



# **AN EXPLORATION OF THE INFLUENCES OF CHILDHOOD SOCIOECONOMIC STATUS ON NEURAL DEVELOPMENT AND FUNCTIONING**

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## **Abstract**

The review of literature examines the relationship between socioeconomic status and neurological development according to current studies. This article specifically investigates how the socioeconomic status of childhood influences the development of the brain and cognitive functioning even into adulthood. The measurements of socioeconomic status like education, household income, and neighborhood demographics are each found to independently influence neural development, thus affecting cognitive functioning. This article investigates how factors of socioeconomic status affect specific brain structures and cognitive functions. Low socioeconomic status was found to negatively impact neural development and hinder cognitive abilities and growth. High parental education specifically is linked to greater cognitive functioning and skills as it contributes to greater cognitive enrichment in the home and healthier habits like nutrition. The volume of brain structures like the amygdala, hippocampus, prefrontal cortex, overall surface area, and cortical thickness of the brain are all impacted by socioeconomic measures. Socioeconomic stressors are associated with poor behavioral outcomes, attention deficits, poor language, and weakened executive functioning. Neighborhood quality contributes greatly to socioeconomic stressors which have an impact on brain reactivity, behavioral intensity, and selective attention. Racial and ethnic minorities are often disadvantaged in neighborhood quality and overall socioeconomic status. Various studies expound upon the significant relationship between the socioeconomic status and neurological development of racial and ethnic minorities. Journal articles, empirical studies, etc. propose home, school, and policy-based interventions to bridge the developmental gaps between low and high-socioeconomic standing children and adolescents. Such studies can be applied to educational modifications and other forms of cognitive enrichment.

## **Keywords**

Socioeconomic Status, Neurological Development, Cognitive Development, Brain Structures, Education, Stress, Amygdala, Hippocampus, Prefrontal Cortex, Cortical Thickness, Surface Area, Brain Volume, Household Income, Poverty, Neighborhood Demographics, Behavior, Attention, Language, Executive Function, Social Demographic

## **Introduction**

The purpose of this review of the literature is to find if there is a relationship between socioeconomic status and neurological development. The intended study population was children and adolescents; however, the neural developmental setbacks continue into adulthood. A greater understanding of this topic is needed when addressing educational modifications and other ways of addressing cognitive deficits and neural developmental setbacks. An understanding of how measures of socioeconomic status directly affect each aspect of neural development can explain the relationship between the independent and dependent variables as a whole. Factors of low socioeconomic status are especially related to neurological deficits, cognitive setbacks, poor development of brain structures, and overall impaired neurological functioning.

## **Measures of Socioeconomic Status**

Studies measuring socioeconomic status and its impact on neurological development conducted in the United States used a combination of ways to define and measure socioeconomic status. According to Dennis et al. (2022), the highest parent education level and household income tend to be the best way of measuring socioeconomic status.

Socioeconomic status describes poverty, education, employment, and depravity measured through the area deprivation index, parental education, and household income (Dennis et al., 2022). Judd et al. (2020) approached socioeconomic status by viewing financial stressors and neighborhood stereotypes. Maternal education, marital status, and income were used in the measure of socioeconomic status (Wickremasinghe et al., 2012; Li et al., 2021). The income-to-poverty ratio (IPR) was used to measure socioeconomic status (White et al., 2022). The comparison of income to poverty, social demographics like education and occupation, and neighborhood characteristics were measured to determine how they affect neurological development.

Household income and poverty thresholds were used as a way of measuring socioeconomic status and were directly associated with neurological development and functioning. The socioeconomic demographic was determined by the parent's education level, marital status, bilingual use, size of household, area depravity index, and crime rates/history (Pat et al., 2022). Parent education was not directly related to cortical thickness; however, income was greatly related to cortical thickness and impaired functioning (Noble et al., 2015). Household income was greatly correlated with greater hippocampus volume and better-developed prefrontal cortex (Taylor et al., 2020). High income-to-poverty ratios were found to be directly related to the development of specific brain structures that other measures of socioeconomic status were not associated with.

