelligence, e.g. verbal, spatial, visual-motor, and memory.

As an applied psychologist, the author offers the following suggestions for continued study and action to further clarify whether air pollution explains I.Q. drop scores, and if they do to reduce the production of toxins in air:

- Analyze blood samples from humans around the world to detect toxins that all share in common. Encourage nations to eliminate all environment-contaminating toxins, especially universal ones.

- Measure and publish environmental air toxin levels locally and internationally. Do this monthly to monitor air toxin levels and progress in reducing them. Publish this data in local newspapers to encourage citizens and governments everywhere to participate in toxin reduction efforts.

- Measure the intelligence of a large sample of groups of children and adults, retesting these same persons annually for ten consecutive years, using the same tests, preferably ones minimally, if at all, influenced by practice effect. Look for declining scores at rates steeper than the natural decline with age for former groups, e.g. on the samples of adults used to norm the Wechsler tests in prior decades.

- Reduce population congestion to reduce concentration of pollutants. Discourage the recent development of megacities of millions of residents. Instead, foster the development of sustainable, small, rural communities to disburse toxic pollutants. The

World Health Organization reports on its web site that only 8% of 2,000 cities around the world recently surveyed met clean air standards.

- As soon as possible, follow the lead of a few passenger car manufacturers who are producing electric and hydrogen-powered vehicles; convert heavy truck, freight train and ship internal combustion engines to non-polluting fuels, such as electricity or hydrogen combustion. Do likewise for airplanes, if possible. Replace all public transportation vehicle engines (busses, subways, surface trains, ships) with electric or hydrogen combustion engines.

- Discontinue combustion use of fossil fuels as rapidly as possible, perhaps by rationing and by outlawing their extraction and/or combustion. During WW II the U.S. reduced civilian gasoline use by 40% via rationing.

- Replace all fossil-fuel-powered utility plants (electricity generating plants) with non-polluting-fuel powered plants, e.g. hydrogen combustion engines, hydropower from dams, geothermal power from deep earth heat sources, etc.

- Urge governments to more tightly regulate chemicals in use. According to the Monitor article cited above (Lu, 2015, pg.68), there are some 83,000 chemicals in use in the United States, of which "only five have been broadly regulated with limits on their production and use. Even asbestos is still legal."

While some citizens may be inclined, financially and/or morally, to ignore the problems of general environmental degradation and resulting extinction of lower species, no citizen is immune from universally toxic air.

One reviewer of this article opined that the strength of the argument would rest on “how representative the sample” is. In the author’s opinion, this is not relevant. The argument is not that the sample is random and represents overall average human intellectual functioning. The argument is that the sample did not change in the sort of humans included from the earlier cohort to the latter cohort and thus reflects a significant drop of intelligence of that cohort. The cohort is described as “children ages 6 through 16 worldwide who have a working knowledge of English sufficient to complete the test presented, with access to the Internet, and curious enough about intelligence to complete the test”. The overall total I.Q. scores for the second cohort were 100, exactly the level generated in the first cohort and using the first cohort raw scores as the norm for computing the I.Q. scores for the second cohort.

Another reviewer thought it was possible that something other than air pollution might account for the lower scores in the present study and that therefore the results should not be published.

It seems to the author that it would be professionally and ethically irresponsible not to report the present findings, and that it should be up to each reader to decide for him or herself whether the findings warrant further studies. Those who discount the findings should not prevent others from the opportunity to take the findings as serious implications warranting further study. Publishers who fear government cancelation of research grant monies in retaliation for publishing findings that threaten polluting industries should be encouraged to have courage for the sake of the common good.

Very large samples enable one to reliably detect small changes. This is an important value of this study, as it permits reliable detection of small but statistically significant negative correlations between intelligence as measured by the tests used and air pollution as measured by the World Health Organization.

No public money was spent to conduct the present study, as its analysis was secondary to a service provided by the author in conjunction with his business affiliate, FunEducation.com.

References:

Akimoto, H. (2003). Global Air Quality and Pollution. *Science*, December 5, 2003, Vol. 302, 1716-1719.

Cal/EPA. Fuels and Your Health. Retrieved from: www.oehha.ca.gov.

Calderon-Garciduenas, L., Azzarelli, B., Acuna, H., Garcia, R., Gambling, T., Osnaya, N., Monroy, Sl, Del Rosario-Tizapantzi, M., Carson, J., Villarreal-Calderon, A, & Rewcastle, B. (2002). Air Pollution and Brain Damage. *Toxicologic Pathology*, 30(3), 373-389.

