





Effects of intervention programs on neural outcome measures in children from low-socioeconomic-status homes

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Executive Summary

Neural plasticity is the capacity of our brains to change according to our experiences in our environments. Our brains adapt to our contexts.

Living in an environment characterized by poverty, in comparison with living in a wealthier environment, has been associated with brain differences.

Recent evidence has shown that we can see neuroplastic changes as a result of interventions for children from low-socioeconomic-status homes.

As our brains adapt to the context of poverty, if that context changes (for example, through cognitive training or economic intervention), our brains will adapt to the new context.

Teachers and policymakers who work with low socioeconomic status students should know that children living in poverty are not "irrecoverable"; research evidence shows that interventions mitigate poverty effects.

Neural plasticity: adaptation to experiences

Neural plasticity is the ability of the central nervous system to change according to experience[1]. Far from the old idea that the brain is immutable, neuroscience has a long tradition showing how the brain adapts through reorganizing pathways, creating new connections among neurons (one type of brain cell), and even generating new neurons (see https://solportal.ibe-unesco.org/articles/neuroplasticity-for-better-and-for-worse/). The concept of neural plasticity is central for neuroscientists and educators, as most learning involves rewiring or making and strengthening connections between neurons (see https://solportal.ibe-unesco.org/articles/neuroplasticity-how-the-brain-changes-with-learning/) Plastic changes are, in short, brain adaptations to life experiences, whatever those experiences are.

Neuroscience of poverty and wrong interpretations of findings

Neuroscience studies have revealed functional and structural brain characteristics associated with living in poverty (https://solportal.ibe-unesco.org/articles/adverse-environments-for-disadvantaged-development-and-learning-which-brain-systems-are-most-impacted/). It is important to emphasize the word "associated": It means that living in poverty tends to be correlated with certain ways of brain functioning or structure, but we do not know whether poverty causes or fully determines that. It could be the case, for example, that some of the neural correlates are caused by a "third variable" (a factor not included in poverty but associated with poverty, such as stress). Further, "associated" means that the differences in brain function and structure apply across groups in general but do not necessarily apply to any one individual in a group specifically. That is, we cannot assume based on this research that a specific child in our classroom who comes from a poorer household (or a wealthier household) would show a specific pattern of brain structure or function. Also, and of main importance for education, we do not know whether the neural correlates of poverty are the cause of any of the behavioral outcomes associated with poverty (lower scores in cognitive tests and lower academic achievement). Even more caveats to consider to not accidentally wrongly interpret this body of research: Most of the studies were conducted in the US (so we do not know if the results would be replicated in other populations), most of the studies have involved only one measure at one point in time (so we do not know whether results will vary across time), and very few of the studies (less than 5%) have used outcome measures related to learning, which would be of particular interest to educators[2].

As described in another brief in this series (see

https://solportal.ibe-unesco.org/articles/poverty-and-neuroethical-implications-for-teaching-inclusion-and-educational-pract ices/), brain differences between people in low- and high- socioeconomic (SES) contexts were initially interpreted as lower intelligence or a deficit in low-SES people, but now there is general scientific agreement that these differences should be understood as an adaptation to everyday life in a low-SES context. Unfortunately, the wrong interpretation is still present in scientific discourse (e.g., [3,4]) as well as in policymakers' discourse[5]. This false belief can have detrimental effects in education: Consider how a teacher who believes that their brains are permanently damaged would approach educating children in poor populations, as compared to a teacher who believes (correctly) that brains can change to adapt to environments, like the school environment? Where are policymakers investing if they wrongly believe that poor children's brains are irrecoverable?

While acknowledging both the importance and the limitations of this body of research, neural correlates of socioeconomic

status (SES) have been documented by approximately 100 studies conducted over the last two decades that have compared the brains of people living in low and high SES contexts_[2]. Evidence from these studies shows that poverty_[10] is associated with structural and functional changes in the brain, mainly in systems related to attention, executive functions, cognitive and emotional self-regulation, language and memory (see

https://solportal.ibe-unesco.org/articles/adverse-environments-for-disadvantaged-development-and-learning-which-brain-sy stems-are-most-impacted/). For example, Tomalsky and collaborators_[6] measured electrical brain activity in 6- to 9-month-old awake babies and observed that brain activity (measured with an electroencephalogram while babies were resting) was significantly lower in infants from poor homes, in comparison with infants from high socioeconomic status homes. This study revealed that, from an early age, socioeconomic status has functional brain correlates in brain areas related to language and attention, although it does not explain whether those correlates are for the better or the worse.