International studies defined socioeconomic status in similar ways to studies conducted in the United States. Kaplan et al. (2001) measured socioeconomic status through maternal education and paternal occupation. Another study measured parental education, family structure, careers, and income of the US poverty threshold (Chin-Lun Hung et al., 2015). Despite being an international study, the US poverty was still used to measure socioeconomic status. International studies reviewed mainly focused on education, occupation, and other social demographics.

Neighborhood quality combines income measures of socioeconomic status and social demographics of parents to understand how it affects neural development. This study argues that neighborhood context explains aspects of developmental differences that socioeconomic status as a whole does not address (Taylor et al., 2020). High neighborhood poverty was greatly related to decreased volume in the right and left hippocampus regions and the prefrontal cortex (Taylor et al., 2020). Children of low socioeconomic status often struggle in their development because they feel unsafe in their neighborhood or often change neighborhoods (George et al., 2021). Even if households are not necessarily in poverty, when children are in neighborhoods of high poverty and/or low quality, they weaken the development of brain structures and ultimately functioning.

Socioeconomic status was found to have a significant relationship with neurological development, but it can be difficult to differentiate between racial/ethnic differences. Racial/ethnic differences greatly contribute to socioeconomic status, thus affecting development as a result of structural racism (Taylor et al., 2020). White children had a much greater income-to-poverty ratio when compared to black and Hispanic participants (White et al., 2022). Racial discriminatory trauma is associated with neural development (Assari et al., 2020). Racial and ethnic minorities were less likely to have larger amygdala volume, even with higher socioeconomic status; so, there are inconsistencies in results regarding socioeconomic status and how it directly impacts neurological development (Assari et al., 2020). Racial and ethnic differences contribute to changes in neurological development, but research is unsure how measures of socioeconomic status as a whole directly affect brain development when considering these differences.

Marital status and social status were used as a way of measuring socioeconomic demographics and then further researched in the studies to identify relationships with cognitive and neurological development. This study used maternal education and marital status as a way of defining socioeconomic demographics (Wickremasinghe et al., 2012). Parents' social status in their community influenced the outcomes of the study (Li et al., 2021). In an international study in Mexico, parent education levels in private schools were greater than those of public schools (Ardila et al., 2005). Not only was income a measure of socioeconomic status, but higher social standing and marital status were marked as high socioeconomic status.

### ***Cognitive Enrichment***

Parent education was shown to have a strong relationship with the cognitive development and functioning of their child/children. Higher socioeconomic status backgrounds consistently show greater connectedness of cognitive functioning because of parental education and the parent's involvement in their child's cognitive development (Tooley et al., 2021). Cognitive differences were mainly driven by parental education as they often provide more cognitively invigorating environments; education and income also relate to diet and stress (Judd et al., 2020). Maternal education especially was used as a measure of socioeconomic status, which greatly impacted selective attention and overall cognitive functions (George et al., 2021). Higher parent education correlates with factors that positively influence cognitive development and strengthen cognitive functioning.

Parent education not only influences the growth and development of cognitive functioning in children but also influences the development of their brain structures. socioeconomic status can alter amygdala volumes, specifically less parental education is associated with greater amygdala size (Pluck et al., 2020). Studies showed that normal cortical thickness and of gray matter were possibly impacted by greater parental education (Dennis et

al., 2022). Greater parental education is linked to positive neurological structures and outcomes in developing children.

