The Influence of Maternal Stress on a Child's Development in the Womb and the Long-term Effects on the Child's Neurodevelopment and Mental Health

Written by Alexa DiVito

Introduction

Stress during pregnancy is common amongst both new and experienced mothers. (Dunkel Schetter and Tanner, 2012) Many can attest to the fact that a stressed mother can impact her children at any age, whether it be requiring them to do extra chores or causing anxiety. However, what many people may not realize is the immense impact stress during pregnancy has on children. Maternal stress does not only affect the mother but the fetus as well, especially during their development and later life. Research shows that when pregnant women experience various stressors (such as grief, daily challenges, or natural disasters), it can lead to significant changes in their children's neurodevelopment. These changes can include a higher likelihood of autism, emotional disorders, and diminished cognitive abilities.

The Fetal Programming Hypothesis

'The Fetal Programming Hypothesis' states that during critical and sensitive periods of development, a disturbance in environmental factors has an organizational effect on biological systems (Seckl and Holmes, 2007). These systems include the central nervous system (the brain and spinal cord), autonomic nervous system (regulates involuntary physiological process such as heart rate and respiration), neuroendocrine (comprised of the hypothalamic-pituitary-adrenal axis), cardiovascular, and immune systems. (Bale, 2015). Disturbances can also negatively affect intrinsic plasticity, which is the nervous system's ability to change its activity in response to stimuli. This can be done by reorganizing its structure, fruition, or connections, to react and adapt to environmental influences. This hypothesis states that fetal conditions can have major impacts later in life. These impacts can be presented in many ways, depending on which part of the brain is affected.

How the Fetal Brain is Physically Affected

Certain parts of a fetus's brain can be affected by maternal stress, hindering proper fetal brain development. For example,in animal models, acute periods of prenatal or postnatal stress have profound effects on HPA function and behavior in adult offspring. This means that maternal stress during prenatal development can affect how the fetus's brain and associated parts of the body will respond to stress later in life. These effects can be different based on sex. Chronic maternal stress increases locomotor activity, which can cause higher sensitivity to change or trouble focusing in adult male offspring; on the other hand, it decreases sensorimotor gating (regulation of sensory information) in adult female offspring. (Emack and Matthew, 2011). Naturalistic studies with humans find similar effects on motor behavior (Huizink et al. 2004). Studies of prenatal maternal anxiety (O'Connor et al. 2002), prenatal exposure to stressful life events (Stott 1973), and even prenatal exposure to dexamethasone (a synthetic glucocorticoid that is an anti-inflammatory and immunosuppressive steroid) (Trautman et al. 1995) are associated with children who are more withdrawn, anxious and depressed.

How the Brain is Cognitively Affected

Various research shows that prenatal exposure to maternal stress increases the risk of behavioral and mental health problems later in life (Van den Bergh et al. 2020). A classic study by Hutten and Niskanen (1978) examined rates of mental illness in samples of children from Finland whose fathers had died either during pregnancy or within their first year of life. Significantly greater rates of schizophrenia and other mental illness were found in the prenatal stress exposure group. Van Os and Selton (1998) also found a significant increase in rates of schizophrenia in Holland as a function of the German invasion during World War II. These studies show specific effects of the timing of the stressor during pregnancy, with the most noxious effects being associated with exposure during the second trimester. Because of this, it has been hypothesized that the timing of the disruption in fetal neural development, rather than the type of disruption, may be even more critical in determining the risk for negative outcomes and which developmental processes are likely to be affected (Mednick et al. 1998). These findings alter the impact of prenatal stress timing on development, a concept further explored by researchers in Project Ice Storm, which examined the effects of a large-scale natural disaster on pregnant women and their children.

Project Ice Storm

Through January 5th and 9th of 1998, a series of freezing rain storms hit Southern Quebec, Canada. There was widespread flooding and ice accumulation causing around 1.3 million power outages,which led to water filtration plants being shut down, leaving many people to seek new shelter. While the meteorological event itself occurred over a period of four days, the recovery process lasted even longer, with long-term impacts lingering for months afterwards (Senesac, 2019). Shortly after, Project Ice Storm was initiated. The objective of this project was to determine the nature and duration of the effects of an independent stressor during pregnancy on the unborn child by using a prospective design with a large sample of families. By conducting repeated assessments of affected women and their children over several years, the impact of objective stress exposure and subjective stress reaction on perinatal outcomes, maternal postpartum depression, and the behavioral, physical, and cognitive development of the children was found. The test group, STORM32, split mothers into three groups depending on the stress levels demonstrated (low, moderate, and high stress), and contrasted the low stress group with the combined moderate-high stress group. They found that moderate to high objective prenatal maternal stress is associated with poorer intellectual and language functioning at the age of two when scientists examined interactions between trimester of exposure and severity of ice storm stress. This is demonstrated by Graph 1.1.

