Neuroscience, Health, and Well-being: A Podcast Series for Adolescents

Sarah E. Lachance, B.ASc. (Hons.), B.Ed.

Department of Graduate and

Undergraduate Studies in Education

Submitted in partial fulfillment of

the requirements for the degree of

Masters of Education

Faculty of Education, Brock University

St. Catherines, Ontario

Abstract

This research project explored brain-based topics as they related to adolescents including diet, exercise, memory, sleep, emotions, and structures and functions of the brain. Research into these topics was used to develop a six-part mini-series of podcasts, which utilized analogical reasoning and scientific explanation, targeted at teenage audiences. The goal of the project was to develop a resource that would modify adolescent thinking on these topics. Cognitive behavioural theory suggests that how we think about the world affects our behaviors (Kelly, Melnyck, & Jacobson, 2011). Therefore, the goal of this study is that listening to the developed podcast, titled *Teen Brain*, may influence adolescent choices. Three Ontario Certified Teachers, who are personal acquaintances of the author, evaluated the product. Evaluators found that the product was appealing and affective for teenage audiences, and believed that it could have the potential to be valuable or even life-changing for a range of audiences.

Table of Contents

CHAPTER ONE: INTRODUCTION

The purpose of this paper is to develop an educational resource designed to introduce adolescents to the importance of the brain for everyday functioning. The aim of this project is to develop a six-part podcast series, which utilizes educational strategies, such as analogical reasoning, and information tailored specifically to adolescents, to pique interest in the topics covered. Each podcast is designed to encourage adolescents to think about the inner workings of their brains and how they can make choices that not only improve brain health, overall health, and well-being, but also point them towards information that can help optimize the brain's function and its ability to function. Podcast topics include a) An Introduction to the Brain and its Functions, b) Sleep and the Brain, c) Diet and the Brain, d) Exercise and the Brain, e) The Role of Memory, and f) Emotions.

This research was written within the context of my core belief as an educator that children and adolescents deserve to be informed about the details of their bodies and minds and how our actions have consequences. I believe that if we give children this knowledge, as well as the background behind it, they can work to use this knowledge to make informed choices about their own health and well-being. Although I understand that giving them this information does not guarantee that they will make healthy choices, if it makes a difference for one person, or if one person changes one unhealthy habit, then it is worth the effort.

Background of the Problem

For the purpose of this research exploration, *adolescence* is the timeframe beginning at the onset of puberty and continuing until full maturation of the brain, which is believed to be around the age of 23 years old (Payne, 2014).

Adolescence is a time of increased independence where individuals begin to make their own decisions about their day-to-day lives. Unfortunately, studies have shown that adolescents are unlikely to make decisions that support a physically and emotionally healthy lifestyle. For example, many adolescents experience chronic *sleep debt*, or an accumulation of multiple nights without enough sleep (Beebe, Difrancesco, Tlustos, & McNally, 2009; Fallone, Owens, & Deane, 2002). Sleep deprivation has consequences for the daily brain functioning of adolescents, including implications for mood regulation (Capaldi, Handwerger, Richardson, & Stroud, 2005; Dahl & Lewin, 2002; Vandekerckhove & Cluydts, 2010), reward-related brain functioning and executive control (Hasler & Clark, 2013), and school attendance and academic performance (Capaldi et al., 2005; Dahl & Lewin, 2002; Fallone et al., 2012).

Moreover, adolescent dietary patterns have been linked to obesity (Francis & Stevenson, 2013), which has been associated with poorer levels of academic achievement (Florence, Asbridge, & Veugelers, 2008), an increased risk of developing type 2 diabetes (T2D) (Malik et al., 2012), and decreases in brain volume (Meeusen, 2014). Oddy et al. (2009) estimated that one quarter of adolescents' dietary intake is in the form of snacks, and energy-dense confectionary items were found to often be eaten in place of meals. In addition, regular exercise is a factor contributing to obesity that is extremely relevant to adolescents. For instance, adolescence marks the greatest decline in physical activity that

persists into adulthood (Dunn & Weintraub, 2008; Hillman, Erikson, & Kramer, 2008; Hortz & Petosa, 2006; van der na, De Geus, van Beijsterveldt, Boomsma, & Bartels, 2010).. Regular exercise improves cardiovascular health, leads to greater bone mineral density, and decreases the risk of stroke and diabetes (Cotman & Engesser-Cesar, 2002). Research has also suggested that exercise is key to brain growth, maturation (Cotman, Bertold, & Christie, 2007), and function (Meeusen, 2014).

Adolescents experience low emotional stability (Zimmerman, & Iwanski, 2014), which affects well-being and makes them more likely to encounter extreme positive and negative emotions (Padilla-Walker, 2008). *Emotion regulation* is the ability to control the instincts and impulses that accompany emotions, both positive (Zimmerman, & Iwanski, 2014) and negative (Lewis, Lamm, Segalowitz, Steiben, & Zelazo, 2006). Zimmerman and Iwanski (2014) found that middle adolescents in particular have a low number of emotional regulation strategies that they use. In addition, individual differences in emotion regulation predict both social competence and personality development (Lewis et al., 2006).

Finally, the prefrontal cortex undergoes major development during the teenage years (Sousa, 2011). While this area is still undergoing development, adolescents are more likely to participate in risk-taking behaviours such as drinking and drug use (Khurana et al., 2012; Romer et al., 2011). This area of the brain is also implicated in academic success due to its control over memory, impulsivity, attention (Baddeley, 2003), reading comprehension, learning, and the ability to solve math problems (Alloway & Alloway, 2010; Baddeley, 2003). Jensen (2008) introduced the idea that instructing students in learning skills and strategies can increase their ability to process new

information. Not all classroom teachers utilize brain-based teaching methods, therefore affecting – or, not positively affecting – their students' ability to achieve academically. Academic achievement has strong implications for well-being because of its relationship with future successes and career goals.

As demonstrated, adolescents may not have the information they need to understand the importance of implementing strategies that improve or maintain their health, well-being, and how to utilize strategies to enhance the productivity of their brains, whether it be for emotional regulation or academic achievement. In order to improve adolescents' relationship with their brains, they need to develop an understanding of its relevance and importance to our daily functions. Although the information may already be available, the issues presented here are still relevant. Therefore, there is still room to increase the knowledge base at this developmental stage.

Rationale

In 2016, Ellen Wartella and colleagues conducted a national survey in the United States on teens, technology, and health, which received responses from 1,156 teenagers aged 13 to 18 years old. The study reported that 84% of teens noted receiving health information online during their lifetime. Of the information searched, 42% was related to fitness and nutrition, 26% was related to diet and nutrition, 19% was related to stress and anxiety, 16% was related to sleep, and 16% was related to depression and other mental health issues. This presents the case that children in this developmental stage are looking for the type of information that the podcasts in this series will provide, and they are using the Internet to do so. Specifically, only 10% of teens reported using books, 9% television news, and 3% from newspapers to research health information. These statistics

demonstrate the importance of developing technological resources for this age group that are both supported by research and are tailored to adolescents themselves.

Cognitive behavioural theory suggests that the way in which a person thinks about the world largely determines and affects their behaviour (Kelly et al., 2011). In this same research study presented above, 34% of teenagers reported changing their behaviours because of what they found when searching the internet for health related information (Wartella et al., 2016). Stephanie Kelly and colleagues hypothesized that they would find a positive relationship between healthy lifestyle beliefs, attitudes, and choices when conducting a survey of 404 teenagers aged 13 to 18 years. What they found supported this hypothesis and demonstrated that an individual's confidence in their ability to lead a healthy lifestyle was positively associated both with their attitude towards the importance of leading healthy lifestyle and with their intentions to engage in behaviours that promote a healthy lifestyle. These findings may suggest that altering one's beliefs about their capability to overcome barriers to a healthy lifestyle can have implications for their motivation to participate in healthy behaviours.

Kypros Kypri and Helena M. McAnally (2005) believe that, "individuals may overestimate their compliance with norms for physical activity and fruit intake. It is also likely that many underestimate the extent to which they fall short of health recommendations for these behaviours" (p. 762). In a previous study, they found that personalized normative feedback had positive effects on drinking behaviour (Kypri et al., 2005, as cited in Kypri & McAnally, 2005). Although examining an older age group (18 to 65 years old), one study found significant overall effects on health behaviours using a computer tailoring technique where health information is tailored towards the individual

using a baseline questionnaire when compared to general health information (Smeets et al., 2007). The researchers believe that tailoring information allows the reader to experience less redundant information and make them more likely to read, save, remember, and discuss the relevant information. An alternate research group also used a baseline questionnaire to tailor health information to a group of Dutch adults over 30 years old (Oenema et al., 2008). They focused on age-specific recommendations and peer reference values to target saturated fat intake and physical activity levels. The intervention produced significant results, with the strongest results occurring within the participants with the highest risk factors. Although a podcast cannot provide the same level of specificity that can be achieved using a baseline measurements and computer tailored intervention, these principals can still be applied to the present study. The presentation of normative and tailored information relevant to adolescents may work to strengthen their relationship with the material presented and increase their likelihood of modifying their behaviour.

Scope and Limitations of the Study

Due to the nature of the project and the range of information available for each of the topics covered, the literature review for each topic is not exhaustive. Because of this, it is important to note that there is a wealth of information available on these topics that will not be discussed in the podcast series.

In addition, each podcast serves the purpose of eliciting an “ah-ha” moment and/or piquing interest in the topic discussed. Therefore, one should be aware that the podcasts are not designed specifically as procedural manuals on how to be proficient in each function, but rather, to stimulate curiosity and a desire to learn more about each

topic. Each podcast will attempt to focus on presenting the facts in a positive light rather than focusing on detriments in the behaviour of adolescents. Author Jesse Payne of *Change Your Brain Change Your Life: Before 25* (2014) comments that high school students are often open and interested in learning about the brain and all the fascinating ways in which it works; however, when the conversation shifts to areas where adolescents are abusing their brains, such as with drugs or alcohol, students tend to become defensive.

Outline of the Remainder of the Document

This document is organized so that the reader may explore the work completed and developed by the author in service of developing the product. Chapter One provided an introduction to the problem and rationale for the development of the product. Chapter Two will provide the reader with a comprehensive literature review on the proposed podcast episode topics, as well as the effectiveness of podcasting in education and the use of analogical reasoning. Chapter Three describes the process through which the product was developed and evaluated, as well as where and how the podcast will be posted. Chapter Four consists of the final product, which can be accessed through a link. Transcripts of the podcast can be found in Appendix A. Finally, Chapter Five provides the reader with a summary of the project, the feedback received from the selected evaluators, implications and recommendations, as well as limitations.

CHAPTER TWO: LITERATURE REVIEW

In this section, information from key literature sources will be presented to demonstrate the relevance of each topic to adolescents, as well as the importance of facilitating learning in these areas. To begin, an introduction to podcast use in educational contexts will be provided, followed by an explanation of the use of analogical reasoning as an educational strategy, which will be used throughout the series. Next, each podcast topic will be explored beginning with an a) Introduction to the Brain and its Functions, b) Sleep and the Brain, c) Diet and the Brain, d) Memory, e) Exercise and the Brain, and finally, f) Emotions.

Podcasting

This section will discuss podcasts as they have been studied in an educational context. Benefits and disadvantages of this digital information, student preferences, and learning outcomes will be discussed. Throughout the research process, only one K-12 educational source was identified (Plankis & Weatherly, 2008); however direct access to this resource was not possible. In addition, all research on this topic was conducted in an educational setting (Baker, Harrison, Thorton, & Yates, 2008; Evans, 2008; Hew, 2009; Merhi, 2005; Plankis & Weatherly, 2008), consequently making education the focus of this discussion on podcasting.

Podcasts are downloadable really simple syndicate (RSS) files that can be played on any device with either its own access to the internet, such as a computer or phone, or with any device which can download and play MP3 files, such as an iPod or MP3 player (Flanagan & Calandra, 2005). One benefit of this technology is that learners can transport learning materials easily and have more freedom over when, how, and where they

participate in learning (Evans, 2008). Because podcasts are file-based, users do not have to contend with the same technical issues that are encountered with streamed media such as a poor connection or buffering (Hew, 2009), and listeners can download numerous podcasts from the internet to listen to without an internet connection. In addition, podcasts are inexpensive to develop, with recording software available that is offered at no cost (Flanagan & Calandra, 2005): the only expense is the producer's time spent developing the material. However, podcasts are not regulated by any governing body, and therefore, content that is found through this medium is not guaranteed to be appropriate despite individuals being responsible for the content they post (Flanagan & Calandra, 2005).

In America, more than 6 million individuals have downloaded podcasts for leisure activities (Savel et al., 2007) . In education, podcasts can serve to supplement classroom learning by incorporating information from guest speakers, conducting topical reviews, and adding complimentary information (Baker et al., 2008). They can also serve a preparatory function, allowing students a peak into information that will be presented in future lessons (Hew, 2009), a learning advantage that will be discussed under the topic of memory further on. Further, podcasts are available at no cost to the listener. For this reason, Mehni (2005) suggests that podcasts may be a way to provide quality education to underserved populations.

Menhi (2005) developed the Podcast Adoption Model to explain factors that influence a person's likelihood of accepting and using new technology, in this case: podcasts. These factors include perceived ease of use, perceived self-efficacy, relative advantage, perceived usefulness, image, perceived enjoyment, and mobility. When 352

undergraduate and graduate students were surveyed, analysis found that a student's intention to use podcasts was influenced by perceived enjoyment of using the podcasts, image or how using podcasts was beneficial for their social status, perceived usefulness, perceived ease of use, self-efficacy or the ability to use the information, and relative advantage of using the podcasts over other resources.

When it comes to student preference, many studies have demonstrated that students enjoy using podcasts (Evans, 2008; Hew, 2009; Menhi, 2005). Evans (2008) found that students aged 18 to 20 years old reported valuing the flexibility that podcasts allow, and 25% reported listening to the assigned podcasts while travelling. Students in this study believed that the podcasts developed were quicker and more useful than textbooks or notes for revision before tests because they created context where notes of their own or a classmates may be lacking. Overall, the students in this study believed that podcasts enhanced their learning process.