Communities and households that fail to provide adequate cognitive enrichment for children (often found in that of low socioeconomic status) correlate with poor cognitive functioning and weakened neural processes. The study conducted by Assari et al. (2020) found that minority families do not have equal access to cognitive enrichment, thus resulting in lower cognitive scores and brain volume (Assari et al., 2020). Judd et al. (2020) concluded that education level regarding socioeconomic status showed twice as strong of an impact on working memory and cognitive functioning. socioeconomic status holds a similar relationship with working memory as education and IQ (Judd et al., 2020). Neighborhoods of high poverty often fail to provide cognitive enrichment, thus weakening cognitive functioning (Taylor et al., 2020). Because low socioeconomic status is linked to poor cognitive enrichment, children and adolescents of low socioeconomic status are not given opportunities that stimulate their cognitive development and necessary growth.

### ***Cognitive Development***

Overall cognitive functioning of children and adolescents with low socioeconomic status was linked to obstacles hindering and slowing down the process of cognitive development. Lower socioeconomic status was found to quicken cortical thinning which results in decreased functioning and slower development of cognitive abilities (Tooley et al., 2021). The "age" of the brain is higher at a young age, yet the children are slow to develop cognitive abilities (Rakesh et al., 2023). Despite the age of the brain being higher, low socioeconomic status hinders the proper development of cognitive processes and abilities.

Socioeconomic status (socioeconomic status) greatly influences neurological development, specifically regarding the cognitive functionality of adolescents. In a study with participants ranging from age three to twenty, Noble et al. (2015) found that household income (a measure of socioeconomic status) is greatly linked to impaired cognitive functioning through changes in the surface area of the brain. Another study conducted in 2020 found that the cognitive functioning of the prefrontal and the right hippocampal regions were heavily affected by household income (Taylor et al.). In both studies, lower socioeconomic status was associated with impaired cognitive functioning.

Cognitive flexibility, including the ability to adapt to change and make decisions, is negatively affected by low socioeconomic status. As socioeconomic status influences the development of the prefrontal cortex and hippocampus, children struggle with cognitive flexibility and working flexibly in school (George et al., 2021). Lower socioeconomic status was associated with poor decision-making processes and variations (White et al., 2022). The reaction to change requires cognitive flexibility that children of low socioeconomic status lack.

Cognitive connectedness impairments were associated with low socioeconomic status. Higher socioeconomic status backgrounds consistently show greater connectedness of cognitive functioning and brain development when compared to those of low socioeconomic status (Tooley et al., 2021). Participants of lower socioeconomic status were less likely to filter through irrelevant information and struggled with their selective attention (Stevens et al., 2021). A lower income-to-poverty ratio was associated with lower connectedness between reward and loss of information/cues (White et al., 2022). Socioeconomic status can damage neurological processes and result in poor cognitive connectivity.

Socioeconomic status correlates with poor situational awareness and struggles in interpersonal relationships specifically relating to theory of mind. Impaired language affects how children view one another (theory of mind) (Pluck et al., 2020). Low-socioeconomic status students are expected to fall behind their wealthier peers (George et al., 2021). Researchers found a strong relationship between socioeconomic status and how students interact with others and read situations (Ardila et al., 2005). The way that students/children view one another and view situations is greatly influenced by their socioeconomic status and that of others.

Working memory was found to be one of the most prominent impairments of cognitive and neural development of low socioeconomic status. The greatest impact on the brain found in a study conducted by Dennis et al. (2022) was working memory rather than overall executive functioning and control. Chronic stress often involved in low socioeconomic circumstances significantly impacts the child's working memory (Dennis et al., 2022). Higher socioeconomic status samples were shown to have greater memory performance (Piccolo et al., 2014). Greater socioeconomic standing demonstrated higher levels of working memory compared to low socioeconomic status.

The stress of low socioeconomic standing can lead to poor executive functioning. Higher cortisol levels of low socioeconomic status contribute to impaired executive functioning (Piccolo et al., 2014). The stress of poverty (along with the pandemic) greatly hinders executive functioning (George et al., 2021). Verbal executive functioning was impacted more than non-verbal executive functioning by parental education (Ardila et al., 2005). The higher amount of cortisol released in the brain and education hinders the intended development of executive function.