Calderon-Garciduenas, L., et al, (2004). Brain Inflammation and Alzheimer's-Like Pathology in Individuals Exposed to Severe Air Pollution. *Toxicologic Pathology*, 32, 650-658.

Calderon-Garcinduenas, L,, et al (2008), Air pollution, cognitive deficits and brain abnormalities: A pilot study with children and dogs, Brain and Cognition, Vol 68, Issue 2, Nov., p117-127.

Cook, Ken (2016). 10 Americans: Industrial Toxins Found in Umbilical Cord Blood. Retrieved from http://siselsensation.com/toxin-free-living/effects-of-toxins-on-newborns/.

Cruts, B., van Etten, L., Tornqvist, H., Blomberg, A., Sandstrom, T., Mills, N. & Borm, P. (2008). Exposure to diesel exhaust induces changes in EEG in human volunteers. *Particle and Fibre Toxicology.*, 5(4). doi:10./1743/8977-5-4.

EIA. Retrieved from: WWW.eia.gov/.

Emanuelsson, I., Reuterberg, S., & Svensson, A. Changing Differences in Intelligence? Comparisons between groups of 13-year-olds tested from 1960 to 1990. (1993). *Scandinavian Journal of Educational Research,* 37(4).

Flynn, J.R. (1984). The Mean I.Q. of Americans - Massive Gains 1932 to 1978. *Psychological Bulletin*, 95, 29-51.

Flynn, J.R. (1987). Massive I.Q. Gains in 14 Nations – What I.Q. Tests Really Measure. *Psychological Bulletin*, 101, 171-191.

Fonken, L.K., et al (2011), Air pollution impairs cognition, provokes depressive -like behaviors and alters hippocamplal cytokine expression and porphology. *Molecular Psychiatry*, Oct: 16(10) p 957-973.

Gammon, K. (2015). Smog's Impact Beyond the Lungs. *Trojan Family Magazine*, Summer.

Guardian (2016). Retrieved from http://www.theguardian.com/environment/2016/jan/16/world-health-or....

Levesque, S., Surace, M., McDonald, J., & Block, M., (2011). Air pollution and the brain: Subchronic diesel exhaust exposure causes neuroinflammation and elevates early markers of neurodegenerative disease. *Journal of Neuroinflammation*, 8(105).

Lu, S. (2015). Chemical Threats. *Monitor on Psychology*, Oct., 63-68.

Mohai, P., Kweon, B., Lee, S. & Ard, K. (2011). Air Pollution Around Schools Is Linked to Poorer Student Health And Academic Performance. *Health Affairs*, May, Vol. 30 no. 5, 852-862.

Neisser, U. (1998). *The rising curve; long-term gains in IQ and related measures*. Washington, D.C.: American Psychological Association.

OSHA. Partial List of Chemicals Associated with Diesel Exhaust. Retrieved from: www.OSHA.gov.

Lilley, J. (2015). Brain smog; Traffic pollution reduces children's ability to learn in school. Retrieved from: *NaturalNews.com*, March 27.

McConochie, W., *The McConochie Kids' I.Q. Test Manual*, available from the author, Bill@testmasterinc.com.

McConochie, W., Intelligence and National Per Capita Income. Retrieved from: Politicalpsychologyresearch.com, Publications Page, Publication #25.

McConochie, W., (2014). *Party Time! How you can create common good democracy right now.* Eugene, OR: Luminare Press. Available via Amazon Books.

Suglia, S.F., Gryparis A, Wright, R.O, Schwartz, J, Wright, R. J, (2008). Association of black carbon with cognition among children in prospective birth cohort study. Am J Epidemiol, 167:280-286.

Sundet, J.M., Garlaug, D.G. & Torjussen, T.M., (2004). The end of the Flynn effect? A study of secular trends in mean intelligence test scores of Norwegian conscripts during half a century. *Intelligence*, 32, 349-362.

Quickstats, U.S. Government Center for Disease Control: Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6303a6.htm.

Wechsler, David. (1991). *Wechsler Intelligence Scale for Children-Third Edition, Manual.*, San Antonio, TX, The Psychological Corporation.

Weir, K. (2012). Smog in our brains. *Monitor on Psychology*, American Psychological Association, July/Aug., 43(7), 32.

WHO. World Health Organization. In general, search the WHO site for "air pollution" and follow leads to various reports, e.g. www.who.int/phe/health topics.

WHO (2016). Ambient air pollution: A global assessment of exposure and burden of disease. Retrieved from www.who.int/entity/phe/publications/air-pollution-global-assessment/en/-30k.