Parsons and colleagues' (2009) study divided 18 to 21 year olds into three groups: one that received a PowerPoint lesson, one group that received podcast lessons, and one group that received vodcast lessons (video). Overall, students in this study found podcasts and vodcasts to be useful resources; however, they preferred them to be included as additional resources because it was difficult to learn advanced topics, such as statistics, from a podcast alone. In Hew's (2009) review of research topics on audio podcasts it was found that students valued the opportunity to learn on their own time, as well as the ability to listen to missed or difficult material multiple times.

Studies have not demonstrated a significant advantage in learning outcomes for students with access to podcasts as supplementary material. Baker and colleagues (2008)

found that when they compared first year university students in the same course, one with access to regular written supplementary material and one to podcasts as supplementary material, no significant difference was found between the groups' scores. However, the study only had 4 participating students in the podcast group compared to 17 in the control group. One study found a 3% higher score for students aged 18 to 22 who listened to 6 weeks of supplementary podcast material when compared to students who only read the transcripts of those podcasts. The podcasts were presented radio style, with two hosts asking and answering questions, music, jingles, section breaks, and images (Abt & Barry, 2007).

Overall, podcasting as an educational tool has demonstrated in research that it does not produce a deficit to students. Although the purpose of the podcasts that will be created for this project will be for those interested in learning on their leisure time, they will be available to educators because of the nature of the resource. The research presented here makes the case that podcasts are accessible and enjoyable for students, and produce similar learning outcomes to information taught in lecture form. Although the participant groups of this study fall at the tail end of adolescent development, the findings may present evidence to suggest that younger adolescents would have the same interests.

Analogical Reasoning in Adolescence

This section works to present literature to support the use of analogical reasoning and an instructional strategy to improve learning. To begin, developmental theories that seek to explain the mechanisms behind analogical reasoning will be discussed. Next, specific studies will be used to demonstrate the adolescents are capable of analogical reasoning and perform well on tasks where this skill is tested.

Analogical reasoning is a, "conceptual strategy enabling children to make inferences about novel phenomena, to transfer learning across contexts, and to extract relevant information" (Richland, Morrison, & Holyoak, 2006, p. 245). The process of using and developing this type of reasoning skill helps to facilitate knowledge transfer, and is important to creativity (Chuang & She, 2013). In order to successfully use and understand analogies, one must be able to pay attention to relevant information, discern the relationships between items, and use them to generate inferences about common principals (Vendetti , Matland, Richland, & Bunge, 2015). One key aspect underlying the ability to execute these skills is *relational mapping,* which is the process of attending to the shared relationships that are common to both concepts involved in an analogy (Vendetti et al., 2015).

Individuals are not adult-like in their ability to use and understand analogies until adolescence (Vendetti, et al., 2015). This has left many researchers interested in how analogical reasoning skills develop. This section will discuss these theories including *increased domain knowledge*, *relational shift*, *relational capacity*, and *cognitive function*.

The theory of *increased domain knowledge* follows Jean Piaget's (1972) work in cognitive development. Piaget (1972) theorized that children intellectually develop through a series of stages. Proponents of this theory suggest that children cannot compare to adult reasoning skills until Piaget's Formal Operations stage, which occurs at 13 to 14 years of age (Richland et al., 2006). During this stage, adolescents have developed the ability to reason in a hypothetical way (Piaget, 1972). The formation of this more abstract way of thinking allows adolescents to better understand the relationships between the subjects in analogies.

Relational shift theory suggests that, when individuals reach a certain developmental period, aground adolescence, their thinking shifts from focusing on perceptual information to relational information (Vendetti et al., 2015). This, then, suggests that as we develop, we begin to prefer thinking about concepts as they relate to one another. Once we acquire more knowledge about relevant background information, we develop the ability to compare things relationally (Richland & Burchinal, 2013). Hence, when we use analogical reasoning, we can build upon the background knowledge of what is known about one concept in order to improve our understanding about another.

Relational complexity theory suggests that children's performance on analogical reasoning tasks is dependent on the complexity of the relationship they are being asked to analyze (Richland et al., 2006). This happens because of the way in which executive functions develop. Once executive functions have matured, older children are capable of handling a larger cognitive load, and therefore, have an easier time analyzing analogies. This ease is because they can effectively map more relations at once (Thibaut, French, & Vezneva, 2010), suggesting that once we reach adolescence, we are capable of understanding more complex analogies.

The theory that *cognitive function* plays a role in analogical reasoning draws from the same ideas as relational complexity. The prefrontal cortex, which is responsible for executive function, slowly develops with age (Rekart, 2013). This area of the brain is responsible for *inhibitory control*, meaning our ability to "block" out distracting information to maintain our focus (Rekart, 2013). This theory postulates that as we develop this area of the brain, it is easier to ignore irrelevant perceptual information in

order to develop an understanding of the deeper relationship in an analogy (Richland et al., 2006).

Some researchers believe that analogies are one of the most important ways that children make sense of their world (Richland et al., 2006; Thibaut et al., 2010). In order to succeed academically, we need to be able to apply previously learned information to new situations (Vendetti et al., 2015). *Analogical reasoning* is practice in mapping relations between concepts, therefore helping apply the skills needed to transfer knowledge (Vendetti et al., 2015). The use of analogies can also have benefits for learning because they allow one to revisit previously learned knowledge, and therefore, increase one's exposure to concepts (Chuang & She, 2013).

Chuang and She (2013) conducted a study with a group of 190 fifth grade students from 6 different classes. The purpose of the experiment was to use an online learning environment and analogical reasoning to improve the young adolescents' understanding of the functions and mechanisms in the human eye. The study demonstrated that the participants significantly benefited from the use of analogical reasoning. The students in the analogical reasoning condition were better able to construction scientific concepts than the students who were in the scientific reasoning condition (Chuang & She, 2013). In this study, researchers showed that young adolescents were able to understand difficult material better when presented in an analogy, suggesting that learning can be increased through the incorporation of analogical thinking skills.

Although not adult-like in their ability to use and create analogies until adolescence, research has demonstrates that children as young as 3 years of age are

capable of analyzing simple analogies (Richland et al., 2006). As children reach adolescence, there is reduced activation in the regions of the brain used during analogical reasoning tasks (Vendetti, Matlen, Richland, & Bunge, 2015). This informs practice because it demonstrates that children go through the process of refining their reasoning skills. This refining also supports the theory that analogical reasoning should be used to aid learning because it allows them to build a strong foundation to aid this process (Vendetti et al., 2015).

One study used scene analogy problems to assess the ability to answer questions using analogical reasoning using participants ranging from ages 3 to 14 (Richland et al., 2006). The study found that 13 to 14 year olds performed better on these tasks, made few relational and/or feature errors, and made fewer errors overall than the younger age groups. The researchers believe that adolescents are more capable of ignoring distracting information in order to understand the relationship present in analogical reasoning than their younger counterparts, although 9 to 11 year olds were capable of performing at a similar level (Richland et al., 2006). This demonstrates that the capacity to use and understand analogies increases with age, supporting multiple theories presented by researchers. A similar study supported these findings by using shape- and colour-themed questions to study the effects of cognitive load on analogical reasoning tasks (Thibaut et al., 2010). The participants were 6, 8, or 14 years of age, and the experimenters controlled for the number (0, 1, 2, 3) and type of distractors. Again, it was found that accuracy on test questions increased with age.

An Introduction to the Brain and its Functions

In this section, I will discuss the structure of the nervous system, evolution, and the major structures of the brain and some of their functions. The purpose of this topic is to develop an interest in the marvels of the brain amongst participants.

The brain is a complex and extraordinary organ. Using electrochemical signals, it is able to act like a control center for every movement and thought that you have had throughout your entire life (Pinel, 2011). Your brain is a part of a complex system of nerves, aptly named the *nervous system*. It is responsible for four tasks: detecting, analyzing, deciding, and executing (Klein, 2000). The nervous system is divided into two parts: the *central nervous system* (CNS) and the *peripheral nervous system* (PNS). The *central nervous system*, the core of your control center, is comprised of the contents of your skull (the brain and its protections) and the contents of your spine (the spinal cord and its protections) (Pinel, 2011).

The *peripheral nervous system* (PNS) is a system of nerves that either directly connect, or find a way to connect, every inch of your body to your CNS. The PNS has two important jobs. It carries messages to the central nervous system to the body and vice versa (Pinel, 2011). Some of the messages that are carried to the CNS come from the external world through your senses. These messages are carried by one-half of the PNS called the *somatic nervous system* (SNS). For example, when you are sitting at the dinner table and you pick up your fork, the nerve endings in your skin – in other words, your sense of touch – feel the fork in your hand while your eyes simultaneously see it (*detecting*). This information is carried by the PNS to the CNS instantaneously. The CNS processes the information and allows you to know you are holding a fork without

consciously thinking about it (*analyzing*). The somatic nervous system is also responsible for the execution of movement because it has nerves attached to your muscles. Therefore, when your CNS remembers past experiences with a fork (*deciding*), it uses your PNS to tell the muscles in your hand, arm, and shoulder how to use it (*executing*) (Klein, 2000).

The PNS also receives and sends signals to your internal environment, specifically your organs (Pinel, 2011). These messages are carried by the autonomic nervous system (ANS). For example, when you feel like you have to use the washroom, the PNS is carrying a signal from your bladder to the CNS (*detecting*), which is recognizing that your bladder needs to be emptied (*analyzing*), and telling you that you need to get to a washroom (*deciding*), and finally, sending a signal to your body via the PNS to get up and walk to a washroom (*executing*) (Klein, 2000).

These are very simplified explanations of extremely complex systems. The information received by the CNS from the ANS helps you to maintain homeostasis. *Homeostasis* essentially means the regulation of your internal environment so that your body can maintain certain levels of energy use (Klein, 2000). This maintenance is done with two systems: the *sympathetic nervous system* and the *parasympathetic nervous system*. The *sympathetic nervous system* is the system that gets your heart beating when you are watching a scary movie. When your CNS senses danger, your sympathetic nervous system increases your heart rate to get more blood flowing to your muscles, increases your respiratory rate to get more oxygen for that blood, and releases energy stores into the blood stream so that you can be prepared to fight or run away – a state referred to as *fight or flight*. Once the danger has passed, or when you turn off the movie, if your CNS believes that you are no longer in danger, it will allow the parasympathetic

nervous system to bring everything back to normal. This restores homeostasis because your body goes back to working at a healthy pace so you can conserve energy (Pinel, 2011). Individuals who experience chronic stress face their sympathetic nervous system getting them prepared for danger without their CNS giving cue that the danger has passed, meaning that the parasympathetic nervous system cannot work to bring their body back to a healthy level; this consequently affects their health and well-being (Pinel, 2011).

To recap, then, there are two systems: the *central nervous system* (brain and spine) and the *peripheral nervous system* (connects CNS to body). The peripheral nervous system is broken down into two systems called the *somatic nervous system* (interacts with organs) and the *autonomic nervous system* (interacts with external environment and muscles). The autonomic nervous system is then divided into two parts of its own: the *sympathetic nervous system* (gets the body ready in threatening situations) and the *parasympathetic nervous system* (restores homeostasis). This is the basic system that controls our everyday life, and is the most complex version of this system that has ever existed. Scientists believe that this system has come developed over 600 million years of evolution (Pinel, 2011).

Evolution is the process of gradual change for the improvement of survival skills. 600 million years ago, the only organisms on earth lived in the water. Fast forward 150 million years, and these organisms have developed long nerves that run down the center of their backs, much like the structure of our spinal cord. With another 25 million years, these organisms developed bones to protect that nerve, much like human spines. These animals are called *vertebrates*, and they are very similar to fish. Approximately 410

million years ago, some of these vertebrates moved onto land. Over time, these vertebrates evolved so that their fins became legs and their gills became lungs. This was the early development of today's amphibians. Approximately 180 million years ago, these creatures started keeping their eggs inside their body for safety instead of laying them, so that their young would be more mature when they were born. They also started using glands to feed their young from their own body. These were our first glimpse of modern-day mammals. Fast forward, and some of these mammals began to walk standing on their back two feet, and using their front two feet for other tasks. These animals were our first primates (Pineal, 2011).

To recap, over a few hundred million years, some animals have developed to walk upright, carry their young inside their bodies until they are mature enough to survive, feed those young from glands on their bodies, use hands to accomplish tasks, and have large skull cavities which scientists theorize held larger brains. These animals are referred to as *hominims*, which are the ancestors of humans. Six million years ago, these hominims evolved into the *homo* species, characterized by larger brain cavities and their ability to make fire and use tools. Only 200,000 years ago do we see the first *homosapians* – humans. Scientists believe that this all took place in Africa until approximately 50,000 years ago when humans decided to migrate and spread out over the land (Pineal, 2011). Again, this summary of evolution is very simplified; the evolution of these specifies took millions of years and very complex processes.

Due to the evolutionary process, many animal species share similar brain structures and these structures perform similar functions as human brains (Dahl & Spear, 2004). Animals enact behaviours that promote the survival of their species. Scientists

believe that, due to evolution, human abilities come from modifications to the abilities of our closest genetic relatives such as rats, mice, and primates (Dahl & Spear, 2004). What may surprise you is that humans share many of these primitive survival behaviours and are not conscious that they are happening. If we focus on adolescents, animal species of all kinds (including humans) who are in this developmental stage show increases in social interactions with peers and conflicts with parents. From an evolutionary standpoint, our brains likely tell us to do this so that we have a better chance of meeting people who have different genes than us. That way, when mating time comes, we will be able to provide our offspring with two sets of different genes, making them stronger than if we mate with someone with similar genes as us such as a family member (Dahl & Spear, 2004). The possibility of mating with a family member may appear to be an irrational idea; however, animal species who are unable to find other mating partners will mate with relatives because otherwise, there would be no offspring and the species would not survive. Although humans are not now concerned with this, the increase in relationships with peers and conflicts with parents may be traced back to these ideas.