Low socioeconomic status is greatly associated with poor language skills and processing. Lower socioeconomic status was found to have impaired language ability (i.e. speaking, literary skills, etc.) based on MRI technological evidence of areas of the brain most prominently affected by socioeconomic status (Tooley et al.,

2021). Because household income significantly impacts the prefrontal cortex, children may show impairments in language processing, especially when forming sentences/verbal communication themselves (Taylor et al., 2020). Parent education was found to most impact verbal executive functioning, particularly regarding the types of language used (Ardila et al., 2005). Low socioeconomic status measures such as parent education and income relate to changes in brain structures that directly function for language processing/operation and the way language is used/formed.

Low socioeconomic status is linked to poor attention skills. Participants of low socioeconomic status struggled with selective attention and often were unable to categorize irrelevant and relevant information (Stevens et al., 2021). Higher maternal education participants gave greater levels of attention during working memory tasks (Li et al., 2021). Lower income-to-poverty ratios correlated with greater attention to rewards and losses (White et al., 2022). Children of low socioeconomic status struggle with selective attention which impacts task performance; yet, attention to rewards and losses is heightened in the cognitive focus.

Childhood socioeconomic status greatly influences neural deficits even into adulthood. Kaplan et al. (2001) present that there is a correlation between childhood socioeconomic status and a higher risk for dementia/Alzheimer's and poorer cognitive function in adulthood. The study showed a relationship between socioeconomic status and cortisol levels in adulthood, especially affecting verbal communication and attention (Piccolo et al., 2014). The impaired neurological development due to low childhood socioeconomic status can lead to cognitive deficits into adulthood.

### ***Socioeconomic Stress***

As overwhelming amounts of stress negatively affect the brain, children are exposed to socioeconomic stressors. Socioeconomic stressors include: not feeling safe in their community, little to no family support, violence, poor access to nutrition (George et al., 2021). Changes in brain structures are greatly related to stressors/exposure to family stress (Noble et al., 2015). The added stressors associated with low socioeconomic status contribute to changes within brain structures.

The fewer resources associated with low socioeconomic status, including nutrition, directly affect brain development. Lower socioeconomic status households are less likely to have adequate food and water sources (George et al., 2021). Changes in brain structures are greatly related to toxins and poor nutrition (Noble et al., 2015). Higher neighborhood poverty can lead to exposure to toxins (Taylor et al., 2020). Poor nutrition and exposure to toxins related to neighborhood poverty are detrimental to neural development.

Socioeconomic status is strongly associated with more aggressive brain reactivity and fewer options for response. The stress triggers of low socioeconomic status showed stronger brain reactivity (Piccolo et al., 2014). Researchers found that higher socioeconomic status could be related to a broader spectrum of brain responses and predictability by age five (Sullivan et al., 2024). A lower income-to-poverty ratio showed greater reactivity in various brain regions, especially regarding rewards and losses (White et al., 2022). Low socioeconomic status is connected to poor and aggressive ways of brain reactivity especially compared to that of children of high socioeconomic status.

Through a review of various studies, children of low socioeconomic status struggled behaviorally with failure of emotional regulation. Low socioeconomic status children have a more difficult time regulating stress and their responses to stress (Chin-Lun Hung et al., 2015). Samples with higher socioeconomic status did not react as intensely to stress (Piccolo et al., 2014). Stress as a result of poverty and the pandemic impair emotional regulation (George et al., 2021). Participants with low income-to-poverty ratios demonstrated worse behavioral performance in tasks compared to children with higher socioeconomic standing (White et al., 2022). Emotion regulation and behavioral responses were healthier amongst higher socioeconomic status.

