Environment and Intelligence

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Environment and intelligence research investigates the impact of environment on intelligence. This is one of the most important factors in understanding human group differences in IQ test scores and other measures of cognitive ability. Historically, there has been great interest in the field of intelligence research to determine environmental influences on the development of cognitive functioning, in particular, fluid intelligence, as defined by its stabilization at 16 years of age.

Neurobiological theory

As babies, our neuronal connections are completely undifferentiated. Neurons make connections with neighboring neurons, and these become more complex and more idiosyncratic as the child ages, up until the age of 16, when this process halts. This is also the time frame for development of what is defined in psychometric studies as the general factor of intelligence, or g, as measured by IQ tests. A person's IQ is supposed to be relatively stable after they have reached maturity.

The capacity of the brain to adapt its connections to environmental stimuli diminishes over time, and therefore it would follow that there is a critical period for intellectual development as well. While the critical period for the visual cortex ends in early childhood, other cortical areas and abilities have a critical period that lasts up through maturity (age 16), the same time frame for the development of fluid intelligence. So for a person to develop certain intellectual abilities, they need to be provided with the appropriate environmental stimuli during childhood, before the critical period for adapting their neuronal connections ends. It should be mentioned that some researchers believe that the critical period effect is a result of the manner by which intellectual abilities are acquired--that changes in neuronal connections inhibit or prevent possible future changes. However, the critical period is observed at approximately the same age in all people, no matter what level of intellectual ability is achieved.

Environmental influences

Sociocultural

Family

Having access to resources of the home, and having a home life conducive to learning, definitely affects scores on intelligence tests. However, it is difficult to disentangle possible genetic factors from a parent's attitude or use of language, for example.

Peer group

JR Harris suggested in The Nurture Assumption that an individual's peer group influences their intelligence greatly over time, and that different peer group characteristics may be responsible for the black-white IQ gap. Several longitudinal studies support the conjecture that peer groups

significantly effect scholastic achievement, but relatively few studies have examined the effect on tests of cognitive ability. There is some evidence that peer groups influence tests of cognitive ability, however.

Education

Education has a complicated relationship with intelligence; it is both a dependent and independent variable. On the one hand, those who did better on intelligence tests in their childhood tend to have a lower drop out rate, and complete more years of school, therefore making intelligence a predictive factor of how well someone will succeed in schooling. However, on the other hand, education has been shown to improve a person's performance on these intelligence tests, from a very young age.

Training and interventions

Research on the effectiveness of interventions, and the degree to which fluid intelligence can be increased, especially after age 16, is somewhat controversial. Fluid intelligence is typically thought of as something more innate, and defined as immutable after maturity. One recent article however, demonstrates that, at least for a period of time, fluid intelligence can be increased through training in increasing an adult's working memory capacity. Working memory capacity is defined as the ability to remember something temporarily, like remembering a phone number just long enough to dial it.

In an experiment, groups of adults were first assessed using standard tests for fluid intelligence. Then they trained groups for four different numbers of days, for half an hour each day, using an n-back exercise that worked on improving one's working memory. It supposedly does so through a few different components, involving having to ignore irrelevant items, manage tasks simultaneously, and monitor performance on exercise, while connecting related items. After this training, the groups were tested again and those with training (compared against control groups who did not undergo training) showed significant increases in performance on the fluid intelligence tests.

Environmental enrichment

Environmental enrichment affects cognition and intellectual development from a neurobiological perspective. In an experiment, four different habitats were set up to test how environmental enrichment or relative impoverishment affected rats' performance on various measures of intelligent behavior. First, rats were isolated, each to its own cage. In an second condition, the rats were still in isolation, but this time they had some toy, or enriching object in the cage with them. The third condition placed the rats in cages with each other, so they were receiving social enrichment, without any enriching object. The fourth and final condition exposed the rats to both

social interaction and some form of object enrichment.

In measuring intellectual capacity, the rats who had both forms of enrichment performed best, the ones with social enrichment performed second best, and the ones with a toy in their cage performed still better than the rats with no toy or other mice. When the volume of the rat's cortices was measured the amount of enrichment again correlated with larger volume, which is an indicator of more synaptic connections, and greater intelligence.

Biological influences

Nutrition

For period of time it was believed that prenatal malnutrition could lead to intellectual developmental deficits. However, through a study of Dutch males who were born during a wartime famine, it was demonstrated that short-term prenatal malnutrition had no relationship to intellectual development.

However, long-term, post-natal malnutrition can have a significant effect on intellectual development. This relationship has been harder to establish because the issue of malnutrition is often conflated with socioeconomic issues. However, it has been demonstrated in a few studies where pre-schoolers in two Guatemalan villages (where undernourishment is common) were given protein nutrition supplements for several years, and even in the lowest socioeconomic class, those children showed an increase in performance on intelligence tests, relative to controls with no dietary supplement.

Early nutrition can affect brain structures that are actually correlated to IQ levels. Specifically the caudate nucleus is particularly affected by early environmental factors and its volume correlates with IQ. In an experiment by Isaacs et al., infants born premature were either assigned a standard or high-nutrient diet during the weeks directly after birth. When the individuals were assessed later in adolescence, it was found that the high-nutrient group had significantly larger caudate volumes and scored significantly higher on verbal IQ tests. This study also found that the extent to which the caudate volume size related selectively to verbal IQ was much greater in male participants, and not very significant in females. This may help explain the finding in other earlier research that the effects of early diet on intelligence are more predominant in males.