As another example, for many animal species, adolescence is a time of increased sensation seeking and risk taking. In human adolescents, there is a 200% increase in morbidity and mortality compared to childhood. Three-quarters of these incidents are preventable (Dahl & Spear, 2004). From an evolutionary perspective, adolescent brains may be telling them to seek new experiences and explore so that they can, once again, distance themselves from their parents. In addition, male adolescents of many animal species are more likely to participate in risk-taking behaviours. In many animal species, females choose which males to mate with based on their physical abilities, because it

suggests that they have good genes to pass on to offspring. Adolescent boys are more likely to engage in risk-taking and violent behaviour to demonstrate their physical prowess to females. Again, humans may not consciously have these thoughts, but our behaviours align with animal species that follow these rules.

Thus far, we have discussed the basic design and potential evolution of the nervous system and how our behaviours may still be motivated by some of the innate behaviours that we inherited from our animal ancestors. Next, we will discuss the inner workings of the brain, which is the main reason that we as humans find ourselves at the top of the food chain and the source of these behaviours. First, it is important to understand the role of *neurons*, which are the tiny cells that send and receive all the electrochemical signals that make each human unique. Neurons carry messages to the various parts of your brain by starting a chain reaction: one neuron fires, which can excite the appropriate neurons around it to also fire, which again excite the neurons around them, and so on until the message gets to where it needs to go – akin to a very complex game of telephone. This process happens because of *neurotransmitters*: when a *neurotransmitter*, a chemical in the brain, is released from a neuron, whatever neurons around it have receptors for that chemical may fire, and carry on the chain reaction. Common neurotransmitters include dopamine, epinephrine, norepinephrine, and serotonin (Pineal, 2011).

Your brain develops from the back to the front (Payne, 2014). The *hindbrain* is found at the top of your spinal cord. It has two main jobs, but plays a role in a variety functions. The first function is safeguarding your survival. Part of that means receiving messages from the ANS and returning instructions to your organs to maintain your vital

body functions. This task is coordinated by the *medulla oblongata (*Pineal, 2011). Your heart rate, body temperature, respiration, and digestion are all controlled from this area of the brain. Damage to the medulla oblongata results in death, because you lose the ability to maintain the function of your vital organs (Klein, 2000). Another part of safeguarding your survival involves making sure you are aware of dangers around you and are not distracted by irrelevant stimuli. The *reticular activating system* (RAS) is the system responsible for your body's levels of alertness. It takes cues from your brain to decide the level of alertness required of your body (Sousa, 2011). For example, you are aware of the colour of the walls in the room you may currently be sitting in, but it is unlikely that your body is alert to these. However, if a stranger were to walk into the room suddenly, your whole body would be alerted to them, because they may be a potential threat. Finally, the hindbrain is the first to receive sensory information from your body, and it is the first leg in the race of getting this information to the necessary brain regions (Klein, 2000). This is the responsibility of the *pons*, the area of the hindbrain that relays sensory information to the *cerebellum* and *thalamus*, which we will discuss later on (Klein, 2000).

The second job of the hindbrain is to coordinate the movements of your body. The *cerebellum* coordinates this incredibly important task and accounts for 11% of your brain's total weight, with more neurons than all other brain regions combined (Sousa, 2011). This makes sense if you think about how this area of the brain is responsible for coordinating nearly 700 muscles into smooth actions such as walking or talking. In order to do this, this area of the brain needs to be aware of every muscle in your body (Sousa, 2011). The cerebellum is also in action when you visualize yourself completing a physical task (Sousa, 2011). For example, a professional figure skater may visualize

his/her jump before going out on the ice for competition. Participating in this type of mental rehearsal triggers that same place in the brain as actually do the action does. Therefore, visualizing movements improves the performance and skill of that movement, a powerful hack for the cerebellum (Sousa, 2011).

Scientists believe that the cerebellum stores certain movements as patterns so that they become automated, meaning that you do not have to consciously think about enacting them. This automation allows your mind to be free to think of other things (Sousa, 2011). A good example of this is when you first learned how to tie your shoes compared to when you tie them now. When you were first learning, you likely had to recite a memory sequence to help you remember the movements, such as the "two bunny ears." However, now it is likely that you can tie your shoes without giving it much conscious thought, and can have a conversation at the same time. This is because your cerebellum stored this sequence of movements together to save your brain energy when doing this task. This applies to many actions. Even just standing up straight: as a baby, balance had to be practiced and engrained in our cerebellums so that we could master it and add to it to create other complex movements (Pineal, 2011). Damage to nerves in this area of the brain is associated with Huntington's disease, which causes jerky, uncontrollable movements (Klein, 2000).

The *midbrain* is a smaller brain area, located directly above and in front of the hindbrain. The midbrain's role is to process sensory information and relay it to the rest of the brain (Pineal, 2011). Part of this task is accomplished by the *tectum*, which is responsible for auditory and visual function including controlling the movement of your eyes and ears and processing the information that is received. The *tegmentum* plays a role

in voluntary motor function (Pineal, 2011). In essence, when you decide you want to make a movement, this area of the brain helps make it happen. It also controls basic body movements such as posture. The tegmentum houses an area referred to as the *reticular formation*, which plays a role in *consciousness*, or your mental awareness, as well as *arousal*, meaning your brain's excitement. This awareness occurs at the basic level such as sleep/wake cycles (Klein, 2000). This is similar to the RAS, located in the hindbrain. The main difference between the two is that the RAS controls your body's alertness and the reticular formation controls your mind's alertness. If the tegmentum is damaged, you will fall into a coma due to the area controlling your consciousness no longer functioning (Sousa, 2011).

Ancient civilizations believed that our thoughts and feelings came from the heart. This is where expressions such as "know it off by heart" originated (Jarrett, 2015). However, scientists now know that the area you would be able to see if you cut off the top of your skull – and everything inside of it – is responsible for our higher cognitive functions such as thoughts, emotions, reasoning and analytics skills, memory, and much more. This area of the brain is called the *forebrain*. The grey and wrinkly part you think of when you imagine a brain is the *cerebrum*. Those wrinkles are actually folds that allow you to have more brain matter without needing more surface area (Klein, 2000). For example, if you took a sheet of paper and wrote notes covering all areas of both sides, then took that piece of paper and crunched it into a ball, you would still have the same amount of information present, but it would take up much less space. The same theory applied to the folds of the cerebrum. The cerebrum is divided into two hemispheres.

Interestingly, each hemisphere processes information from the opposite side of the body; for example, your right hemisphere controls your left hand (Sousa, 2011).

The cerebrum is covered by the *cerebral cortex,* which is divided into four distinct lobes: the *occipital lobe, parietal lobe, frontal lobe,* and *temporal lobe.* The *occipital lobe* is located at the back of your skull. It's main task it to analyze visual information. Damage to this area of the brain causes you to lose your visual capabilities. If the area of your brain responsible for visual function is still intact, your eyes would actually still see, but your brain would be unable to recognize most of what it sees (Sousa, 2011). The *temporal lobe* plays the same role for auditory capabilities. It is the area of the brain that holds language, including some parts of speech (Sousa, 2011). This region is also responsible for face and object recognition and contributes to long-term memory (Pineal, 2011). A man referred to as H.M had a portion of his temporal lobe removed due to a seizure condition. After the surgery, H.M was no longer able to form long-term memories, which meant he could not retain any new information (Jarrett, 2015). Cases like these are what help scientists to pinpoint what specific brain regions are each responsible for.

The *parietal lobe* takes information that comes from the hindbrain about the body and analyzes it. It is what lets us know where objects are in space, including our bodies (Pineal, 2011). Oliver Sacks (1998) wrote an interesting story of a man who he studied who woke up and saw a leg in his bed. Shocked by the leg, he threw it from the bed. The man also fell to the floor: it had been his own leg all along. Some scientists believe that the feeling that his leg was not his own may be caused by damage to the parietal lobe of the brain (Pineal, 2011). Another interesting fact about this area of the brain is that it

analyzes sensations that come from our facial muscles. The facial expressions that you make have an effect on what the parietal lobe tells your brain (Klein, 2000). Therefore, when you smile, even if it is forced, your parietal lobe interprets that in a way that actually affects your brain.

The final area of the cerebral cortex to discuss is the *frontal lobe*, which is a particular area of interest for individuals who study adolescence (Dahl & Spear, 2004). This interest is due to the fact that this is the last area of the brain to fully develop: some have estimated that development of the brain, and the frontal lobe in particular, may not be completed until 23 to 25 years of age (Payne, 2014). In particular, the frontal lobe undergoes major development during the teenage years (Sousa, 2011) and is the location of complex cognitive processes such as planning, evaluating the outcomes of behaviour, impulse control, forethought, judgment, empathy, and more (Payne, 2014). This is the area of your brain that allows you to consider hypothetical questions, and process reading, music, speaking, math, and writing (Sousa, 2011). Most importantly, your frontal cortex makes you who you are; damage to this area of the brain is associated with personality changes (Pineal, 2011). The frontal lobe is the home of the *prefrontal cortex*, which controls working memory, attention, and inhibition (Sousa, 2011) – executive functions that will be discussed in later sections. Finally, the frontal lobe plays a major role in language production. Scientists were able to figure this out when they studied that case of a man who had a lesion on his frontal lobe. The man was capable of understanding speech, but was only able to produce one syllable and one phrase in total. This showed scientists that when the frontal lobe is unable to function as it should, humans are unable to properly produce language (Jarrett, 2015).

Returning to the forebrain, the inner structures of the cerebrum assist in the processing of information that is received by the cerebral cortex. To start, the forebrain uses the *thalamus* to process all incoming sensory information, except smell (Pineal, 2011). As you may remember from our discussion about the pons, *the thalamus* receives sensory information from the pons, which receives it from the ANS. The thalamus takes this information and distributes it to the sensory cortex, which makes sense of it. The thalamus also acts as the administrative assistant of the brain and distributes information between brain regions (Klein, 2000). For example, the *motor cortex* is the area of your brain that that tells the cerebellum when we need to move; in order to get this information where it needs to go, the motor cortex first sends it to the thalamus to forward to the right place.

The forebrain also houses a series of structures referred to as the *limbic system*. This system consists of the *hippocampus*, the *amygdala*, the *cingulate gyrus*, and the *hypothalamus*. Each of these structures is mirrored in each of the two cerebral hemispheres (Sousa, 2011). The *hippocampus* has many roles: this area of the brain is involved in a few memory processes, and one in particular is spatial memory (Pineal, 2011). If you were to close your eyes and imagine the layout of your bedroom, this is the area of the brain that encoded that information for you to be able to remember it. One of its major roles is converting information held in working memory by comparing new information with what has already been experienced (Sousa, 2011). Finally, the hippocampus helps us recall facts, objects, and places (Pineal, 2011). This project will review more about the processes involved with memory in another section. Damage to neurons in the hippocampus is associated with Alzheimer's disease, which is

characterized by the gradual inability to form new memories and retrieve old ones (Sousa, 2011).

The *amygdala* also plays a role in memory because of its involvement in the experience and production of emotions (Pinel, 2011). Some researchers believe that this area is where emotional memories are stored; others believe that it encodes the emotional experience of the situation onto the memory for better long-term storage in the brain. Either way, this area of the brain is responsible for the experience of emotions when we remember an event (Sousa, 2011). It is the area of the brain that signals the "gut punch" feeling that reminds you how you felt when you embarrassed yourself, for instance.

The *cingulate gyrus* plays an important role because it uses input received from the structures of the limbic system and cognitive centers of the brain to control how you shift your attention (Payne, 2014). It also plays a role in how you interpret information by assigning positive or negative affects to it (Klein, 2000). When this area of the brain is overactive**,** you may have a hard time letting go of encounters that were upsetting to you. You will think about them over and over. Over-activity in this area of the brain is associated with anxiety disorders such as Obsessive Compulsive Disorder (CD) because the individual is unable to let go of the anxiety-provoking thought (Payne, 2014).

Finally, the *hypothalamus* in involved in the regulation of motivated behaviours such as sleep, eating, and sex (Pineal, 2011). This area of the brain receives information from the body – such as low glucose levels, for example, which then signals your stomach to growl, motivating you to get something to eat – and is the area of the brain that makes you salivate when you smell food (Klein, 2000). It regulates these functions using hormones that are released from the pituitary gland (Sousa, 2011). In summary, the

limbic system has a role in memory, emotions, and motivated behaviours. This area of the brain undergoes a surge of growth, development, and activity during the adolescent years, which may explain the tendency for them to be highly emotional during this developmental period (Payne, 2014). Over-activity in this area of the brain is associated with mood disorders such as depression (Payne, 2014).

Conclusively, the brain is an extremely complex and interesting organ. A recent study demonstrated how a 17 year old male was functioning normally after having one whole hemisphere of his brain removed at the age of 2 due to a tumor (Danelli et al., 2013**).** Information like this makes it difficult to understand how people believe we only use 10% of our brains. Our brains use up 20% of our body's energy consumption (Jarrett, 2015), and you can see from this introduction that our brain is packed with structures that are consistently in use. However, the way that we treat our brain, especially when it is developing, has impacts on the way it functions for the rest of our lives (Dahl & Spear, 2011). Adolescence in particular is a time of major development where we become bigger, faster, stronger, and smarter than we have ever been before (Dahl & Spear, 2011). The purpose of this collection of podcasts and the information presented in the following sections is to help adolescents understand the impact their actions have on their brains and their lives. It is my hope that this introduction will help prime their cerebral cortex towards this type of thinking, and get them started on the path of making choices that help the development of their brains, rather than hinder it.

Sleep and the Brain

In this section, I will discuss the underlying causes, developmental and environmental factors, and consequences of sleep deprivation in adolescents. The intent

is to use this information to demonstrate the importance of sleep and outline why it is an important topic to discuss with adolescents. First, I will discuss developmental changes in sleep patterns at the onset of puberty. Second, environmental factors that affect the sleep patterns of adolescents will be explored. Lastly, the consequences of sleep deprivation on day-to-day and long-term functioning of adolescents will be presented.

