What is the impact of the changing brain on learning?

Focus on the adolescent brain.

‘It appears that the brain changes characteristic of adolescence are among the most dramatic and important to occur during the human life span.’

(Steinberg, L. 2010)

Adolescence is the period of life bridging the gap between childhood and adulthood (Sawyer, Azzopardi, Wickremarathne, & Patton, 2018). Sawyer et al (2018, p.223) suggest delayed timings in education completion, marriage and parenthood have led to a shift in perceptions of when adulthood truly begins, going as far as to say “a definition of 10-24 years for adolescent growth” corresponds more closely to this life phase rather than the previous perceptions of 10-19 years. Arguably, as the shifting period from childhood to adulthood now occupies a larger part of the life course than ever before at a time when unprecedented social forces, such as popular culture, marketing and digital/social media, are affecting health and wellbeing across these years (Sawyer et al, 2018, p.223), the role education plays in the lives of teens is crucial to their future success.

New findings are changing our understanding about the adolescent brain. The science of adolescent brain development is still relatively new (approximately 20 years) yet systemic studies are revealing consistent data and the “fact that there are significant changes to the brain during adolescence is no longer debatable” (Steinberg, 2010, p.160), refuting claims by non-neuroscientists such as Epstein (2007) that the adolescent brain is a myth. Over the past two decades, advances in neuroimaging technologies - particularly those encompassing structural and functional magnetic resonance imaging (sMRI and fMRI) – have revealed a “whole new picture of the adolescent brain” (Armstrong, 2016, p.4). These new discoveries are clearly pertinent when exploring the success of adolescents in school, and ultimately their ability to function well in the world after education.

This essay looks at the changes in the brain during the adolescent years and its impact on their ability to learn effectively. Firstly, the adolescent brain is significantly different from both the child brain and the adult brain (Armstrong, 2016; Siegal, 2014; Steinberg, 2010). There are differences in its morphology and its function, as well as the levels of brain structures, regions, circuits, and systems (Steinberg, 2010). Howard-Jones (2009) asserts neuroscience has shown to a surprising extent that the adolescent brain continues to develop throughout this life phase – particularly in the
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frontal (involved in many different aspects of reasoning and movement) and parietal (heavily involved in integrating information from different sources and some mathematical skill) cortices. Steinberg (2010) claims there is an increase in white matter and a decrease in grey matter in this area, partly due to synaptic pruning and myelination.

Neuroplasticity - Synaptic Pruning and Myelination

Synaptic pruning is a key change that occurs during adolescence, “allowing unnecessary brain connections to be eliminated while important connections are maintained” (Armstrong, 2016, p.19). The net decrease in synaptic density in the pre-frontal cortex during adolescence is essential in the “fine tuning of functional networks of brain tissue, rendering the remaining synaptic circuits more efficient” (Blakemore & v Choudhury, 2006, p.297). The synaptic pruning aids the development of cognitive processes associated with the frontal lobes, throughout adolescence.

Myelin is a fatty substance which insulates nerve fibres, making electrical transmission of messages quicker and more efficient, and “able to connect to areas of the brain that previously had been more diffusely connected” (Armstrong, 2016, p.19). This process is called Myelination and increases during adolescence. Myelination improves the efficiency with which information is communicated in the brain and Howard-Jones (2009) suggests the process could favour an increase in the speed with which neural communication occurs.

These processes come under the umbrella of Neuroplasticity, and from an educator’s perspective, adolescent neuroplasticity is hugely significant because the teenage brain is still developing. According to Armstrong (2016) the adolescent brain wires itself in relation to the experiences and environmental influences and this holds huge consequences for adulthood. Howard-Jones (2009) reinforces this, arguing formal education, as well as social experiences, may have a vital role to play in the shaping of the teenage brain, stressing the importance of education at this age. He claims that “the brain is still developing…it is thus presumably adaptable, and needs to be moulded and shaped”.

Pertinent to an adolescent’s ability to learn effectively is the fact the prefrontal cortex is the last part of the brain to be pruned and myelinated, meaning the areas of the brain responsible for executive functions (including decision making and impulse control) are not at their most efficient until mid-adolescence (Armstrong, 2016). The frontal lobes also form part of the brains emotional circuit and Willis (2012) asserts “because students have not reached the brain maturity to completely manage their emotions, middle school teachers need to monitor and model supportive emotional climates”.

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The second part of this essay looks at ways this support can be given to maximise the effective learning for adolescents.

**Helping ‘Teens’ to learn**

Judy Willis, a board-certified neurologist, has combined fifteen years as a practicing neurologist with ten subsequent years as a teacher to provide an insight into learning and the brain. She claims teachers need to adjust their pedagogy to help adolescents learn whilst they are adjusting to the added peer group influences of secondary school.

Stress and anxiety can inhibit learning potential. Neuroimaging has shown how the amygdala becomes metabolically hyperactive in adolescents during periods of emotional anxiety and stress (Armstrong, 2016; Siegel, 2014; Willis, 2012) resulting in the pathways in the brain which normally conduct information in and out of the amygdala to become significantly less active. Consequently, new information and new learning is blocked from passing into the memory banks. However, in contrast, when the adolescents are participating in learning activities of high interest, which engage them fully, their brains transport information at a high rate (Willis, 2012). It is also worth mentioning an opposing view - Howard-Jones (2009) discusses a correlation between stress (psychological not physical) promoting memory which could have a positive effect on adolescents during exam periods.