Table 1. Changes in Kids Verbal I.Q. Test Raw Scores for total world samples by age and test for 2009-2015 versus 2006-2008. Sample sizes in column 1 are for the 2006-2008 and 2009-2015 groups respectively. The total samples of children between ages 6 and 16 were approximately 112,300 and 163,000 for the two time periods. Change scores are given in raw score amount and percentage change between the "2008" group and the "2015" group. For example, for 6-year-olds the 2006-2008 mean score for the Information subtest was 20.5. For the 2009-15 group the mean was 19.8. The drop of .7 points is 3.4% of 20.5. The Student's t-test significance level is for the Total Score change. (Notes: Cases omitted if any section scores were below 1, to screen out spurious cases, e.g. persons who just scanned the tests to look at the items.)

Age and sample sizes (m=male, f=female)	**Informa-tion**	**Similar-ities**	**Arith-metic**	**Compre-hension**	**Vocabu-lary**	**Total Score change**	**Total score t-test sig. level**
6m/3827 &4034	-.7 3.4%	-1.2 5.5%	-.7 3.3%	-1.3 5.7%	-1.4 6.6%	-5.4 5.0%	.0005
6f/4034 &3498	-1.3 6.3%	-1.3 6.3%	-1.8 8.7%	-1.3 5.8%	-1.6 7.6%	-7.9 7.4%	.0005
7m/2493 &4741	-.6 2.3%	-1.1 4.6%	-.5 2.0%	-.9 3.7%	-.4 1.8%	-3.6 3.1%	.001
7f/2557 &3916	-.8 3.5%	-1.2 5.1%	-1.4 5.7%	-.7 2.9%	-.8 3.6%	-4.8 4.1%	.005
8m/3033 &5560	-.5 2.0%	-1.2 4.8%	-.5 1.8%	-1.0 3.8%	-.3 1.3%	-2.9 2.3%	.001
8f/3219 &4610	-.8 3.4%	-1.2 4.9%	-1.0 3.7%	-.8 3.1%	-.7 3.0%	-4.3 3.4%	.0005
9m/3388 &6125	-.4 1.6%	-1.1 4.3%	-.3 1.0%	-.7 2.5%	-.5 2.0%	-2.8 2.1%	.0005
9f/3742 &5588	-.5 2.1%	-1.0 4.0%	-.6 2.1%	-.2 1.0%	-.3 1.2%	-2.7 2.1%	.0005
10m/4745 &9357	-.3 1.1%	-1.0 3.7%	-.5 1.5%	-.6 2.1%	-.4 1.5%	-2.8 2.0%	.0005
10f/5802 &10152	-.1 0%	-.5 2%	-.2 1%	-.4 1%	-.1 0%	-1.3 1%	.005

11m/5457 &9893	-.3 1%	-1 3.6%	-.5 1.5%	-.6 2%	-1.0 3.6%	-2.9 2%	.0005
11f/8543 &12963	-.1 0%	-.6 2%	-.3 1%	-.4 1%	-.3 1%	-1.8 1%	.0005
12m/6185 &10087	-.5 1.8%	-1.1 3.9%	-.8 2.3%	-1.0 3.2%	-.7 2.4%	-4.0 2.6%	.0005
12f/11173 &14254	+.1 1%	-.5 1.8%	-.3 1%	-.3 1%	-.1 0%	-.9 1%	.005
13m/5655 &10673	-.6 2%	-1.2 4.2%	-.9 2.6%	-1.2 3.5%	-.8 2.7%	-4.7 3.0%	.0005
13f/10673 &12191	+.1 0%	-.4 1.4%	-.5 1.5%	-.5 1.6%	-.1 0%	-1.4 1%	.0005
14m/3895 &6365	-.7 2.4%	-1.3 4.5%	-.8 2.2%	-1.3 4.0%	-.7 2.3%	-4.8 3.0%	.0005
14f/7158 &9725	-.1 0%	-.4 1.4%	-.4 1.2%	-.6 2.9%	-.1 0%	-1.7 1.1%	.0005
15m/2507 &4103	-1 3.3%	-1.5 5%	-.8 2.2%	-1.5 4.5%	-.8 2.6%	-5.6 3.5%	.0005
15f/4705 &6251	-.1 0%	-.9 3%	-.6 1.7%	-1.3 4.0%	-.3 1%	-2.8 1.8%	.0005
16m/1811 &3006	-.6 2%	-1.2 4%	-.7 2.0%	-1.4 4.1%	-.9 2.8%	-5.0 3.1%	.0005
16f/3478 &4584	-.1 0%	-.4 3.4%	-.4 1%	-.8 2.4%	-.1 0%	-1.9 1.2%	.0005
Mean Male						2.9%	
Mean Female						2.3%	
Average						2.6	

Table 2. United States Verbal I.Q. Test Raw Score <u>Changes</u> between Two Time Period Samples (2006-2008 versus 2009-2015).