Sleep is becoming a major international health concern (Fallone et al., 2002). When children reach adolescence, they begin to get less sleep, despite the fact that they still require 10 hours of sleep a night (Capaldi et al., 2005; Dahl & Lewin, 2002; Fallone et al., 2002; Hasler & Clark, 2013). What is known about sleep is that sleep deprivation has consequences for the daily brain functioning of adolescents including implications for mood regulation (Capaldi et al., 2005; Dahl & Lewin, 2002; Vandekerckhove & Cluydts, 2010), reward-related brain functioning, and executive control (Hasler & Clark, 2013). It also plays a role in school attendance and academic performance (Capaldi et al., 2005; Dahl & Lewin, 2002; Fallone et al., 2002).

The circadian rhythm is something experienced by all living things. Because the earth rotates 360 degrees on a 24 hour cycle, living things have evolved to predict the changes that are associated with it (Olds, 2015). In humans, for example, we have a *suprachiasmatic nucleus* (SNS), which is located in the hippocampus behind our eyes. This SNS detects light and uses that detection to cue the rest of the body (Reinsoso-Suárez, de Andrés, & Garzón, 2011). The SNS is especially important for the secretion of *melatonin*, a hormone that makes us tired (Dahl & Lewin, 2002). In normal sleep schedules, melatonin release begins at the onset of night and begins notifying our bodies that it is time for sleep (Hasler & Clark, 2013).

Sleep is divided into three main stages: wakefulness, non-REM sleep, and REM sleep. This is referred to as the *sleep-wake cycle* or SES. *Wakefulness* is a more obvious stage; this is everything we consciously remember being a part of. *Non-REM sleep* is light sleep or dozing, and this can account for up to 50% of a night's sleep. The good stuff is *rapid eye movement* (REM) (Reinsoso-Suárez et al., 2011). To prep for this stage of sleep, the body releases hormones that paralyze your limbs; this prevents you from acting out the dreams that are characteristic of this sleep stage (Randall, 2012). However, the eyes still move around behind the eyelids, hence its name. Unfortunately, this isn't a perfect system. For individuals with sleep disorders, the body does not effectively paralyze the limbs and it can result in some dangerous situations. Some people have reported jumping form windows, tackling nightstands, or walking three blocks in the winter with no shoes on, all while sleeping (Randall, 2012). When we sleep, our prefrontal cortex sleeps, too. This is the part of the brain that is responsible for conscious decision making and processing of information from the body; therefore, individuals who sleep walk do not make conscious decisions about their actions and likely feel no pain (Randall, 2012).

Scientists are not sure why we dream. What they do know is that blood flows to the emotional and memory centers of the brain, which explains why dreams typically involve people and places that we recognize (Randall, 2012). Calvin Hall (2012) collected descriptions of dreams from over 50,000 people. What he found was that, on average, dreams tend to be negative in nature or feature mean or aggressive characters. Some scientists believe that dreams are the mind's way of doing a trial run of anxiety-provoking situations. In fact, our bodies respond to dreams as if they were really

happening (Randall, 2012). Another theory is that dreaming is the result of the hippocampus sorting through and organizing all the information that we process in a day. As we will discuss further on, this is why sleep is important for learning new things (Randall, 2012).

Developmentally, adolescents experience biological changes associated with puberty. Despite these changes, evidence suggests that adolescents do not need less sleep (Capaldi et al., 2005; Dahl & Lewin, 2002; Fallone et al., 2012; Hasler & Clark, 2013). What researchers have found is that this age group typically demonstrates more daytime sleepiness and decreased sleep on school nights (Fallone et al., 2012). This happens because of *delayed circadian preference*, meaning that adolescents begin to prefer to stay up later and sleep in later in the morning (Capaldi et al., 2005). This preference begins to affect their entire circadian system, very similar to jet lag. Delayed circadian preference is associated with increased likelihood of depression, decreased reward responsiveness, and increased sensation seeking (Hasler & Clark, 2013).

Because adolescents prefer to stay up later, but are still required to rise early for school, their delayed circadian preference causes them to experience sleep deprivation (Friedman, Corley, Hewitt, & Wright, 2009) and *circadian misalignment* (Hasler & Clark, 2013), which refers to the process by which a person's preferred SWS do not match with the demands of his/her social schedule. This misalignment causes adolescents to experience *chronic sleep debt* (Beebe et al., 2009; Fallone et al., 2012), which happens because of an accumulation of multiple nights without enough sleep and leads to adolescents reverting back to a delayed circadian preference on the weekend to accommodate for the lack of sleep during the week (Hasler & Clark, 2013). What this

then does is prevent the adolescent from forming a normal SWS that conforms to the required school start times (Fallone et al., 2012). Hasler and Clark (2013) believe that adolescents develop a delayed circadian preference because they become more resistant to something called *homeostatic sleep drive*: a signaling system within the body that is responsible for maintaining wakefulness throughout the day and helping us sleep at night. This increases with time spent awake and decreases during sleep (Hasler & Clark, 2013).

Another developmental factor that influences adolescent sleep is emotional variability (Dahl & Lewin, 2002). During adolescence, individuals' threat perception increases, they experience a greater cognitive basis for generating worries, and they have a more difficult time managing their emotions (Dahl & Lewin, 2002). From an evolutionary perspective, Dahl and Lewin (2002) reported that our brains evolved to rely on social connectedness and belonging to feel safe. Because of the complete loss of muscle tone and consciousness experienced during REM sleep, our ancestors needed to rely on each other for safety during sleep periods. Adolescents' increased threat perception makes them especially susceptible to social stress, which prevents the body from experiencing the safe feeling that is needed to be able to undergo REM sleep (Dahl & Lewin, 2002). REM sleep plays a role in the processing and consolidating of daily experiences both positive and negative (Vandekerckhove & Cluydts, 2013). When individuals are unable to experience the REM sleep stage, they have a more difficult time processing negative life events and consolidating memories created throughout the day (Vandekerckhove & Cluydts, 2013). This has implications for academic achievement because adolescents may not be consolidating material learned throughout the school day.

Environmentally, Dahl and Lewin's (2002) theory demonstrates that academic pressures, social influences, anxiety, and stress can all play a role in the quality of sleep that adolescents experience (Friedman et al., 2009). Another environmental factor that plays a role in sleep behavior is light and arousal, including feeding, exercise, and social interaction (Hasler & Clark, 2013). As we know, the SNS, which is sensitive to light, controls the release of melatonin in the brain, which is responsible for helping us synchronize our circadian system (Dahl & Lewin, 2002). However, light and artificial light suppress the release of this hormone (Hasler & Clark, 2013). It has been suggested that adolescents' access to stimulating activities and electronic devices that produce artificial light play a role in their difficulties falling asleep at night because of the suppression of melatonin (Friedman et al., 2009; Hasler & Clark, 2013). This age group is also influenced by social factors including an increased desire to stay up late, self-determined bed times, and decreased adult supervision at later hours (Dalh & Lewin, 2002; Hasler & Clark, 2013).

Adolescents who do not get enough sleep at night show poorer academic performance (Capaldi et al., 2005; Fallone et al., 2002; Hasler & Clark, 2013). One key component of decreased performance is concentration (Beebe et al., 2009; Capaldi et al., 2005; Hasler & Clark, 2013). Studies have found that adolescents with increased daytime sleepiness have difficulty participating in low stimulation activities such as repetitive tasks and paying attention in class (Dahl & Lewin, 2002). It has also been found that sleep deprivation may cause adolescents to have a difficult time on tasks requiring both emotional and cognitive skills (Dahl & Lewin, 2002). Beebe et al. (2002) found that adolescents in their sleep-deprived group were able to perform well on attention-

demanding tasks, but were unable to perform well on tasks requiring the shifting of attention. Finally, students who do not get enough sleep at night are more likely to miss school, another factor in academic performance (Capaldi et al., 2005; Hasler & Clark, 2013).

Another consequence of lack of sleep is mood disturbance (Hasler & Clark, 2005). Vandekerckhove and Cluydts (2009) reported in their article that lack of sleep causes the *amygdala*, or the component of the emotional response, to fail, therefore making it more difficult to control and inhibit the emotional response. This means that adolescents who do not get enough sleep are more likely to show stronger emotional reactions to situations (Dahl & Lewin, 2002). Capaldi et al. (2005) expected to find that the adolescents in their sleep-deprived group would show more stress response to stimuli than their control group. What they actually found was that adolescents showed less stress response to stress-related stimuli. The authors hypothesized that that less sleep affects the brain's ability to attend to stimuli (Capaldi et al., 2005). A link has also been found between not getting enough sleep and depression (Hasler & Clark, 2013; Fallone et al., 2002; Vandekerckhove & Cluydts, 2010).

Additionally, risk taking is a factor that is affected by the amount of sleep adolescents get (Capaldi et al., 2005; Fallone et al., 2002). One possible explanation is impaired executive control caused by lack of sleep (Friedman et al., 2009; Hasler & Clark, 2013). This impairment makes adolescents more likely to participate in alcohol and drug use (Friedman et al., 2009). Other factors that increase the adolescents' likelihood of alcohol and drug use include later peak hours of the day due to delayed circadian preference, less supervision by parents at later hours, and an increase in

sensation seeking (Hasler & Clark, 2013). Another possible explanation for the relationship between sleep and risk taking is that adolescents experience reduced reward responsiveness (Hasler & Clark, 2005). This response happens because melatonin plays a role in the production of *dopamine*, which plays a large role in the reward system in the brain. Therefore, if adolescents are experiencing a suppression of melatonin release due to exposure to arousing activities and artificial light, it is likely that their dopamine system is also not functioning properly, making them require more sensation to reach the same dopamine levels (Hasler & Clark, 2005).

Developmental and environmental factors associated with sleep, as well as the consequences of a lack of sleep, demonstrate the importance of informing adolescents about how their brains operate without enough sleep. Many factors presented, such as self-determined bed times and exposure to artificial light, are situation which the adolescent has the power to control. If they were able to modify their behavior to improve sleep even a little bit, we would be likely to see less of the consequences associated with chemical release in the brain, such as risk taking and circadian misalignment, which would help to improve the associated factors such as academic performance.

Diet and the Brain

In this section, I will discuss the importance of proper nutrition including the risk of obesity and the health issues associated with it, the impact that Western dietary habits have on our brains, the role of glucose for energy, the role of a few essential nutrients, the implications of diet on mental health, and the impact of family meals and breakfast consumption on cognitive function.

Diet is an environmental factor that plays a key role in the health and well-being of adolescents, both at their current developmental phase and into adulthood. Adolescence is a stage where individuals begin to make their own decisions about their day-to-day lives and is often characterized by poor dietary habits (Laska, Murray, Lytle, & Harnack, 2012). Poor dietary habits, and consequentially, nutrition, can lead to poor academic performance (Francis & Stevenson, 2013; Videon & Manning, 2003), affect brain development and function (O'Connor & Cryan, 2014a; Isaacs & Oates, 2008; Jacka et al., 2010; Mahoney, Taylor, Kanarek, & Samuel, 2005; Meeusen, 2014), and lead to chronic diseases (Bourre, 2004; Francis & Stevenson, 2013; Jacka et al., 2010; Meeusen, 2014; Oddy et al., 2009; O'Connor & Cryan, 2014; Videon & Manning, 2003). Nutrition is most important for brain development during growth spurts, one of which typically occurs between 10 and 12 years of age, and another between 14 and 16 years of age (Isaacs & Oates, 2008).

Florence, Asbridge, and Veugelers (2008) suggest that healthy dietary habits adopted in adolescence are likely to continue into the future. This means that the food choices adolescences make can have an impact on their future (Hoyland, Dye, & Lawton, 2009). Malik et al. (2012) found that women who had healthy eating habits in high school were more physically active, less likely to smoke, gained less weight, had better dietary habits, and were less at risk for developing type 2 diabetes. These findings demonstrate the importance of educating adolescents about how their diet affects their bodies; the habits we help them form now will play a major role in their futures.

Obesity is a public health concern, especially when we speak in term of children and adolescents. Obesity has been linked to poorer levels of academic achievement

(Florence et al., 2008), increased risk of developing type 2 diabetes (T2D) (Malik et al., 2012), and decreases in brain volume (Meeusen, 2014). It has been found that obesity is strongly linked to Western dietary patterns (Malik et al., 2012) and poorer academic performance in adolescence (Nyaradi et al., 2014). A Western diet can be characterized by an excess intake of dietary fat and refined sugars, and an inadequate intake of fruits, vegetables, and whole grains (Francis & Stevenson, 2013). This dietary pattern is the primary reason for the current obesity rate in children and adolescents (Francis & Stevenson, 2013). Oddy et al. (2009) estimated that one-quarter of adolescents' dietary intake is in the form of snacks, and energy-dense confectionary items were often eaten in place of meals. This, paired with frequent intake of sweetened beverages, high fast-food consumption (Laska et al., 2012), and reduced intake of fruits, vegetables, and whole grains (Francis & Stevenson, 2013), puts adolescents at risk of becoming obese (Florence et al., 2008). One study found that 70% of the adolescents reported not eating at least two vegetables the day before, 55% did not eat at least two fruit the day before, and 47% did not have at least two servings of dairy in the previous day (Videon & Manning, 2003).

Francis and Stevenson (2013) conducted a study that demonstrated that Western diets also interact with the body to create numerous other side effects. For example, diets high in saturated fat and refined sugar (HSF) have been found to have long-term impacts on the brain and its functioning including affecting cognitive tasks such as memory, attention, and inhibition. The researchers also found that HSF diets decrease the level of *brain-derived neurotropic factor* (BDNF), which plays a key role in memory and in learning. One interesting finding from Francis and Stevenson's (2008) study was that HSF diets affect energy regulation in the hippocampus and prefrontal cortex, areas of the

brain that play a role in inhibition and memory. Implications for decreased energy regulation in these brain areas are increased food consumption due to less inhibitory control, and less accuracy recalling past food eaten, which also leads to increased food consumption. This finding was especially prevalent in the brains of obese individuals (Francis & Stevenson, 2008). Therefore, eating foods that are high in saturated fat and refined sugar makes you more likely to continue eating them and less able to resist eating them.