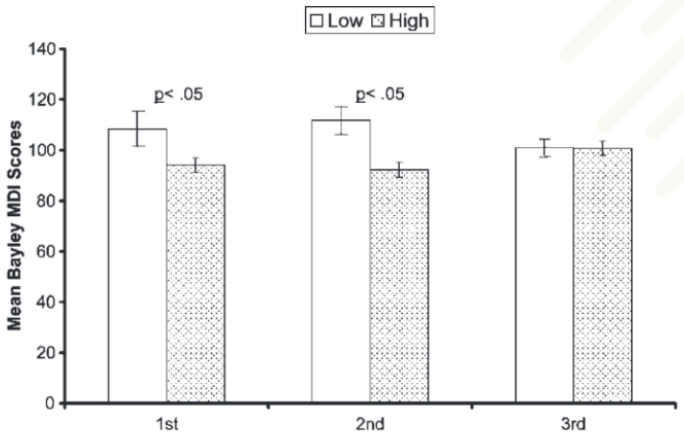

Figure 1. Toddlers' mean (+/- standard error) Bayley mental developmental index (MDI) scores at 2 years of age, as a function of objective prenatal maternal stress levels (low, high) and trimester of exposure (1st, 2nd, or 3rd).

These findings were reinforced by the results of their analyses of the children's play behaviors (Laplante et al.2004). For intellectual abilities, children whose mothers were exposed to the ice storm during their 1st or 2nd trimester of pregnancy and who experienced moderate or high objective stress had significantly lower Bayley MDI scores (a neural development assessment). This is demonstrated by Graph 1.2.

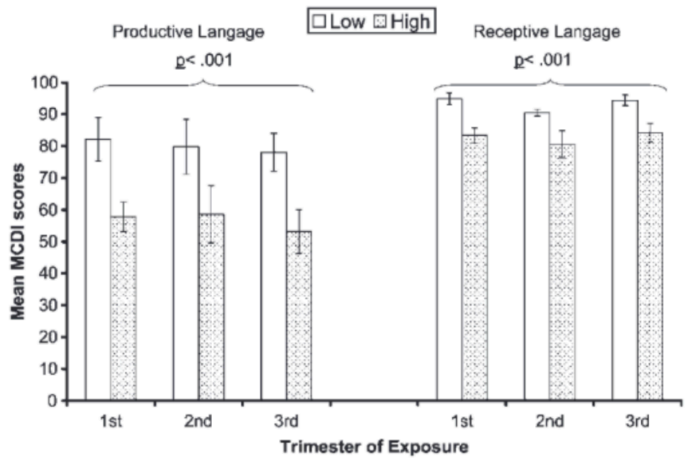

Figure 2. Toddlers' mean (+/- standard error) MacArthur communicative development index (MCDI) scores for productive and receptive language abilities at 2 years of age, as a function objective prenatal maternal stress levels (low, high) and trimester of exposure (1st, 2nd, or 3rd).

The findings from Project Ice Storm strongly suggest that major stressful events, independent of maternal personality factors, can have a negative impact on cognitive and language development of the unborn child.

Conclusion

Maternal stress during pregnancy has far-reaching effects that go beyond the immediate challenges of pregnancy. The evidence shows that stress during this crucial period can leave lasting marks on a child's neural development and mental health, with impacts that may only surface after birth. Whether it's everyday stress or more severe circumstances, the timing and intensity of stress exposure during pregnancy can influence the child's risk for cognitive and emotional difficulties. Supporting mothers during pregnancy isn't just about the mother's well-being at the moment– it's also about safeguarding the long-term health and development of their children. Addressing maternal stress will help ensure healthier outcomes for future generations.

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About the Author

Alexa DiVito is a freshman at the University of Illinois. She is currently an undeclared major on the Pre-Nursing track and plans to declare as a Psychology major next year. Alexa became part of Brain Matters to develop her knowledge of the brain and share her new knowledge with others. Apart from writing for Brain Matters, Alexa is involved in Greek life, RSO's, and is working on getting her CNA license.