Age group	'08 mean	'08 s.d.	'08 num.	'15 mean	'15 s.d.	'15 num	'08-'15 score diff	% diff	t score	Sig. lev.
6	104.82	44.69	7384	100.68	42.09	5210	4.14	-3.9%	5.24	.0005
11	143.82	26.36	10072	145.48	25.20	13250	-1.66	+1.2%	4.88	.0005
16	159.47	25.61	4357	160.88	25.15	4453	-1.41	+1.0%	2.61	.005

Table 3 Pearson Product Moment Correlations (r) between Kids I.Q. scores and WHO air pollution data for first cohort of 110,457 children (2006-2008 cohort). Nations: Australia, Canada, Egypt, India, Ireland, Mexico, New Zealand, Pakistan, Philippines, South Africa, United Kingdom and United States. Over 5000 additional children from "other" nations could not be

included because their nations were not separated at that stage of the data collection. Note: "n.s." means *not statistically significant*.

1. Age	2. N	3. Mean total raw score	4. r total score with latitude,	5. Significance level,	6. r total score with latitude controlling for pollution	7. Sig. level	8. r total score with urban pollution, controlling for lat.	9. Sig. level	10. r total score with urban/ rural pollution controlling for lat.	11, Sig. level
6	7527	106.98	.003	.79 n.s.	-.002	.87 n.s.	-.0.01	.29ns	-.01	.24 ns
7	4819	117.22	.015	.31 n.s.	.000	.97 n.s.	-.03	.034	-.03	.038
8	5959	126.05	.05	.000	.021	.10 n.s.	-.06	.000	-.06	.000
9	6802	131.85	.03	.006	.001	.94 n.s.	-.08	.000	-.08	.000
10	10494	139.03	.03	.005	-.014	.16 n.s.	-.11	.000	-.11	.000
11	13234	143.91	.02	.05	-.012	.15 n.s.	-.08	.000	-.08	.000
12	16374	149.13	.01	.12 n.s.	-.023	.00	-.10	.000	-.10	.000
13	15553	151.94	.02	.007	-.013	.11 n.s.	-.10	.000	-.10	.000
14	10489	154.28	.03	.003	-.009	.38 n.s.	-.10	.000	-.10	.000
15	6838	157.51	.01	.30 n.s.	-.031	.01	-.13	.000	-.13	.000
16	5026	159.63	.07	.000	.018	.20 n.s.	-.14	.000	-.14	.000
17-26	1456	152.72	.12	.000	.038	.14 n.s.	-.17	.000	-.17	.000

Table 4 Pearson Product Moment Correlations (r) between Kids I.Q. scores and WHO air pollution data for second cohort of 178,038 children.

1. Age	2. N	3. Mean I.Q.	4. r total I.Q. with latitude,	5. Signifi-	6. r total I.Q. with latitude	7. Sig. level	8. r with urban pollution,	9. Sig. level	10. r with urban/	11, sig. level

				cance level,	**controlling for pollution**		**control-ling for latitude**		**rural pol-lution control-ling for lat.**	
5	5595	100.7	.047	.000	.042	.002	-.04	.002	-.04	.003
6	8223	100.5	.043	.000	.015	.19 (n.s.)	-.05	.000	-.05	.000
7	8657	100.5	.082	.000	.034	.002	-.09	.000	-.09	.000
8	10170	100.6	.10	.000	.012	.22 (n.s.)	-.16	.000	-.16	.000
9	11712	100.6	.13	.000	.019	.048	-.21	.000	-.21	.000
10	19511	100.6	.14	.000	.008	.27 (n.s.)	-.25	.000	-.25	.000
11	22854	101.0	.13	.000	.010	.15 (n.s.)	-.26	.000	-.26	.000
12	24340	100.7	.13	.000	.021	.001	-.27	.000	-.26	.000
13	20053	100.8	.10	.000	-.016	.023	-.26	.000	-.25	.000
14	16089	100.7	.10	.000	-.026	.001	-.28	.000	-.27	.000
15	10353	100.8	.12	.000	.003	.79 (n.s.)	-.25	.000	-.24	.000
16	7590	100.7	.15	.000	-.003	.78 (n.s.)	-.29	.000	-.29	.000
17-26	4517	101.7	.19	.000	.006	.68 (n.s.)	-.29	.000	-.29	.000