However, this does not mean that all sugar is bad. In fact, our brains and bodies need *glucose*, a carbohydrate and simple sugar, to provide energy to our cells (Mahoney et al., 2005; Isaacs & Oates, 2008). The level of glucose circulating in your blood, or blood sugar, is written in a measure called the glycemic index. Food high on the glycemic index (e.g., French fries, white bread, soda crackers) peak your blood glucose level at first, but lead to a lower level of glucose circulation in your bloodstream. Foods low on the glycemic index (e.g., whole grains, sweet potatoes, bran) peak your blood sugar less but maintain a more ideal blood sugar level for your body (Mahoney et al., 2005). A rise in blood glucose in the brain of adolescents can also have positive effects. This effect happens because children's brains are more metabolically active, which means they need more glucose than adults to compensate for energy spent (Benton & Jarvis, 2007; Hoyland et al., 2009). One study demonstrated that a glucose drink improved ratings of alertness for 90 minutes (Wesnes, Pincock, Richardson, Helm, & Hails, 2003). Another study found that a glucose drink improved decision time in a reaction test, decreased information processing time, and improved word recall (Bellisle, 2001).

Too much sugar in your blood can cause dysfunctions in the cells of the brain that lead to increased *oxidative stress*, which has been linked to many neurodegenerative diseases including dementia (Francis & Stevenson, 2013). *Oxidation* is damage caused at the cellular level by *free radicals*, uncharged molecules that are missing electrons. Basically, these free radicals move around the body stealing electrons from other molecules to make themselves whole, leaving destruction in their path (Klein, 2000). *Oxidative stress* happens when the body is unable to counteract or repair the damage done by oxidation.

Antioxidants are substances that inhibit oxidation. Antioxidants can be found in fruits, vegetables, nuts, grains, poultry, and fish. Some even say that antioxidants help to keep the brain and body young (Payne, 2014). *Polyphenols*, macronutrients that are found in plant-derived foods, act as powerful antioxidants in the human body (Meeusen, 2014). They help protect against damage done to the brain by neurotoxins, help suppress inflammation in the brain, promote memory, learning, and cognitive function, and reduce the risk of dementia by protecting against neurodegeneration (Meeusen, 2014). Polyphenols can be found in parsley, celery, citrus fruits, herbs, soy, wine, berries, onions, leeks, broccoli, green tea, chocolate, cocoa, kiwis, plums, apples, grapes, and peanuts (Pérez-Jiménez et al., 2010).

Early exposure to sweet and fatty foods creates a lifelong preference for them (Francis & Stevenson, 2013). These foods actually create changes in the brain's reaction to food that is similar to the brain's reaction to addictive drugs such as alcohol, cocaine, and heroine (Francis & Stevenson, 2013). Refined sugar and fatty foods are energy-dense and are metabolized easily, meaning that they make us feel full for a shorter period of

time compared to higher fiber, low-energy density foods, which make us feel full longer and reduce the risk of obesity (Ambrosini, Emmett, Northstone, Howe, & Jebb, 2012). In children aged 7 to 15 years old, energy-dense, low-fiber dietary habits were associated with greater body fat (Ambrosini et al., 2012).

We know that diets high in saturated fat can be detrimental to the functioning and development of the brain. The opposite is true for essential fatty acid known as *unsaturated fats*, specifically *polyunsaturated fats* (PUFAs). PUFAs, especially omega-3 fatty acid, are critical for normal brain development (O'Conner & Cryan, 2014). Fatty acids decrease the incidence of cardiovascular disease and work in the body to maintain cell membranes. Cell membrane maintenance makes them important for nutrient transport in the brain due to the part they play in what passes into the cell (Bourre, 2004). We do not get enough of these essential fatty acids in our Western diet (Bourre, 2004). Bondi et al. (2014) fed rats a PUFA-deficient diet: they found that when those rats had children, those children were likely to have behavior deficiencies including increased anxiety and hyperactivity, possessed increased goal-irrelevant behavior and decreased goal directed behavior, and showed changes in dopamine-related neurotransmission systems, systems that are distinct to adolescents. The rats were also found to be slower at learning tasks and had more issues with short-term memory-related tasks. In summary, when the rats did not eat enough PUFAs, it affected the health and well-being of their offspring. The implication is, if these findings could be generalized to humans, that our Western dietary habits are potentially affecting the lives of our future children. PUFAs also play a role in vision and hearing due to the fat content required in the retina and its role in maintaining the cells of the cerebral response (Bourre, 2004).

Because PUFAs maintain cell membranes, they are partially responsible for preventing cell degeneration. Cell degeneration is a key factor in chronic diseases such as dementia, schizophrenia, and depression (Bourre, 2004). Depression and other mental health issues have been recognized by the World Health Organization as major health issues for adolescents (Oddy et al., 2009). In fact, for three-quarters of psychiatric illnesses, the onset occurs during adolescence or early adulthood (Jacka et al., 2010). This places nutrition and diet as important environmental factors to be studied in relation to mental health issues (Bondi et al., 2014). Oddy et al. (2009) found that higher scores on the Child Behavior Checklist (CBCL) in early adolescence, meaning poorer mental health, was associated with high intake of foods associated with Western dietary patterns including take-out foods, red meat, and confectionary foods. The researchers also found the lower scores on the CBCL, meaning higher mental health rating, were associated with more consumption of leafy green vegetables and fruit, but not overall diet (Oddy et al., 2009). This also supports research conducted by Jacka et al. (2010), which demonstrated that greater consumption of unhealthy or processed food was associated with self-reported depressive symptoms in adolescents, and that even one healthy dietary practice significantly decreased the odds for depression. For example, leafy green vegetables and fruit can help to prevent the inflammation in the brain that is associated with depressive symptoms and are high in folate, which enhances cognitive development. Lycopene in tomatoes can help reduce oxidative stress, another process associated with major depressive disorder (Oddy et al., 2009).

Depression and other mental health issues are only one example of how our bodies and minds react to the food that we eat. For example, Mahoney et al. (2005)

reported that ingestion of a meal high in carbohydrates increases the brain's level of *tryptophan*, which helps the body feel relaxed and calm and is a precursor to the synthesis of serotonin. Lack of serotonin in the brain is also associated with depression. However, increased tryptophan in the brain is not always a good thing because it causes fatigue and decreased alertness. Therefore, to counteract this effect, it is important to consume our carbohydrate meals with protein. Your body needs protein in order to form new cells and repair old ones (Hanna, n.d.), but it also increases *tyrosine* levels in the brain (Mahoney et al., 2005). *Tyrosine* increases dopamine and norepinephrine synthesis, increases alertness and reaction time (Mahoney et al., 2005), and assists with cognitive performance by reducing the negative effects of acute stress (Meeusen, 2014). Dopamine is also important because of the role it plays in motivation and reward processing (O'Connor & Cryan, 2014). Tyrosine can be found in high protein foods such as soy produces, chicken, fish, turkey, peanuts, almonds, avocadoes, milk, cheese, yogurt, and sesame seeds (Meeusen, 2014).

Adolescents' eating habits are influenced and established by internal and external factors including food preference, availability, body weight perception, and parental and peer influences (Hoyland et al., 2009; Isaacs & Oates, 2008). One way to ensure that adolescents are getting the essential nutrients that they need is through the practice of family meals. There is a positive association between consumption of regular meals and academic performance (Florence et al., 2008). In adolescence, the frequency of family meals decreases (Hoyland et al., 2009). In a study conducted on adolescents by Hoyland et al. (2009), they found that consumption of at least three family meals a week reduced

the likelihood that adolescents would skip breakfast and increased the likelihood of consumption of fruits, vegetables, and dairy.

Breakfast is an important meal for learning, school performance, and cognitive function (Benton & Jarvis, 2007; Mahoney et al., 2005; Wesnes et al., 2003). More specifically, researchers have found that skipping breakfast, a habit practiced by 42% of adolescents (Mahoney et al., 2005), particularly girls and older adolescents (Videon, & Manning, 2003), resulted in impaired attention and episodic memory, especially later in the morning (Benton & Jarvis, 2007; Hoyland et al., 2009; Wesnes et al., 2003). A study by Mahoney et al. (2005) found that in children aged 9 to 11 years old, those who ate oatmeal for breakfast, which has a low glycemic index, recalled more items in a spatial memory task, improved short-term memory for girls, showed better scores on a visual perception task, and had fewer false alarms on an auditory perception task compared to participants who ate cereal, which has a high glycemic index, or no breakfast. However, eating breakfast cereal rather than no breakfast at all is associated with a healthier body weight and healthier lifestyle choices (Hoyland et al., 2009; Laska et al., 2012). The effects of breakfast on school performance are especially profound in nutritionally at-risk children (Benton & Jarvis, 2007; Hoyland et al., 2009). Undernourished children already have decreased school attendance and academic performance compared to their well-nourished peers (Florence et al., 2008). For this reason, school breakfast programs can be very effective in improving academic performance and cognitive function of at-risk students (Bellisle, 2001; Florence et al., 2008).

We currently live in a culture where fruits and vegetables are more expensive than fast food and refined sugar (Florence et al., 2008). Nutrition is a key environmental factor

on which to focus because of how modifiable it is (Isaacs & Oates, 2008; Nyaradi et al., 2014). With higher parental education being associated with greater adolescent intake of vegetables, fruits, and dairy (Videon & Manning, 2003), the aim of this podcast and information is to give children the conversation starters to take home to discuss healthy eating with their parents, as well as kick-start thinking about how food affects our brains. Nutrition's effect on the brain has important implications for children's future. Jacka et al. (2010) stated that even one healthy dietary habit could have mental health benefits for adolescents. Although the information presented above is not an exhaustive look at the effects of nutrition on the brain and body, if this podcast encourages an adolescent to change one habit, then it is worth it.

The Role of Memory

In this section, I will discuss memory as a process, including working memory and its role, the role of executive functioning, phonological loop, visio-spatial sketchpad, and episodic buffer. I will also introduce the different types of memories, the process of memory retrieval, and consequences of poor working memory skills. Finally, I will focus on a few strategies that can be used to improve memory performance. Due to the large role of working memory, information presented will be largely focused here.

Memory is a key factor in human life. From an evolutionary standpoint, memory has kept humans from going extinct. It is what allowed us to remember important information such as where to find food and who our enemies were, and is the essential component of learning (Tokuhama-Espinosa, 2011). In modern Western culture, we no longer need our memory for surviving in the wilderness, but it still plays a key role in our health and well-being. Memory, specifically working memory, has been associated with

academic performance, which has implications for future success (Alloway & Alloway, 2010; Gradisar, Terrill, Johnston, & Douglas, 2008). In fact, in children, working memory has been found to be more predictive of academic success than IQ (Alloway & Alloway, 2010). Working memory has a part in reading comprehension, learning, and the ability to solve math problems (Alloway, & Alloway, 2010; Baddeley, 2003). In adolescents, poor working memory scores are associated with risk-taking behaviours (Romer et al., 2011), including alcohol consumption (Khurana et al., 2012).

Memory is the dynamic process taken on by many different brain regions to store and retrieve information (Jensen, 2008).First, we encounter a *stimulus*, which is recognized by our receptors and converted to sensations in the body. Once this happens, our neurons convert those sensations into *perceptions* and, depending on the attention we give these perceptions, some are transferred to memory (Dharani, 2015). *Short-term memor*y is the first step in the memory chain. Processed in the prefrontal cortex, information in short-term memory can be maintained for 10 to 12 seconds (Dharani, 2015) and we can hold seven plus or minus two pieces of information at a time (Dharani, 2015; Rekart, 2013). *Working memory* is, "a flexible, capacity limited, mental workshop used to store and process information in the service of ongoing cognition" (Morrison & Chein, 2011, p. 47). One job of working memory is handling information in short-term memory (Alloway & Alloway, 2010; Mellanby & Theobald, 2014; Rekart, 2013). The relationship between working memory and short-term memory can be demonstrated by asking an individual to remember a series of numbers and then asking them repeat them backwards. Short-term memory is responsible for remembering the series of numbers, while working memory manipulates the numbers so that they can be repeated backwards

(Rekart, 2013). Although remembering a series of number backwards might not be common, this is the same sort of thought processes that is involved with solving math problems. For example, using mental math to add two numbers requires you to hold those two numbers in your head, while applying whatever strategy you will use to solve the problem (Alloway & Alloway, 2010). The limited storage capacity of short-term and working memory means that as new pieces of information are introduced, older pieces of information will need to be forgotten (Baddeley, 2003). Working memory also has a relationship with long-term memory. In order to apply strategies, for instance, you must be able to incorporate information that is already in memory (Dharani, 2015).

The *central executive* – also referred to as *executive function* – is a part of working memory that is responsible for attention (Alloway & Alloway, 2010; Baddeley, 2003; Eysenck, Derakshan, Santos, & Calvo, 2007; Holmes, Gathercole, & Dunning, 2009), and it plays a role in strategy use (Luciana, Conkin, Hooper, & Yarger, 2005). It controls attention through inhibition and shifting (Eysenck et al., 2007). *Inhibition* allows us to resist reacting to disruption or interference to our attention, while *shifting* allows us to focus our attention on the task (Eysenck et al., 2007). Conkin et al. (2007) found that performance on tasks requiring high central executive demand improved throughout adolescence. This suggests that executive control develops with age, with adolescents reaching near-adult performance (Luciana et al., 2005). One study found then when adolescents were compared in age ranges from 9 to 20 years of age, the ability to strategically self-organize behavior and executive working memory function performance increased with age, leveling off around 16 years of age (Morrison & Chein, 2011).

One serious implication for executive function deficit in adolescents is risk taking. Romer et al. (2011) found that deficits with the central executive were associated with acting without thinking, a tendency to make impulsive decisions that have been linked to alcohol use and other risk-taking behaviors. Adolescents without executive function deficits still partake in risk-taking behavior, but it is more associated with sensation seeking, or the tendency to seek out exciting or novel experiences (Khurana et al., 2012). As determined by Khurana et al. (2012), a 4-year study found that sensation-seeking adolescents were less likely than those who act without thinking to show an increase in drinking behaviors.