### ***Maternal/Prenatal Influences***

Low socioeconomic status greatly increases stress especially during pregnancy, thus impacting the development of the child. Assari et al. (2020) found that maternal stress was greatly associated with amygdala volume in their children. Prenatal stress often impacts the diets of the mothers. Mothers may ingest toxins and glucocorticoids that increase the risks of premature delivery; premature delivery greatly increases risks for cognitive impairments (Judd et al., 2020). The socioeconomic stressors felt by mothers are associated with developmental delays and impairments in their children.

Low socioeconomic status stressors and factors contribute to poor prenatal neural development. Low socioeconomic status was related to increased probability of chronic hypoxia, placental hypertrophy, and prematurity; all of which are related to increased cognitive impairments (Chin-Lun Hung et al., 2015). Unmarried women with low education levels were described as more likely to have children with cognitive disabilities (Wickramasinghe et al., 2012). Wickramasinghe et al. (2012) suggests the combination of neurobiological and socioeconomic factors to predict cognitive risks. Measuring socioeconomic status can help predict developmental risks because low socioeconomic status relates to weakened neural formation.

### **Brain Structures**

Despite the slower cognitive development discussed previously, low socioeconomic circumstances quicken aging for the brain. Low socioeconomic status circumstances display a steeper curvilinear decrease in cortical thickness at younger ages than high socioeconomic status backgrounds; researchers theorize that the quickened thinning of cortical thickness (maturation) is caused by stressors of low socioeconomic status (Tooley et al., 2021). The "age" of the brain is higher at a young age due to quicker cortical thinning (Rakesh et al., 2023). Stressors and cortical thinning of low socioeconomic circumstances contribute to accelerated aging of the brain.

Socioeconomic status affects overall brain structures within neurological development. MRI technology showed that no particular brain structure was especially affected by socioeconomic status, but there were noticeable differences in volume/overall surface area (Judd et al., 2020). Neurological abnormalities, including hard and soft signs, were prevalent in those of low socioeconomic status from four months of age to seven years old (Chin-Lun Hung et al., 2015). Children of low socioeconomic status are shown to have impaired/abnormal brain structures, thus creating shifts in proper neural development.

In this review of literature, cortical thickness was a very common theme across many research studies. Cortical thickness decreases socioeconomic status with time, but especially quickly in children of low socioeconomic status. Research claims that cortical thickness declines rapidly during childhood and plateaus in adulthood in children of low socioeconomic status (Noble et al., 2015). In a study by Tooley et al. (2021), cortical thickness was greatly decreased in children with low socioeconomic status; these findings are based on multiple age groups of children and adolescents. These findings are also consistent with children of high socioeconomic status. Children with higher socioeconomic status showed greater cortical thickness especially in the prefrontal cortex of the brain (Dennis et al., 2022). Increased cortical thinning is a commonality across children of low socioeconomic status.

Low socioeconomic status contributes to smaller surface areas in the brains of children and adolescents. Children with lower socioeconomic standing have a smaller surface area of the brain (Rakesh et al., 2023). One study that explored the changes in neural development between ages fourteen and nineteen found that overall, the surface area of the brain decreased significantly especially with low socioeconomic status. They concluded that socioeconomic status was not a factor in brain surface area differences at fourteen., yet a change in surface area was greatly related to socioeconomic status at age nineteen (Judd et al., 2020). On the other side of the socioeconomic spectrum, higher socioeconomic status was related to greater surface area of the brain (Noble et al., 2015). Higher socioeconomic status is associated with greater surface area of the brain and lower socioeconomic status is associated with decreased surface area.

Current studies show varying conclusions about amygdala volume. As discussed previously, low socioeconomic status can be associated with lower amygdala volume; however, some studies have discussed other findings. For example, Judd et al. (2020) found that amygdala volume does not change based on socioeconomic status. Another study done by Noble et al. (2015) found that parental education in particular affects amygdala volume; higher education was associated with greater amygdala volume than lower education. Further research on amygdala volumes in particular must be done to truly conclude whether or not socioeconomic status is a factor in that particular brain structure.