Interventions with neural outcomes used with children from low-SES homes

Knowing that children from low- and high-SES homes tend to show brain differences is important, but even more important is knowing whether neuroplasticity allows for further brain changes that help children adapt to the learning environment of the classroom. In this section, we focus on intervention studies with low-SES children analyzing neural outcomes. Traditional intervention studies with low-SES children have shown a positive impact on behaviors (see [7,8] for reviews), but have left open the question of neural changes with intervention.

Brain and behavioral outcomes of cognitive intervention in low-SES children

The first study to show that behavioral intervention (cognitive training) can lead to functional brain changes in poor children was conducted in the US, with low-SES preschoolers and their parents/caregivers_[9]. This study tested whether the combination of child attention training and an 8-week training program targeting attention by teaching parents to engage with their children would change the children's brain functioning and academic achievement. The children were divided into three groups. In the first group of 66 children, the experimental group, parents/caregivers participated in a 2-hour, small-group training session each week for 8 weeks. These sessions addressed strategies for family stress regulation, contingency-based discipline (reinforcement to encourage skill acquisition), parental responsiveness (i.e., high sensitivity to children's needs), language use, and facilitation of child attention. Over the same 8-week time period, the children participated in small-group training activities aimed at improving the regulation of attention and emotional states, carried out during weekends or after school. The second group of 38 children received regular preschool education but no supplemental activities and their parents received no training for the 8 weeks. The third group of 37 children received another type of attentional training for the same amount of time as the first group, but here children were trained directly (not trough parents) in small groups during school time.

Children in the three groups were evaluated before and after the 8-week period with behavioral measures (standardized laboratory assessments of nonverbal IQ, receptive language, and pre-literacy skills) and a neural measure of attention using electrical brainwave recording (called event-related potentials or ERPs). At the end of the 8-week period, the experimental group receiving the parent and child interventions not only had higher scores on the standardized measures of language and intelligence but also showed greater change in the neural attentional response (i.e., children's brain functions supporting selective attention increased more in the ERP task after intervention in the experimental group than in the other two comparison groups). Thus, neural attentional processes are modifiable – through parent/caregiver and child training – in low-SES preschoolers.

Neural outcomes of an economic intervention in low-SES families

The findings from a recent study are even more surprising in terms of demonstrating how functional plasticity allows the brain to adapt to the environment [10]. This study with 435 mother-infant dyads examined changes in brain activity after a purely economic intervention; that is, the researchers explored whether simply giving money to low-SES mothers of infants would be associated with brain changes in the babies. In this study, mothers who had just given birth were randomly divided into two groups: one group was given a low monthly amount of money (USD 20, which is not enough to cover basic needs) and the other group was given a high monthly amount of money (USD 333). The mothers did not have to do anything in exchange for receiving this money, only to participate in the study. Thus, the study design was analogous to what is sometimes called an "unconditional cash transfer program". A year later, each baby had their brain activity recorded while they were at home, in a resting state. Infants in the group with mothers who had received the larger amount of money each month had greater activity over frontotemporal brain regions (areas linked to language and cognition) in comparison to infants in the group

whose mothers had received the smaller amount of money each month. For infants in low-SES households, brain activity can be changed by reducing poverty.

Concerns and significance of neural correlates of intervention

The studies reviewed here (still few, but being the available evidence) showed how conducting specific cognitive or economic interventions can change function in low-SES children's brains. Further, other studies have showed that children from lower-SES families were more likely to benefit from the intervention than children from higher-SES families no only behaviorally but also neurally[11]. It is not strange to hear the myth that children living in poverty are "irrecoverable" and to hear that that claim is supposedly based on neuroscience evidence. Far from that, the studies reviewed here show that, as the brain adapts constantly, specific interventions that change the child's environment and experiences can also change the child's brain. This is an important message for educators and policymakers working with low-SES students: neuroscience has shown that our brains adapt to our environments, to experiences such as living in poverty as well as to experiences such as educative or economic interventions.

These studies measured poverty as family income. It is important to highlight that family income refers to monthly or annual total income but does not specifically address child poverty. Given the same income, some families can designate more of it to children than others, and a family income measure does not address those potential differences. However, family income is still considered a good proxy for child poverty.

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