Working memory also consists of three other processes: the *phonoarticulatory loop, visuospatial sketchpad,* and *episodic buffer* (Baddeley, 2003; Rekart, 2013). It is the central executive's responsibility to decide which working memory process new information will be directed to (Eysenck et al., 2007; Rekart, 2013). The *phonoarticulatory loop* is, "specific short-term store for verbal material" (Mellanby & Theobald, 2014, p. 22). Some researchers refer to this as the, "mind's voice" because it is the voice that you hear when you talk to yourself internally (Baddeley, 2003; Rekart, 2013). When we engage in tasks that use this memory process, the language centers of the brain are active (Dharani, 2015). The phonoarticulatory loop is responsible for processing auditory and speech-related information (Eysenck et al., 2007; Rekart, 2013) and is involved in the use of the *articulary rehearsal* strategy (Morrison & Chein, 2011). Studies have found that participants who were trained to use *articulatory rehearsal*, or inner speech to maintain stored information, were able to overcome deficits in working

memory to improve performance on working memory tasks for both adults and children (Morrison & Chein, 2011).

From age 8 and up, we begin to use the phonoarticulary loop to solve math problems (Rekart, 2013). This means that we talk ourselves through math problems in our heads and utilize language more than visuals to solve them. This also means that spoken language can interfere with the ability to solve these problems (Rekart, 2013). Because of what we know about the limited capacity of working memory, when the phonoarticulary loop is being used to solve a problem and someone else begins to talk, the new verbal information presented will overtake the information in working memory.

The *visuospatial sketchpad* is responsible for processing, holding, and manipulating visual or spatial information (Baddeley, 2003; Eysenck et al., 2007; Mellanby & Theobald, 2014; Rekart 2013). Much like other aspects of working memory, it is limited in capacity to three or four pieces of information at a time (Baddeley, 2003). This is the process, for example, that is in effect when you attempt to visualize the layout of an old bedroom (Rekart, 2013). Some research suggests that the phonoarticulary loop and visuospatial sketchpad work independently of one another (Mellanby & Theobald, 2014). Other research has presented the idea that they work together in some processes, such that the phonological loop may hold information for the visuospatial sketchpad to manipulate (Baddeley, 2003).

Our memories are created by binding together our perceptions (Baddeley, 2003; Rekart, 2013). Memories can be either explicit or implicit. *Explicit memories* are learned by effort and are either semantic or episodic (Jensen, 2008; Mellanby & Theobald, 2014). *Semantic memories* are our memories for facts and knowledge (Mellanby & Theobald,

2014) and are stored in the temporal lobe (Dharani, 2015). This memory is responsible for our knowledge and understanding of words. Without this form of memory, it would be difficult to have a conversation because words would not make sense (Dharani, 2015). *Episodic memories* are autobiographical (Tokuhama-Espinosa, 2011), consciously accessible, (Baddeley, 2003) and are often vivid and emotionally driven (Mellanby & Theobald, 2014). Answers to questions such as, "what did you do yesterday?" will utilize episodic memory (Jensen, 2008). This type of memory is the most naturally used (Alloway & Alloway, 2010). Working memory manipulates episodic memories when they are recalled, causing the addition of new representations to the memory (Alloway & Alloway. 2010). The hippocampus is responsible for encoding these memories (Dharani, 2015). The hippocampus is connected to the limbic system, which is why our memories tend to have emotions connected with them, we will discuss this more further on (Dharani, 2015).

Implicit memories are interesting because they do not have to be consciously acquired (Mellanby & Theobald, 2014). These are the skills that we automatically perform, such as driving a car, in which you do not think about every aspect of your body's movements, but those actions are still memories that were acquired (Mellanby & Theobald, 2014). When we were first learning these skills, we needed our hippocampus to create an episodic memory, but over time, our hippocampus trained our cerebral cortex, or movement center, to take over and make the process more efficient (Dharani, 2015).

Negative emotions can interfere with memory and the central executive (Eysenck et al., 2007; Rekart, 2013). When we experience any emotional reaction, our central

executive shifts our attention to understanding and experiencing that emotion (Rekart, 2013). This presents the idea that students worrying about academic success actually decrease their ability to perform academically (Rekart, 2013). This is a factor in math anxiety: when students are anxious about answering math questions in class, they use up their working memory and short-term memory capacity (Rekart, 2013), therefore causing them to increase effort to counteract the inefficiency of their processing system, increasing time spent solving problems (Eysenck et al., 2007). In addition, negative emotions increase our likelihood of thinking about negative memories (Dharani, 2015). This process may play a role in depression, where the person experiencing negative emotions is unable to overcome the likelihood of experiencing negative thoughts and memories (Dharani, 2015).

Positive emotions and arousal also play a role in memory by facilitating learning (Jensen, 2008; Mellanby & Theobald, 2014). Because episodic memory is tied to emotion and motivated by novelty, curiosity, life experience, expectation, and sensory input, it has been suggested that increasing arousal will increase the likelihood of information being stored in long-term memory (Jensen, 2008; Mellanby & Theobald, 2014). Novelty actually produces a surge of stress hormones that cause the central executive to shift attention to the novel item (Jensen, 2008). This means that introducing adolescents to new information and teaching methods increases memory effectiveness. Teachers need to be aware of a concept called *habituation*, the process by which response to material is decreased because of repetition, a major source of boredom (Mellanby & Theobald, 2014). This means that if lessons are taught in the same way every day, the brain will actually prevent you from paying attention to it.

Poor working memory skills have serious effects on an adolescent's ability to perform academic tasks. Poor working memory decreases a person's ability to remember classroom instructions, decreases his or her ability to process and store new information, and makes it difficult to keep track of his or her progress on difficult tasks (Alloway & Alloway, 2010). Holmes et al. (2009) stated that, in a classroom, out of 30 students, 4 or 5 would have poor working memory skills, resulting in low academic progress. For them, this creates a bottleneck effect, in that learning must filter through working memory, so if a child cannot retain learning episodes effectively, it prevents him or her from building on that learning in the future and hinders success. This effect can have serious implications for adolescent students who are beginning to have more cumbersome workloads in middle school, and who have to make the transition to high school learning tasks. Unfortunately, these issues often go undiagnosed or are mistaken for attention problems because of their effects on self-discipline and their link to mind-wandering (Alloway & Alloway, 2010).

However, influences on memory can be overcome with a few strategies. For example, a way to increase the effectiveness of working memory is through a process called *priming*, which involves an introduction to information before it is taught to increase one's ability to learn it (Jensen, 2008; Mellanby & Theobald, 2014). This process works because it allows the brain to begin the process of categorizing the new information, therefore increasing the effectiveness of the relationship between working and long-term memory (Jensen, 2008).

This relationship between working and long-term memory can also be capitalized on by incorporating context into learning tasks (Baddeley, 2003; Jensen, 2008; Mellanby

& Theobald, 2014; Rekart, 2013). Transfer to long-term memory is facilitated by providing a framework of connections to the new material (Mellanby & Theobald, 2014). When information in working memory is connected easily to information from long-term memory, it allows that information to be retained longer in short-term memory, therefore increasing the likelihood of transfer of the new information to long-term memory (Jensen, 2008). People who compete in memorizing competitions utilize this theory by devising a mental story, connecting relevant information to memorize to information already stored in long-term memory, thus making the information more memorable to them (Morrison, & Chein, 2011).

Chunking is another strategy that utilizes this idea (Baddeley, 2003; Morrison & Chein, 2011). *Chunking* is the process of combining information into more meaningful parts to increase memory's ability to retain more information. This process works most effectively if the content is meaningful to the student (Rekart, 2013). For example, researchers have found that we are more capable of remembering a sentence with 15 words in it than a list of 5 random words (Baddeley, 2003). This is because the sentence is more likely to tie to previously stored information in long-term memory than a list of five unrelated words.

The use of strategies is not the only way to improve performance on memory tasks. Some research has shown marked improvement in working memory function after explicit memory training. A study of 22 10-year olds with low working memory scores were placed in a computer training program for 35 minutes a day for 20 days over a 5- to 7-week period. Results showed that 6 months after training, working memory scores significantly increased; there were also significant improvements in the storage and

manipulation capabilities of visuospatial and verbal material (Holmes et al., 2009). Another study conducted with 25 undergraduate students who were asked to complete a working memory computer-training program 5 days a week for 4 weeks also found significant improvements in working memory function; this included increased cognitive control, reading comprehension, and attention coordination (Chein & Morrison, 2010).

Jensen (2008) introduced the idea that instructing students in learning skills and strategies can increase their ability to process new information. He suggests that this increases self-confidence in their ability to learn, and they become more proactive learners. If adolescents begin to internalize information about how memory works, they may be able to understand their individual learning and memory storage capabilities, and work to compensate for areas that are preventing success.

Exercise and the Brain

In this section, I will discuss brain functions associated with exercise including effects in the hippocampus and cognitive decline, cognitive function, and academic achievement. Subsequently, exercise and mental health and well-being will be introduced, followed by the prevalence, effects, and factors of sedentary behaviour. Factors that influence physical activity participation will be explored, followed by an example of a physical education program that improved students' participation in exercise activities and their academic achievement. Finally, I will discuss best practices in physical activity.

Exercise behaviour is an important factor in the health, well-being, and academic performance of adolescents. Research has linked exercise participation to reductions in many physical and mental disorders including decreased risk of cardiovascular disease,

colon and breast cancer, Alzheimer's disease, depression, and anxiety (Hortz & Petosa, 2006; Meeusen, 2014). Regular exercise also improves cardiovascular health, leads to greater bone mineral density, and decreases the risk of stroke and diabetes (Cotman & Engesser-Cesar, 2002). Research has also suggested that exercise is key to brain growth, maturation (Cotman et al., 2007), and function (Meeusen, 2014).

Many schools have cut physical education class times in order to accommodate more time spent on academic subjects, as a means to improve standardized test scores (Hillman, et al., 2008). Many studies, as summarized by Sattlemair and Ratey (2009), have shown that participation in physical activity and physical education actually improves academic performance. Although not all studies on this interest area have demonstrated an improvement in academic performance, no study has found a decline in academic performance following physical activity interventions (Hillman et al., 2008; Sattlemair & Ratey, 2009). This suggests that participation in exercise-based activities does not have a downside for students; on one hand, they are improving their physical and mental health, and, on the other, they may be improving academic performance.

Because of adult prevalence of the mental and physical disorders mentioned above, adolescence may be an important time for intervention. Adolescence marks the greatest decline in physical activity that persists into adulthood (Dunn & Weintraub, 2008; Hillman et al., 2008; Hortz & Petosa, 2006; van der na et al., 2010). Ultimately, exercise habits that are created in adolescence may persist into adulthood, thereby reducing the risk of many physical and mental health issues (Usyal et al., 2005).

One important way in which exercise influences brain function and development is through the hippocampus, a brain system that undergoes developmental changes in

adolescence (Usyal et al., 2005). The hippocampus is responsible for memory and spatial learning (Cotman et al., 2007; Utter, Neumark-Sztainer, Jeffery, & Story, 2003), and it develops in tandem with higher cognitive abilities (Usyal et al., 2005). Exercise has been demonstrated to increase the number of neurons, and promote their survival, in the hippocampus of adolescent and adult rats (Cotman & Engesser-Cesar, 2002; Usyal et al., 2005). The addition of these new neurons increases *synaptic plasticity*, which is the strengthening of connections between neurons (Abel & Rissman, 2013; Cotman et al., 2007; Cotman & Engesser-Cesar, 2002; Sattlemair & Ratey, 2009). The process of creating new neurons improves learning and memory (Cotman et al., 2007; Sattlemair & Ratey, 2009).

One study found that in adolescent rats, when they were given voluntary access to a running wheel, gene expression for genes related to synaptic plasticity and cell signalling increased (Abel & Rissman, 2013). In particular, Abel, and Rissman (2013) found that there was a 128% increase in the expression of *brain-derived neurotropic factor* (BDNF) in the hippocampus. BDNF has neuroprotective effects, as well as being important for neuron function and survival (Cotman & Engesser-Cesar, 2002). Cotman and Engesser-Cesar (2002) also found an increase in BDNF in the brain of adolescent rats after 2-7 days of wheel running. In their study, they exposed the rats to a four-quadrant water maze with an escape platform in one quadrant. After a few exposures, they removed the escape platform. What they found was that the rats that were in the exercise condition were more likely to head straight to where the escape platform had been and spend more time exploring that quadrant in its absence. This suggests that exercise, and subsequently, BDNF increase, improves spatial memory (Cotman & Engesser-Cesar,

2002). Deficits in BDNF in the brain have been associated with depression and other mood disorders (Cotman et al., 2007).

Additional neurons in the hippocampus are not the only beneficial effect on the brain moderated by exercise. Sattlemair and Ratey (2009) argue that exercise places physiological stress on the brain. The process of recovery from this stress promotes adaptation and growth in the brain, aiding brain function and giving your brain the tools to handle future challenges (Sattlemair & Ratey, 2009). Additionally, exercise can aid in the reduction of brain injury (Cotman et al., 2007). Not to mention, physiologically, exercise reduces factors that affect cognitive decline such as hypertension, insulin sensitivity, and dislyidemia, and it improves immune function of the body (Cotman et al., 2007).

Exercise also increases the amount of specific neurotransmitters in the brain. For example, it increases the body's level of tryptophan, which is needed to produce serotonin (Ratey, 2008). Lack of serotonin in the brain is associated with depression (Mahoney et al., 2005). It also increases the levels of norepinephrine in the brain, which influences attention, perception, and motivation (Ratey, 2008). Finally, it increases the amount of dopamine in the brain, which increases satisfaction and happiness (Ratey, 2008).

Cognitive decline is a major area of research that has demonstrated the positive effects of exercise on the brain. In elderly individuals, exercise has been shown to enhance learning and memory and improve cognitive function (Cotman et al., 2007; Meeusen, 2014). In addition, exercise has been associated with delay of onset and improvement of cognitive decline, particularly associated with neurodegenerative

diseases such as Alzheimer's disease, Parkinson's disease, and Huntington's (Cotman et al., 2007; HIllman et al., 2008; Meeusen, 2014; Sattlemair & Ratey, 2009). Prevalence of these diseases, as well as the mental and physical disorders mentioned in the introduction to this topic area, make a case for education on exercise for adolescents.

