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Title: Brain Development Education Pathways

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Adolescence marks the beginning of a metamorphic phase of physical, emotional, social and intellectual development. Due to the complexity of this transition, heightened mental health problems have been associated with this progressive stage (Loftus, Kelly and Mustillo 2011). The exposure to a range of environmental and sociological factors, in addition to cognitive vulnerabilities may considerably increase the risk of adolescents developing mental illness. Therefore in the first instance it is essential to raise awareness of adolescent brain development, in order to assist practitioners in recognising and detecting mental illness and ensuring early intervention and prompt treatment.

Brain Development:

By the age of six years a child's brain has already grown to 96% of its total brain volume, the remaining 4% continues to develop during adolescence through to adulthood, whereby maturation of the brain is concluded by the age of 25 years (Johnston 2009). A key period for brain growth occurs during the ages of 12-16 years when the functions of both grey and white matter are responsible for developing certain regions within the brain, this process concludes with maturation of the pre-frontal cortex.

Grey matter (cells, dendrites and neurons) account for 40% of the brain providing the surface of the cerebral cortex, during childhood the growth and thickness of grey matter increases, in order to develop extra brain connections. However this reaches a peak in adolescence following the commencement of puberty, when excess brain connections are eliminated or pruned (Lenroot & Giedd 2011).

This signifies the beginning of the re-modelling phase of brain development, where grey matter decreases, and white matter (found within the deeper tissues) increases accounting for 60% of the brain. White matter consists of myelin sheaths formed by glial cells which act as insulators to speed up the transmission of signals, these are responsible for communicating to different regions within the brain, with growth continuing into adolescence and adulthood.

Figure One: Adolescent Brain Development

Recent studies have indicated there are different brain development trajectories for both genders (Ruigrok *et al;* 2014), such as the male brain being 8-10% larger, as well as having a greater volume of grey matter than females, and increased volumes within certain regions of the brain such as putamen, globus pallidus, cerebrum, cerebellum and the left amydala. Essentially development is seen predominantly within the basal ganglia structures of the brain which have a major role in normal voluntary movement, motivation, learning, emotions and memory. Interestingly the basal ganglia is involved in certain conditions typically associated with males which include ADHD and Tourette's Syndrome (Lenroot & Giedd 2011).

Whereas the female brain reaches peak volumes of grey matter approximately 1-2 years earlier than males, due to commencing puberty at an earlier age (Asato *et al;* 2010). Subsequently females use ten times more white matter than males and have increased volumes within certain regions of the brain such as caudate, cingulate gyrus, right amydala and the right hippocampus (Figure Two). This indicates development within the limbic system, otherwise known as the emotion centre of the brain, which also has a major role in emotions, formation of memories, learning, arousal, and behaviour. Similarly the limbic system is involved in female biased disorders such as depression and anxiety (Baron-Cohen *et al;* 2011).

Figure Two: Gender Differences in Brain Development

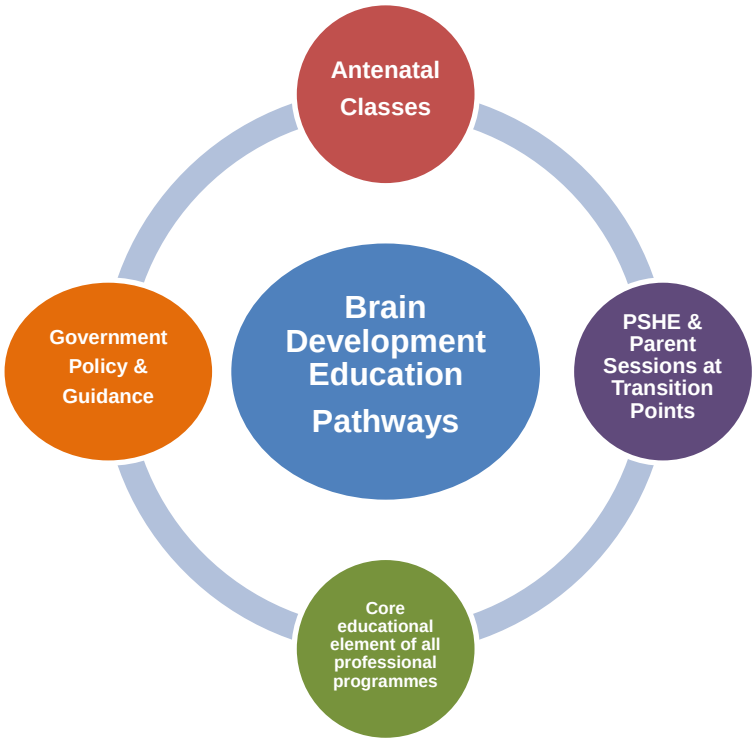
Males	Females
Brain volume 8-10% larger than females	Reach peak grey matter volume earlier than males
Use 7 times more grey matter than females	Use 10 times more white matter than males
Larger Left Amydala volume which increases more than females	Larger Right Hippocampus volume and Right Amydala
Larger Putamen, Globus Pallidus, cingulate gyrus, cerebrum and cerebellum	Larger Caudate, Cingulate Gyrus,
Predominantly uses left side of brain	Uses both left and right sides of brain

This reinforces the need to educate young people, parents, and professionals on brain development in childhood and adolescence, as during this transformative stage the brain is extremely malleable (ability to adapt and change with experience/stress) thus creating vulnerability and the risk of mental health disorders developing.

Educational Pathways:

Therefore we must consider utilising a range of multifaceted educational pathways (Figure Three) to raise awareness of this crucial period of development. This should begin pre-birth by for example; introducing theoretical sessions on the importance of brain development and attachment in childhood/adolescence for pregnant women during antenatal sessions. Similarly this could also include educating young people and parents within both primary and secondary school settings on brain development and emotional health and wellbeing, as part of their PSHE sessions and parent open evenings during key transition points. Finally brain development should be a core component within all professional educational training programmes such as Nursing, Medicine, Teaching, Childcare, Social Work, Youth Work, Public Health. In order to equip practitioners with foundational knowledge of brain development, which is inextricably linked to children and young people's physical, social, emotional, and intellectual health, which if affected has the potential to impact upon their development into adulthood.

Figure Three: Brain Development Educational Pathways



730 Words

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