Educators of adolescents cannot fail to notice the overwhelming influence peers have over one another during the teenage years. Neuroimaging research has evidenced the power of peers – an fMRI study (Chein, Albert, O’Brien, Ukert, & Steinberg, 2011) suggests in the presence of their peers, adolescents may be more willing to take bigger risks for big rewards. The study showed the teenagers were prepared to take bigger risks on a computerized driving simulation game when they were informed two same age, same sex peers watching them play on a television monitor. The study also concluded their risk taking rose significantly compared to adults, when high rewards were available. Armstrong (2016, p.66) asserts “adolescents are primed in the reward regions of their brain to respond to what their peers think about them”.

Taking this information into an education setting, it is clear adolescents are more attuned to social learning rather than listening to teacher directed lessons/lectures. Educators need to harness the power of peer associations to help create more engaging and therefore effective classroom learning. Paus (2005, p.64) discusses the “interplay between cognitive and emotion-related processes...which are particularly crucial in peer-peer interactions”, suggesting changes in the brain during adolescence (particularly feedback and feedforward between the Superior Temporal Sulcus) enhances a
teenagers neural responses to social stimuli. Accepting these changes in the brain, educators should aim to build learning environments which promote cooperative learning, peer mentoring programmes, peer teaching and collaborative learning projects. Willis (2012) claims community and self-esteem building are not just “nice to do” but, as neuroimaging research has shown, such practices lower threat and stress, and “serve to facilitate the successful passage of knowledge through the brain’s filters and into cognitive processing.” As a result, the students learn more.

Revisiting the suggestion that adolescents are likely to take more risks, and respond to what their peers think of them, it raises alarms that at age 14 pupils are expected to make decisions which could affect the rest of their lives. Choosing their G.C.S.E option subjects at this time, could result in choosing subjects they later come to regret, or even worse, fail to choose subjects they later realise they need for their chosen career. At 14, it is likely some may choose subjects to ensure they remain in the same classes as their peers, rather than making the right choices for themselves.

It makes perfect evolutionary sense (Steinberg, 2010) that adolescents are more motivated by appetitive inclinations, more oriented toward sensation-seeking, and more willing to take risks, as it is the time they need to work out their own identity. It is the start of a journey which lasts for the rest of their lives, deciphering what has meaning in their lives (Siegel, 2014). “From an evolutionary perspective, adolescent risk-taking is a good thing, not a bad one” (Steinberg, 2010).

This essay has gone some way to acknowledge adolescence as a time of great challenge and opportunity, both for the adolescents themselves and for the adults involved in supporting them. It is important to ignore the myths of old – that teenagers are “crazy”, “lazy”, that they “go mad” or “lose their minds”, and instead embrace the emerging scientific evidence which tells us these behaviours are resultant of significant changes in the development of the brain. We now know brain maturation plays a significant role in the social and cognitive development which occupies adolescence.

Educators need to acknowledge what adolescents have to offer to our world – capturing their drive and their ingenuity to find new solutions. With the correct support Siegel (2014) suggests adolescents can use their “emerging minds to find new ways of dealing with these challenging times”. Supporting teenagers through school to enable them to thrive, rather than simply survive, the combination of education and adolescence should be the key objective for secondary school teachers.
Unfortunately, an added obstacle faced by educators within secondary school is the disparity between social time and biological time, particularly during the later teenage years. Kelley, Lockley, Foster and Kelly (2015) have explored the impact of the conventional school day – 9am-3pm – on adolescence. Their study indicates a change in the start time for secondary schools to a later start could have significant positive effects in education, including academic outcomes. They suggest the current timings of education causes “chronic sleep deprivation” (Kelley et al, 2015, p.217) in teenagers and consequently effective learning is inhibited. Synchronizing education to adolescent biology can only benefit what is already a challenging period for teenagers, and could rectify what appears to be a significant disadvantage. Howard-Jones (2009, p.14) supports this idea, asserting sleeps facilitates the consolidation of what has been learnt during the day. He suggests sleep not only helps the understanding of what has been learnt that day, but also prepares us for more learning the next day, claiming “regular and sufficient sleep is essential for the brain to learn effectively” (2009, p.14). It can only be detrimental to their effective learning if teenagers are losing considerable amounts of sleep during term time, due to school timings.

Continuing with Kelley et al (2015) research, there are indications that there should be a shift in the time of day particular educational subjects are taught. Kelley et al (2015) cite a previous study of theirs (2013), where pupils aged 13-14 were given a word pair test at 10.00 and another at 14.00 and all performed better in the later test, reflecting adolescents are more alert later in the day. If the attention of adolescents is better in the afternoons, why are Maths and English, our core subjects, taught first thing in the morning to Year 6’s (11 year olds)? This research suggests upper Key Stage 2 year groups should consider moving Maths and English to the afternoons to maximise the learning outcomes for those pupils.

Similarly, National Curriculum Assessments for Year 6 children test on Mathematical Reasoning and Arithmetic, Reading Comprehension, Punctuation, Grammar and Spelling, and all are tested between 09.00 and 11.30 which again tends to suggest these pupils are being disadvantaged.

However, despite evidence to suggest changes to the timings of the school day has the potential to maximise learning and improve academic outcomes, any change in education policy to accommodate them (particularly a later start for adolescents, but not necessarily for younger primary aged children) could prove problematic for working families when organising childcare. The difficulties could manifest themselves both logistically and financially for the parents, so government policymakers would need to consider all options carefully.
To conclude, the knowledge educators now have regarding the critical period of neurobiological processes that underlie higher cognitive functions and social and emotional behaviour during adolescence, can help shape the education of teenagers. Yurgelun-Todd (2007, p.251) suggests increased abilities in abstract reasoning, attention shifting, response inhibition and processing speed run parallel to the maturation of the pre-frontal cortex. She claims the imaging evidence confirms for educators, this maturation in adolescents “plays a critical role in the cognitive and emotional behaviours displayed” and cannot be ignored when establishing how best to help them learn.
Bibliography