Research has also demonstrated improvements in cognitive functioning related to physical activity and executive function. Physically fit children have larger *dorsal stratum*, a brain region involved in cognitive control and inhibition (Meeusen, 2014). One study by Hillman, Snook, and Jerome (2003) subjected undergraduates to an executive function task where they were required to respond as fast as they could with their left hand to one letter on a computer screen, and with their right hand to another. What they found was that individuals in their exercise group, who were exposed to bouts of cardiovascular activity, were better at this task. These finding suggest that cardiovascular activity may influence attentional resources in the brain (Hillman et al., 2003). In addition, greater amounts of aerobic fitness have also been connected to executive control. Executive control tasks with aerobically exercised individuals showed longer reaction times in the case of tasks where an error has been previously made (Hillman et al., 2008). This demonstrates that exercised individuals were able to control their reaction in order to correct a previous error.

Academic achievement is another area that has shown positive effects in most research. Preliminarily, with exercise's relevancy to immune function, reduction in the number of sick days can improve academic performance in itself (Field, Diego, & Sanders, 2001). In addition, in studies of children and adolescents, exercise has been linked to spatial memory performance, visual discrimination, and consolidation of

information into long-term memory (Abel & Rissman, 2013). Further, perceptual skills, achievement on intelligence, math, and verbal tests, and improved academic readiness have all been associated with exercise participation (Hillman et al., 2008). Field et al. (2001) found that their group of high-exercising high school students had higher grade point averages and were less likely to report drug use than their low exercise or no exercise counterparts. Sattlemair and Ratley (2009) also found that vigorous exercise outside of school positively predicted grades. The findings from such studies suggest the academic achievement is more affected by vigorous exercise, a finding that is relevant to the structure of our physical education classes in school.

One factor that further demonstrated the need for physical education and exercise is the rate of obesity. Body mass index and physical activity account for 24% of the difference between high academic achievers and low ones (Sattlemair & Ratey, 2009). Unfortunately, we are not giving children and adolescents the education they need to be successful exercisers. As mentioned in the introduction to this topic, there has been a decrease in physical education time allotted to children (Hillman et al., 2008). One study demonstrated that a 240-minute weekly increase in physical education class actually led to higher scores on standardized math tests (Sattlemair & Ratey, 2009). This finding emphasizes the unnecessary cuts to physical education programs. One program, called *PE4Life*, reports that their model of physical education creates higher physical fitness levels, reduces rates of obesity, lowers incidents of disciplinary action, and improves academic achievement among their students (Sattlemair & Ratey, 2009). Students in one school that participated in the program went from far below average on standardized tests to 17% to 18% above average, had a reduction in the number of suspensions and

academic probation, and improved literacy scores (Sattlemair & Ratey, 2009). This program is successful because it emphasizes lifelong fitness, personal progress, and goal setting, and it gives adolescents the skills to achieve (Sattlemair & Ratey, 2009). Knowledge is power when it comes to adolescents' physical activity levels.

In addition to cognitive function, brain health, and academic achievement, exercise mediates mental health and well-being. De Geus and Moor (2011) reported that regular, voluntary exercisers score lower on neuroticism, higher on extraversion, conscientiousness, and sensation seeking, have higher vigour, lower levels of anxiety, depression, tension, apprehension, and fatigue, have higher self-esteem, life satisfaction, and happiness, and better perceived health and quality of life. Some training studies have demonstrated, especially for individuals who have low baseline levels of well-being, that aerobic exercise can improve mood, coping behaviour, and reduction in depression and anxiety (De Geus & Moor, 2011).

Adolescent depression is a major public health concern, and by adulthood, 25% of adolescents will have experienced at least one major depressive episode (Dunn & Weintrub, 2008). Adolescent depression, combined with the prevalence of adult depression, makes adolescence an important time for intervention (Nabkasorn et al., 2005). Exercise has been shown to not only increase psychological well-being, but also reduce the effects of, and even prevent, anxiety and depression (De Geus & Moor, 2011). These effects are especially important for women, who show higher levels of depression and lower levels of regular exercise. One study of women aged 18 to 20 years old demonstrated that an 8-week jogging program improved depressive effect and relationships with others. The authors concluded that because relationship loss is a

distinctive feature of depression, this effect alone could be significant in reducing depressive symptoms (Nabkasorn et al., 2005). In high school students, high levels of exercise were associated with better relationships with parents (Field et al., 2001). Overall, this research demonstrates the positive effect that exercise can have on depression and relationships.

Despite this research about brain benefits, health factors, and improved mental health, in America, 74% of adults do not get the daily-recommended amount (30 minutes) of physical activity (Hillman et al., 2008), with no exercise on a regular basis (van der na et al., 2010). Children's lifestyles are also becoming increasingly sedentary and unfit (Cotman et al., 2007; Hillman et al., 2008; Meeusen, 2014). A main contributor to children's health is regular exercise during leisure time (Huppertz et al., 2012). It has been argued that television is replacing physical activities in the leisure time of our youth (Hancox, Milne, & Poulton, 2004). In American households, 99% of adolescents have access to a television, with 65% having one in their bedroom (Utter et al., 2003). One longitudinal study by Hancox et al. (2004) concluded that television-viewing habits in childhood might persist into adulthood. Some researchers believe that hours spent watching television may be equivalent to time spent in school (Hancox et al., 2004). Television viewing has been positively associated with BMI (Hancox et al., 2004; Utter et al., 2003) and consumption of high dietary fat and refined sugar foods (Utter et al., 2003). With BMI being negatively associated with school achievement (Gligoroska et al, 2012), it is clear that getting adolescents active is important.

In one study, van der na and colleagues (2010) found that the prevalence of sedentary behaviours increases in late adolescence. In addition, another study found that

13% of the adolescents who participated in the study did not take part in any type of leisure activity (Abel & Rissman, 2013). Abel and Rissman (2012) also found girls to be more sedentary than boys, a finding supported by van der na and colleagues (2010), and when girls were active, they were more likely to participate in moderate, rather than vigorous, physical activity.

Environmental, social, and heritable factors play a role in the exercise habits of adolescent girls and boys. In van der na and colleagues' (2010) adolescent twin study, heritability factors such as endurance, strength, flexibility, and motor coordination played a role in boys' and girls' likelihood of becoming regular exercisers. This was especially prevalent for boys, who were more likely to stick with exercise activities that they were good at due to the boost in self-esteem it provides and the prevalence of the athletic role models for boys in the media. For twin adolescent girls, shared environmental factors such as parents, siblings, and peers who ensured attendance at activities, and who provided positive feedback, played a large role. However, in mid to late adolescence, when peer perception increases in importance compared to parents, actual exercise ability (a heritable factor) determines girls' likelihood of liking exercise enough to continue with it (van der na et al., 2010). Actual exercise ability is strongly reinforced culturally, increasing a person's chance of experiencing competence and mastery and making them more likely to continue exercising (De Geus & Moor, 2011). This effect is higher in adolescents, when peer ranking is high in perceived importance (De Geus & Moor, 2011). In terms of social support from parents, Abel and Rissman (2013) found that boys received more parental support and were more likely to be encouraged to participate in team sports, whereas girls were given less parental support and were more likely to

participate in individual sports. This finding has interesting implications because it has been found that participation in group sports is one form of physical activity that remains relatively stable over adolescence (van der na et al., 2010).

Psychological factors and the actual effect of exercise can also influence a person's likelihood of becoming a regular exerciser. Individuals who have stronger self-regulation skills are less likely to be deterred by the adverse effects of exercise (e.g., soreness) because of the feeling of accomplishing the physical challenge (De Geus & Moor, 2011). People whose feelings towards the adverse effects of exercise outweigh the perceived or actual positive effects are likely to become non-exercisers. The after-effects of exercise may be especially potent for novice exercisers, who may not know how to modify the intensity of their workouts (De Geus & Moor, 2011). In general, individuals do not like participating in activities that they are not good at. Therefore, when people achieve low levels of performance, it is easy to become discouraged, especially in competitive environments (De Geus & Moor, 2011).

One program called *Planning to be Active* uses social cognitive theory to attempt to combat some of these factors that affect exercise participation (Hillman et al., 2008). The program targets *sport skills, self-regulation, self-efficacy, outcome expectancy, social situation,* and *fitness knowledge*. *Sport skills* focus on mastery, rules, and competition. *Self-regulation* focuses on goal setting, strategic planning, self-monitoring, and self-reflection. *Self-efficacy* covers identification of barriers to physical exercise and strategies for overcoming them. *Outcome expectancy* includes self-evaluation. *Social situation* helps with targeted evaluation and creating a social environment to support your goals. Lastly, *fitness knowledge* includes the benefits of physical activity and the principles of

fitness and heart rate monitoring. A study on the effectiveness of this program demonstrated an 18.9% increase in the number of students who participated in moderate exercise behaviour in their leisure time, with the most improvement being found for those who reported zero active days at baseline (Hillman et al., 2008). These findings demonstrate that educating adolescents on the skills and knowledge that they need can be effective in improving physical activity.

The best physical activity is *aerobic exercise*, any sustained activity that elevates the heart rate and increases the body's need for oxygen. The more conditioned the body is, the better it reacts to stress, utilizes oxygen available in the body, and burns more calories (Passer, 20008). In addition, participation in strength training can build muscle, protect joints, decrease anxiety, improve mood, and increase confidence. The best strength training involves moderate rather than very heavy weights (Ratey, 2008). Overall, the best way to exercise is to do it every day. Committing 45 minutes to an hour to exercise a day can show results (Ratey, 2008). In fact, one study asked participants to engage in one aerobic exercise session. After only one session, they biopsied muscles of the exercisers and found that the muscles contained more of the proteins that are necessary for fat synthesis (Ratey, 2008). Therefore, the body was more capable of burning fat after only one bought of exercise, although they did not know how long the effects would last. In general, committing at least 6 hours a week to exercise is committing 6 hours a week to improving the function of your brain (Ratey, 2008).

In the year 2000, Canada spent approximately 2.1 billion dollars on expenses related to physical inactivity (Gligoroska et al., 2012). This statistic speaks for itself in demonstrating the importance of educating adolescents, our future adults, about the

effects of exercise on their bodies and minds. Sattlemair and Ratey (2009) presented effective programs that have increased participation in exercise though fitness education.

Emotions

In this section, I will discuss what emotions are, reasons why adolescents experience them, and how they experience them. Next, I will discuss emotion regulation, including maladaptive strategies such as rumination. Further, the family environment and its influence on both emotional affect and emotion regulation in adolescence will be presented. Finally, adaptive interventions and strategies that have been shown to be affective in improving emotion regulation in adolescence will conclude this section.

Adolescence is a time of social and psychological development that affects social awareness and the ability to regulate emotions (Burnett, Bird, Moll, Frith, & Blakemore, 2008). Adolescents experience low *emotional stability* (Zimmerman & Iwanski, 2014), which makes them more likely to encounter extreme positive and negative emotions (Padilla-Walker, 2008). Social emotions, such as guilt and embarrassment, are experienced every day, which makes it an important time for learning how to express these social emotions in different social contexts (Burnett et al., 2008). Their ability to regulate these emotions is important for well-being, academic performance, and positive adjustment throughout the lifespan (Metz et al., 2013). Zimmerman and Iwanski (2014) found that middle adolescents in particular have a low number of emotional regulation strategies that they use.

During this developmental period, adolescents begin to find peer relationships more rewarding than they did in childhood (Silvers et al., 2012). However, this emphasis on peer relationships heightens their self-consciousness, makes them more aware of

other's opinions of them, and they become more sensitive to peer influence and peer rejection than children and adults (Blakemore, 2008). Not to mention, this period is marked by increased conflicts with parents and decreased perceived support from parents (Padilla-Walker, 2008; Zimmerman & Iwanski, 2014). In summary, adolescence is a highly emotional time, and learning about emotions and how to regulate them is an important tool for teenagers to have.

Emotions are feelings that differ from an individual's normal state and comprise three central features. First, they involve a change in physiological arousal, meaning that they affect our body's homeostasis in ways such as increasing stress hormones, or blood pressure. Second, they have an affective component in the brain. This component refers to how we label these feelings such as happiness or guilt. Third, they motivate our behaviours, dependent upon which emotion we are experiencing. For example, when we experience fear, our instincts likely tell us to run away or fight (Klein, 2008). There are two main types of emotions experience by adolescents: *basic emotions* are emotions that require representation of our own mental state such as sadness, anger, happiness, and surprise, while *social emotions* are emotions that require the representation of our own and other's mental states such as guilt, shame, pride, and embarrassment. (Burnett et al., 2008; Burnett & Blakemore, 2009). *Emotion regulation* is the ability to control the instincts and impulses that accompany these emotions, both positive (Zimmerman, & Iwanski, 2014) and negative (Lewis et al., 2006), and will be discussed further on.

Adolescence is a time highly influenced by hormones, as well as changes in the social environment, and neuroanatomical changes in the social brain (Padilla-Walker, 2008). There is also a marked increase in the frequency and intensity of social emotions

during this developmental period (Burnett et al., 2008), which may contribute to increased feelings of distress (Metz et al., 2013). As stated above, social emotions require the ability to interpret one's own and other's mental states (Burnett et al., 2008; Burnett & Blakemore, 2009). Burnett and colleagues (2008) found that when processing personal social emotions and those of a third party, in this case their mother, adolescent brains utilize the same regions that are involved in *mentalizing*, which takes place mostly in the prefrontal cortex. Researchers found that this area was more active in adolescents then adults, suggesting that adolescents may need to use more effort to imagine mental states than adults, who have more experience, and whose brain has already undergone refinement. Burnett and Blakemore (2009) produced similar findings. They found that mentalizing regions of the brain showed greater functional connectivity during a social emotion task when compared to a basic emotion task, and this activity was more pronounced in adolescents than adults.

Another characteristic of adolescence is lack of sleep, a byproduct of later bedtimes in response to biological, psychosocial, and social developmental and early school start times (Baum et al., 2014). Baum and colleagues (2014) found that after several nights of realistic sleep deprivation (approximately 6 hours of sleep) mood was adversely affected, not to mention resulting in decreased energy, increased fatigue and confusion, increased feelings of tension, anger, anxiety, nervousness, and restlessness. Researchers also found greater irritability and oppositional attitude, and decreased ability to regulate emotion including increased emotional outbursts and exaggerated responses to small triggers. If adolescents are not getting enough sleep, then, they could be battling these emotional issues on a daily basis.