Higher socioeconomic status is associated with greater hippocampal volume and overall development. In an investigation of the Adolescent Brain Cognitive Development (ABCD) study, the hippocampus also displayed greater size and space in children with high socioeconomic status (Dennis et al., 2022). Per the previously stated study, the hippocampus was greater in those with higher socioeconomic status at fourteen, but did not change over time (Judd et al., 2020). One study explicitly states that parental education greatly affected hippocampal volumes (Noble et al., 2015). Using the findings of such studies supports the idea that lower socioeconomic status is associated with lower hippocampal volumes as the opposite is true.

From early childhood development to adolescent activation of the brain, lower socioeconomic status levels are associated with impairments in the prefrontal cortex of the brain. In a study that investigated the differences in socioeconomic status in structural neurodevelopment, infants of low socioeconomic status showed lower overall, frontal and parietal volume including that of the prefrontal cortex (Rakesh et al., 2023). In addition to smaller volumes, lower socioeconomic status was associated with lower activation in the frontal regions of the brain, including the prefrontal cortex (Li et al., 2021). Lower socioeconomic status correlates with poor development of the prefrontal cortex.

### **Possible Interventions**

Educators often have to make modifications for students of low cognitive ability, but they also must consider socioeconomic factors when planning assignments and lessons.

Pluck et al. suggest interventions to improve behavior regulation of children with low socioeconomic status should focus on language skills instead of a focus on executive functioning as a whole (2020). Along with a focus on language skills, a study conducted to find the relationship between cognitive development and the

pandemic points out the need for adequate technology in education. This study proposes that schools should provide hotspots/Wi-Fi and adequate technology as well as access to summer school learning opportunities for better development for students of low socioeconomic status (George et al., 2021). Noble et al. (2015) explore school-based interventions as a way to make significant impacts on cognitive functioning and development. School-based interventions for students with low socioeconomic status (who may struggle cognitively) are effective in improving functioning such as language, behavior regulation, etc.

The level of parent education is very significant to the cognitive development of children as they create a cognitively stimulating environment at home. Noble et al. (2015) conclude that home-based interventions and intentional action by parents to educate their children are necessary to address cognitive setbacks. Another research study that studies the influence of socioeconomic status on cognitive attention recommends attention training, carried out by parents, for children to target the advancement of cognitive skills (Stevens et al., 2021). The conclusions of these studies demonstrate the need for cognitive stimulation at home to better develop neural functions.

As researchers apply their findings with the hope of bettering the neural development of low socioeconomic status children and adolescents, they suggest policy-based interventions. In a study of 1,099 children and adolescents in the United States, researchers suggest the creation of policies to increase support and reduce family poverty can have significant impacts on cognitive functioning and development (Noble et al., 2015). These interventions specifically target the household income measure of socioeconomic status. A research article that targets the changes in neural development during the pandemic views the passing of the CARES Act and the economic relief package as a step in the right direction to stabilize schools and better socioeconomic status circumstances; however, the researchers call for educational policies to be passed (George et al., 2021). Although the articles address two different aspects of socioeconomic status, each advocates for better circumstances for children to aid their cognitive and neurological development.

## Conclusion

In conclusion, socioeconomic status is positively correlated with neurological development and cognitive functioning. Low socioeconomic status contributes to poor cognitive functioning like executive functioning, connectedness, flexibility, language, etc. as a result of poor neurological development. Brain structures of higher socioeconomic status were developed appropriately, especially compared to those of lower socioeconomic standing. Diversity in studies was often lacking or misunderstood in findings. Further research could be done to determine how racial differences themselves contribute to differences in neurological development instead of socioeconomic status as a whole. The differences in neurological development observed by researchers amongst differing socioeconomic statuses affirm that there is a relationship between the two variables. Factors of low socioeconomic status are related to cognitive setbacks due to lack of resources/enrichment, neuro-structural impairments, high levels of stress, and obstacles that hinder neurological development.

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