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The importance of early developmental neuroscience for research, practice, and policy

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The most intense rhythm of brain maturation in humans occurs in early childhood – the period between zero and 5 years of age. Such significant structural or functional development is not observed at any other homologous period throughout the lifespan. From a simple tubular structure in the foetal period (the neural tube), in a few years the brain develops a highly complex cytoarchitecture (Dubois et al., 2021; Ouyang et al., 2019). Its size also increases significantly, with the brain of a 6-year-old having nearly the volume (95%) of the adult brain (Lenroot & Giedd, 2006). In addition, early childhood is the most productive period in creating new synapses – for example, reaching 15,000 connections per neuron between 2-3 years of age – twice as many as the amount observed in adults (Huttenlocher, 1979). Brain metabolism also peaks at 200% of the adult pattern at about 4 years of age (Chugani, 1998). These maturational phenomena are the foundation of a child's physical and mental health, determining longevity and the ability to learn from contextual changes and adapt to them (Cruz et al., 2020; Sampaio & Lifter, 2014). In turn, these phenomena are influenced by an array of genetic and environmental factors. As described by the National Scientific Council on the Developing Child (2012, p. 1), "experiences 'authorize' genetic instructions to be carried out and shape the formation of the (brain) circuits as they are being constructed". This sentence illustrates how early experiences may be biologically embedded in the development of multiple systems, including long-term impacts on the brain. More specifically, experiences associated with caregiver psychopathology, neglect, poverty, or social exclusion both pre and postnatally have been shown to compromise optimal brain development (McLaughlin et al., 2011). Finally, the early years are an open window of susceptibility to experience, making it a period of heightened sensitivity and plasticity to the effects of both positive and negative biological and psychosocial experiences on the developing brain (Black et al., 2017; Fox et al., 2010), highlighting the need to implement intervention programmes as early as possible.

Recent evidence shows that approximately 43% of children younger than 5 years living in low or middle-income countries, such as Brazil, are at risk of failing to reach their developmental potential due to extreme poverty and stunting (Black et al., 2017). Indeed, advances in early developmental neuroscience have provided robust evidence on how poverty and other early adverse experiences have long terms effects on brain development and, consequently, on the development of early social, emotional, and cognitive abilities (Luby, 2015; Noble et al., 2015; Shonkoff & Garner, 2012). These will, in turn, affect health and development prospects throughout the life cycle (Weaver, 2014).

From an economic viewpoint, the studies by James Heckman and his team strongly support the investment in the early years rather than remedial interventions later in development (Heckman, 2008). Their studies were unequivocal in documenting that early intervention programs targeted towards socioeconomically disadvantaged young children are estimated to have high cost-benefit ratios, with no equity-efficiency trade-off – i.e., increasing economic efficiency while reducing lifetime inequality –, contrasting with the programs targeted toward later years, usually associated with lower economic efficiency and lower rates of return (Doyle et al., 2009; Heckman, 2008, 2012). Specifically, interventions in infancy have the potential to promote multiple personal and social benefits as well as government savings, such as sustained economic efficiency, reduced delinquency, reduced lifetime inequality, increased opportunities in terms of educational attainment, quality of learning and work productivity, and better developmental outcomes such as improved physical and mental health and decreased mortality and morbidity (IOM/NCR, 2014; Shonkoff, 2010). Recently, evidence pointed to intergenerational gains, with the children of those that directly benefited from these programs in early childhood also presenting better outcomes (Heckman & Karapakula, 2019). Taken together, the evidence summarised here not only highlights the strategic importance of promoting optimal early childhood development but also the urgency of investing in the scientific study of the brain in this critical period of human development.

The relatively new area of developmental neuroscience is beginning to change the way we think about development in early childhood as well as early childhood development interventions. As separate fields of study come together, we gain more knowledge on how the brain matures, brain-behaviour relationships, and what factors may promote or hinder optimal human development, particularly in more socioeconomically disadvantaged contexts. In turn, developmental neuroscientists must also embrace their responsibility of synthesizing the most up-to-date knowledge, translating it into accessible language, and transferring this evidence-based knowledge from research to policy and practice (Shonkoff & Bales, 2011).

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