Another study done by Lucas et al. confirms the conclusions about the importance of nutrition in the cognitive development of individuals born prematurely. It also found that the cognitive function of males was significantly more impaired by poorer postnatal nutrition. A unique finding however, was that there was a higher incidence of cerebral palsy in the individuals who were fed the non-nutrient enhanced formula.

Breast feeding has long been purported to supply important nutrients to an infant born premature,

and has been correlated with increased cognitive gains later in childhood. However, this effect has also been demonstrated for infants born at normal weight. When controlling for other environmental influences and maternal IQ, a study by Johnson et al. still found that the initiation of breast feeding predicted the scores of three year olds on intelligence tests. On average, breast feeding resulted in a 4.6 higher score on intelligence tests.

Exposure to toxic chemicals and other substances

Lead exposure has been proven to have significant effects on the intellectual development of a child. In a long-term study done by Baghurst et al. 1992, children who grew up next to a lead-smelting plant had significantly lower intelligence test scores, negatively correlated with their blood-lead level exposure. Even though lead levels have been reduced in our environment, some areas in the United States, particularly inner cities, are still at risk for exposing their children.

Furthermore, prenatal exposure to alcohol can greatly affect a child's performance on intelligence tests, and their intellectual growth. At high doses, fetal alcohol syndrome can develop, which causes mental retardation, as well as other physical symptoms, such as head and face deformities, heart defects and slow growth. It is estimated that 1 in 1,000 babies born in the general population are born with fetal alcohol syndrome, as a result of heavy use of alcohol during pregnancy.

However, studies have shown that even at slightly less severe doses, prenatal exposure to alcohol can still affect the intelligence of the child in development, without having the full syndrome. Through a study done by Streissguth, Barr, Sampson, Darby, and Martin in 1989, it was shown that moderate prenatal doses of alcohol, defined as the mother ingesting 1.5 oz. daily, lowered children's test scores by 4 point below control levels, by the age of four. They also showed that prenatal exposure to aspirin and antibiotics is correlated with lower performance on intelligence tests as well.

In another study, prenatal drug exposure was shown to have significantly negative effects on cognitive functioning, as measured at the age of five, compared again controls matched for socioeconomic status and inner-city environment. The researchers concluded that prenatally drug-exposed children are at greater risk for learning difficulties and attention problems in school, and therefore should be the subject of interventions to support educational success. It could be hypothesized that the effect of these drugs on the development of the brain prenatally, and axon guidance could be the root of the negative consequences on later deficits in intellectual development.

Specifically, prenatal exposure to marijuana affects development of intelligence later in childhood, in a nonlinear fashion, with the degree of exposure. Heavy use by the mother within the first trimester is associated with lower verbal reasoning scores on the Stanford-Binet Intelligence Scale;

heavy use during the second trimester is associated with deficits in composite, short-term memory as well as lower quantitative scores on the test; high exposure in third trimester associated with lower quantitative scores as well.

Perinatal factors

There is also evidence that birth complications and other factors around the time of birth (perinatal) can have serious implications on intellectual development. For example, a prolonged period of time without access to oxygen during the delivery can lead to brain damage and mental retardation. Also, low birth weights have been linked to lower intelligence scores later in lives of the children. There are two reasons for low birth weight, either premature delivery or the infant's size is just lower than average for its gestational age; both contribute to intellectual deficits later in life. However, the correlations are relatively small unless the weight is extremely low (less than 1,500 g) - then the effects on intellectual development are more severe and often result in mental retardation.

Development of genius

It has been hypothesized that the development of genius in an area results from early environmental exposure to the topic in which the "genius" has prodigious knowledge or skill. This is utilizing the definition of genius that is not just a significantly higher than average IQ score, but also having some type of exceptional understanding or ability in a specific field. Einstein is often used as an example of genius; he did not demonstrate generalized exceptional intelligence as a child, however there is evidence that he started exploring the ideas of physics and the universe at a young age.

This fits with the model of development of fluid intelligence before age of maturity because the neuronal connections are still being made in childhood. The idea is if you expose a child to concepts of, for example theoretical physics, before their brain stops responding to the environment in a plastic way, then you get exceptional understanding of that field in adulthood, because there was a framework developed for it in early childhood. However, Garlick proposes that early environmental experience with their field of genius, is necessary but not sufficient to the development of genius.

There are many environmental influences on intelligence, typically divided into biological and non-biological factors, often involving social or cultural factors. The commonality between these two divisions is the exposure in early childhood. It seems as though exposure to these various positive or negative influences on intelligence levels, defined as fluid intelligence, as measured most often by IQ tests, needs to happen early on in the development of the brain, before the neuronal connections have ceased forming.

Training

Training at an early age reduces synaptic pruning, which helps save neurons.

Musical

Early musical training in children is said to improve IQ. However, a study claimed that musical training improves verbal, but not spatial IQ. Significant differences in brain structure between musicians and non-musicians have been found.

Studies have shown that listening to Mozart before taking an IQ test will improve scores. This is called the Mozart Effect. The Mozart Effect improves spatial-temporal reasoning.

Chess

Studies have shown that chess requires auditory*(can't find this reference)-verbal-sequential skills, not visuospatial skills. A German study found that Garry Kasparov, a Soviet / Russian former World Chess Champion, regarded by many as the greatest chess player of all time, has an IQ of 135 and an extremely good memory. One study found that students who were taking a chess class improved mathematical and comprehension performance.