

Poverty, Development and the Brain

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Description

Poverty is not an easily defined entity. Many studies have used low Socio-Economic Status (SES) as a surrogate to study its effects. Children in poverty exist in both developing and developed countries. In the United States in 2014, 21% of all children younger than 18 years (15.5 million) lived in "poor" households (i.e. with incomes below 100% of the Federal Poverty Line [1]).

Cooper and Stewart showed that poorer children have worse cognitive, socio-behavioural and health outcomes not just because poverty is correlated with other household and parental characteristics, but in part because they are poorer, because money makes a difference to children's outcomes [2]. The authors showed that effect sizes associated with a US\$1000 increase in income (in 2013) ranged from 5% to 27% of a standard deviation for cognitive outcomes and from 9% to 24% for social and behavioural outcomes. Sirin et al. in a meta-analysis of socio-economic status and academic achievement, showed that the parent's location in the socio-economic structure has a strong impact on students' academic achievement and that family SES at the student level is one of the strongest correlates of academic performance [3].

Studies have shown that poverty affects children in 4 main ways: language and reading, memory, executive functioning (EF) and socio-emotional processing, all factors critical for school success.

Language is a key life skill; significant impairment has long lasting effects for both the child and the adult. Language development also depends on memory and executive functioning, which are both affected by poverty. Perkins et al. in a review of poverty and language, showed the effect on vocabulary, phonological awareness and syntax and reported that there was almost a full standard deviation of difference between the language of children from high and low SES [4]. Hart and Risley showed that word usage in the home was the single strongest determinant of child vocabulary growth, and that low language complexity in lower income homes was a major predictor of vocabulary growth in children [5]. By 26 months, the highest SES children had double the word types of those in the lowest SES. Ursache et al. on reviewing the studies on reading, suggested that among children at risk of reading difficulties, those from higher SES families may recruit alternate, possibly complementary neural networks to develop better reading skills [6]. High SES homes have rich Home Literacy Environments (HLEs, a composite score of literacy activities, maternal engagement and learning materials), with the reverse true in low SES homes [4]. 70% of children with high stable HLEs performed at or above the national norms for language and literacy skills at prekindergarten compared to only 7% of those with low HLE scores [7].

The Centre for the Developing Child has reported that there is a set of underlying core capabilities that adults use to manage life, work, and

parenting effectively [8]. These include, but are not limited to: planning, focus, self-control, awareness, and flexibility. These come under the umbrella of EF skills. These skills are supported by the prefrontal cortex and are "as important for early success in school as general intelligence" [9]. Lawson et al. in their meta-analysis of SES and EF in children showed the presence of SES disparities in EF that were between small and medium in size [10]. Children's EF skills have been shown to be robustly predicted by chronic exposure to poverty and to environmental hazards associated with poverty [11]. Low SES tends to be associated with worse performance on memory tasks, and individuals of higher SES are reported to recruit additional neural resources, which may buffer age-related decline [6]. Among middle school youth, low income predicted learned helplessness, significantly affected youths' self-report of psychological distress and teachers' ratings of self-regulatory behaviour [12].

There are now numerous studies demonstrating the differences in brain structure and function in areas between children from high and low SES. Noble et al. showed that family income was significantly associated with total surface area, with the strongest relationships in bilateral inferior temporal, insula and inferior frontal gyrus, and in the right occipital and medial prefrontal cortex—regions linked with various language and executive functions [13]. Emotional processing and cognitive control over emotion which are central to self-regulation are affected by the development of the amygdala, hippocampus and PFC which work together to regulate emotion, which is also important for language development. Hanson et al. have shown the relationship between income and total hippocampal gray matter, an area important for learning and memory [14]. Kim et al. showed that adults with lower family income at age 9 had reduced ventrolateral and dorsolateral prefrontal cortex activity and failure to suppress amygdala activation at age 24 [15]. Both areas are important for stress and emotional regulation. Poor cognitive and academic performance among children in poverty has been shown to be mediated by a small hippocampus and frontal and temporal lobes [16]. The decrease in volume of the latter 2 explained as much as 15% to 20% of the achievement deficits found. Children from low income families have also been shown to have slower trajectories of growth during infancy and childhood, with volumetric difference associated with the emergence of disruptive behavioural problems [17]. They also had lower volumes of gray matter (tissue critical for the processing of information and execution of actions) in both the frontal and parietal lobes.

Noble et al. have showed that this relationship between poverty and the brain is not linear but logarithmic. Income related most strongly to brain structure among the most disadvantaged children; for every dollar increase in increased income, the increase in children's brain surface area was proportionally greater at the lower end of the spectrum [13]. The proportion of IQ variance attributable to genes and environment has also been shown to vary non-linearly with SES [18].

The effect on brain function has been seen in early infancy. Tomalski et al. found socioeconomic disparities in frontal gamma power in infants as young as 6-9 months, pointing to very early risk for language and attention difficulties [19]. Gao et al reported that marginally significant positive SES-brain correlation was observed at 6 months of age for both the sensorimotor and default-mode networks, indicating SES effects on functional brain maturation [20].

Lipina summarized the available literature in 3 statements [21]:

- The different experiences of adversity related to poverty are associated with changes in the structure and function of neural systems that are related to cognitive and emotional regulation, language and learning skills. The authors cautioned against concluding that changes represent deficits or dysfunctions, that such findings are irreversible or that correlational evidence equalled causality.
- These influences could occur at different times during human development.
- The hypothetical mechanisms through which these changes occur involve different factors that are related to childcare through the quality of language environments and through cognitive stimulation and emotional support at home and in education contexts.

Can the trajectory of these children in adversity be changed so that they have a better chance of success? There have been numerous programs to reduce the adverse outcome of poverty on children, which have shown various positive effects. High quality care giving is a key strategy; it can “serve as a key lever of change through which effects of disadvantageous experience on biology and behaviour can be altered” [22]. Bann et al. showed that a home-based parent implemented early developmental intervention from 1-36 months of age resulted in significantly higher scores in the Mental Development Index than the control group [23]. Several early childhood programs have reported good success. The Chicago School Readiness Project, a multicomponent trial implemented in 35 Head Start centers suggested significant benefits on children’s pre-academic skills, as measured by vocabulary, letter-naming and maths skills [24]. The Perry School Project was a 2-year preschool intervention for disadvantaged children. At 40 years of age, the treated group had higher rates of high school graduation, higher salaries, higher percentages of home ownership, lower rates of welfare assistance as adults, fewer out of wedlock births and fewer arrests than controls [25]. The children in the Abecedarian project in North Carolina, a randomized controlled trial of early childhood education for children from low-income families were followed up at 30 years of age [26]. There were significant and moderately large educational gains, with treated individuals having 13.46 years of education and compared to 12.31 years in the controls. 23% had Bachelor’s degrees compared to 6% of the controls. 75% worked full time compared to 53% of the controls. The odds of being the head of one’s own household were almost twice as high for the treated group. The probability of needed public welfare in the control group was more than 6 times that of the treated group. Other programs have shown various levels of success. These include the early identification of families in need of services, home visiting, nutrition support, early childhood education, access to comprehensive health care and tax policies and direct financial aid (from poverty and child health in the USA) [1]. Bringing all the critical components together requires coordinated public policy measures, which is a huge challenge. However, to bridge the achievement gap between the children from high and low SES and possibly to protect the next

generation from the same adversity, it is a public health step that needs to be taken.

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