Not only is the experience of emotions taxing on the adolescent brain, emotional stimuli is attention grabbing and difficult to ignore (Blakemore, 2008). Monk and colleagues (2003) found that, when viewing fearful faces, goal-directed attention in the frontal cortex was more activated in adults than adolescents, and adolescents were more influenced by the emotional stimuli in the photos demonstrated by activation in the frontal cortex, cingulate cortex, and amygdala. It was suggested by the researchers that maturation of the social brain involves increased ability to participate in goal-directed behaviour even in the presence of distracting emotional stimuli (Monk et al., 2003). These findings have implications for the understanding of adolescent emotionality; it may be difficult for them to shift attention away from emotional contexts to be able to focus on relevant tasks. Attention also plays a key role in emotion regulation. Developing emotion regulation skills is protective against emotional and behavioural difficulties such as anxiety, depression, self-injury, substance abuse, impairment of goal-directed behaviour, as well as helps to prevent chronic activation of stress hormones which interfere with learning consolidation, therefore affecting academic performance (Metz et al., 2013).

Emotion regulation is a skill refined throughout childhood and adolescence that requires that ability to delay gratification, monitor attention (Metz et al., 2013), and use inhibition (Lewis et al., 2006). All of which are skills predominately associated with the prefrontal cortex and executive function (Metz et al., 2013). Executive functioning is a valuable tool in self-regulation of emotional responses that is in the prime of its development during adolescence (Wagner, Alloy, & Abramson, 2015). Adults are thought to regulate their emotions primarily through the use of attention (Lewis et al.,

2006). Some studies have demonstrated greater activation of the prefrontal cortex during emotion based research tasks in adolescence than in adults (Lewis et al., 2006). One explanation is that during the development of the prefrontal cortex, the adolescent brain is refining emotion regulation skills and therefore, is likely basing regulation on the emotional nature of the situation, where the adult brain is more mature and requires less activation in the prefrontal cortex (Blakemore, 2008; Lewis et al., 2006; Wagner et al., 2015).

Essentially, *emotional regulation* requires the adolescent to be able to monitor his or her own emotional response to a situation and modify that response in a socially acceptable manner. Lewis and colleagues (2006) used an emotion induction task to study child and adolescent emotional responses. The task involved 3 blocks – Block A, Block B, and Block C – in which the participants could earn points to gain a prize. During Block A, individuals were asked to press a button every time a certain letter appeared, but not when another appeared to earn points. However, Block A was manipulated so that all participants would receive points. During Block B, participants were asked to complete the same task with different letters; however, this block was manipulated so that participants lost all their points. Block C was included so that the children and adolescence would get their points back to still receive a prize. What the researchers found was that during Block B, response time was fastest and accuracy lowest, suggesting more impulsive clicking during feelings of frustration and anger. However, this effect decreased with age, suggesting that adolescents are becoming better at inhibiting emotional responding. Individual differences in emotion regulation predict social competence and personality development (Lewis et al., 2006).

Silvers and colleagues (2012) also found that older adolescent experience greater regulation success than younger adolescents. They found that success in emotion regulation was related to the social content of the situation and the individual's *rejection sensitivity*: he affinity to anxiously anticipate and perceive rejection, and becomes a lens through which individuals interpret interpersonal information, form expectations, and respond to interpersonal cues (Silvers et al., 2012). Silvers and colleagues (2012) also found that adolescents, particularly early adolescents, who were high in rejection sensitivity, were less successful at regulating responses to negative stimuli. Another factor could be that rejection sensitivity forms because of a low ability to self-regulate. Individuals who are rejection sensitive are more vulnerable to relationship violence, more likely to have low perceptions of self-worth, and experience reduced interpersonal functioning.

The way in which we regulate our emotions depends on the strategies that we use to overcome negative emotions, which can cause stress on the brain and body. Problems with the regulation of negative affect are associated with psychiatric and clinical disorders including depression, and anxiety, all which have a high rate of onset during adolescence (Silvers et al., 2012). *Response styles theory* suggests that our responses to depressed mood influences how severe and how long that mood lasts (Wagner et al., 2015). Zimmerman and Iwanski (2014) found support seeking to be less common during middle adolescence for fear, sadness, and anger compared to early adolescence and adulthood. This could be due to the relative instability of peer and romantic relationships and decreased perceived support from parents during this period. Zimmerman and Iwanski (2014) also found that individuals aged 13 to 15 years old were decreasing likely

to use adaptive emotion regulation when experiencing fear, and increasing likely to demonstrate dysregulation in anger situations. Essentially, adolescents at this age are likely to suppress fear to appear unaffected and can be quick to blame anger on others. In terms of gender differences, this study also found that females were more likely to use support seeking and dysfunctional rumination, whereas males were more likely to use passivity, avoidance, and suppression (Zimmerman, & Iwanski, 2014).

One common maladaptive strategy used in the face of negative emotions or stressful events is *rumination*, a repetitive focus on distress, as well as the possible causes and consequences of it (Michl, McLaughlin, & Shepherd, 2013; Wagner et al., 2015), without engaging in active coping or problem solving to relieve the distressed mood (McLaughlin & Nolen-Hoeksema, 2012; Michl et al., 2013). Increases in rumination have been found to occur between 12 and 17 years of age, and is more common in girls than boys beginning in early adolescence (Wagner et al., 2015; Zimmerman, & Iwanski, 2014). Rumination has been linked to impaired function on executive functioning tasks (Wagner et al., 2015) and has been associated with deficits in other prefrontal functions. These prefrontal functions included deficits in inhibition, thought to prevent the individual from ceasing the negative thoughts, and an underlying attentional inflexibility, preventing them from shifting their focus away from the thoughts (Wagner et al., 2015). Wagner and colleagues (2015) found that adolescents prone to rumination, paired with high depressive symptoms, demonstrated low sustained attention. This has implications for academic performance due to the inability to maintain attention, especially in the case of adolescents already managing a depressive mood. Rumination has also been linked to

enhanced and prolonged depressive symptoms and increased anxiety (McLaughlin, & Nolen-Hoeksema, 2012; Michl et al., 2013).

Attention to negative thoughts and feelings, autobiographical memory for previous negative events, negative self-schema activation, and exposure to stressful events also can have an effect on the duration and severity of rumination (Michl et al., 2013). *Control theory* suggests that negative events can create a discrepancy between how you want to feel and how you are actually feeling that can be difficult to resolve (Michl et al., 2013). Michl, McLaughlin, and Shepherd (2013) found that adolescents' self-reported exposure to stressful events was associated with increased engagement in rumination at a four-month follow-up and increased anxiety at a seven-month follow-up. The researchers suggest that this could be due to the reaction to events perceived as stressful being generalized to other areas of life, or possibly that the emotional and cognitive resources required to manage the outcomes of the stressful event may use up regulatory resources needed to engage in adaptive coping (Michl et al., 2013). With adolescence being marked by increased emotionality (Zimmerman & Iwanski, 2014) and vulnerability to peer rejection (Blakemore, 2008), it is likely that individuals in this age group experience what they perceive as stressful events frequently, emphasizing the important of teaching emotion regulation skills to this age group to prevent prolonged periods of negative affect, depression, and anxiety.

Rumination has also been associated with internalizing problems (McLaughlin & Nolen-Hoeksema, 2012). McLaughlin and Nolen-Hoeksema (2012) found that high levels of rumination in adolescents were associated with increases in the degree and quality of communication with peers, especially for girls. What is interesting is that the

increased communication with peers was found to be associated with increases over time in overt, relational, and reputational victimization by peers. The researchers suggested that when adolescents who are prone to rumination seek support from peers, it is likely that they engage in co-rumination, which may elicit frustration, animosity, and negative affect from peers. This could be due to their ruminating tendencies being perceived as needy, dependent, and excessively concerned with relationships, which may lead to social rejection (McLaughlin, & Nolen-Hoeksema, 2012).

Much of how adolescents learn about emotion regulation and their overall emotional affect comes from the family environment. For example, parental praise is associated with positive emotions, positive self-concept, and increase the likelihood of the adolescent participating in prosocial behaviours (Padilla-Walker, 2008). Although adolescents spend less time with parents, and more time with peers or alone, parental responses to emotional situations play a role in how adolescents learn to respond to similar situations (Buckholdt, Parra, & Jobe-Shields, 2014; Padilla-Walker, 2008). For example, Buckholdt, Parra, and Jobe-Shields (2014) found that parents' own emotional dysregulation is associated with parental invalidation of adolescent emotions that is related to adolescent emotional dysregulation. Invalidating parental responses teach adolescents that emotions are unacceptable and can work to heighten youth distress, not to mention limit their opportunities to learn to cope with these emotions (Buckholdt et al., 2014). When parents are unable to regulate their own emotions, adolescents' fluctuating emotions can be overwhelming. On the other hand, supportive responses from parents create an environment where youth feel supported and comforted, feel like their parents

are there to help them cope with distress, and can learn more effectively how to understand, regulate, and express emotions (Buckholdt et al., 2014).

Adolescents also experience increased conflict with parents, typically over everyday issues such as household rules, that can be accompanied by strong emotions from both the parent and adolescent (Buckholdt et al., 2014; Burnett et al., 2008). Adolescents' perception of the appropriateness of the parental response plays a role in how this conflict affects their emotional state (Padilla-Walker, 2008). For example, if they perceive parental responses as appropriate, they are more likely to report less negative affect, and are more likely to attend to the parental message. Padilla-Walker (2008) found that yelling and power assertion from parents positively related to adolescent feelings of anger and frustration, while talking and inductive strategies were related to feeling happy and guilty. Guilt is an important social emotion that matures during adolescence. It allows for moral internalization of parental messages and increases prosocial behaviours (Padilla-Walker, 2008).

Understanding emotion regulation is an important skill for adolescent well-being. One effective strategy to help placate negative thoughts and emotions is *reappraisal*, which involves changing one's thoughts about distress in order to change the emotional response associated with it (Silvers et al., 2012). *Reappraisal* requires an individual to be aware of their own mental states and the mental states of others. Silvers and colleagues (2012) found a strong increase in the use of cognitive reappraisal with age, and adolescents used perspective-taking during reappraisal more than children and adults. Although using the same brain regions as adults for this task, the adolescents showed

more activation suggesting, again, that they may need to work harder to perspective-take and that this skill undergoes refinement in adolescence.

Additional adaptive views of negative emotions are implicit theories of personality or beliefs about the malleability of socially relevant traits (Yeager, Lee, & Jamieson, 2016). The *entity theory of personality* encompasses the view that traits are fixed and leads to the belief that social failures are indicative of lasting social reality. The *incremental theory of personality* encompasses the belief that people have the potential to change and social failures are a problem to be solved. Whichever theory of personality one subscribes to determines how they appraise situational demands. If one believes that they have the resources to cope with stressors, they view the situation as a challenge, and the body responds by preparing the body for approach-oriented behaviours such as increased delivery of oxygenation blood to the brain, vasodilation, and increased cardiac efficiency. If one believes that the stressor exceeding their coping resources, they view the situation as a threat, and the body responds by preparing for damage or social defeat by activating the hypothalamic-pituitary-adrenal (HPA) axis which reduces cardiac efficiency and increases production of the stress hormone cortisol. This is referred to as the *biopsychosocial model* (Yeager et al., 2016). Entry into a threat state results in a slow return to homeostasis and can lead to prolonged stress responses that have negative outcomes for long-term health and cognitive performance (Yeager et al., 2016). Yeager, Lee, and Jamieson (2016) found that teaching ninth graders the incremental theory of personality improved cognitive, cardiovascular, neuroendocrine, and behavioural reactions to social stress, not to mention reduced HPA activation a week later and improved students' grades seven months later. In other words, educating students about

the different implicit personality theories reduced their likelihood to enter into a threat condition and therefore reduced their overall stress.

Mindfulness-based programs have shown success in improving emotion regulation, as well as attention skills, sleep quality, depression, anxiety, and externalizing symptoms (Metz et al., 2013). They emphasize two primary mechanisms: first, *self-regulation of attention* that promotes awareness of emotional, cognitive, and physical experiences as they occur, and second, *non-judgmental awareness of experience* that is characterized by curiosity, openness, and acceptance of experience to increase coping and decrease reactivity (Metz et al., 2013). Essentially, mindfulness-based programs encourage individuals to be aware of their emotions as they experience them, and give them the tools to modify their reaction to those emotions. One program in particular called the *Learning to BREATHE* program is specifically focused on emotion regulation for middle and high school students. Using guided group practice, it focuses on six core themes including body awareness, understanding and working with thoughts, understanding and working with feelings, integrating awareness of thoughts, feelings, and bodily sensations, reducing harmful self-judgments, and integrating mindful awareness into daily life (Metz et al., 2013). Metz and colleagues (2013) found that the *Learning to BREATHE* program has a positive effect on emotion regulation, self-regulation efficacy, psychosomatic complaints, and self-reported stress levels of its participants.

In summary, adolescence is a time when emotions run high and the effects of those emotions, particularly negative ones, play a role in their overall health and well-being. With adolescence being marked by the onset of clinical and psychiatric disorders including depression and anxiety, it is a key time to educate individuals about emotions

and their regulation. Because, in some cases, the family environment can hinder the development of these skills, explicit education in this area can give adolescents the support they may not be receiving at home and help to break the cycle of intergenerational emotional dysregulation proposed by Buckholdt and colleagues (2014). In conclusion, I believe exposure to the idea of emotionality as a universal theme of adolescence may assist to help placate anxieties that teenagers have about their emotions and start conversations that can be adaptive and informative about how to begin to regulate them.

CHAPTER THREE: PRODUCT DEVELOPMENT

This section will review the need for the product as described in Chapter One, as well as describe the process through which the podcasts were be produced. Finally, I will explore means of evaluating the product.

Need for Product

As mentioned in Chapter Two, research has demonstrated that adolescents are not taking good care of their brains. Adolescent dietary patterns have been linked to obesity (Francis & Stevenson, 2013), as issue which carries many health risks of its own including decreases in brain volume (Meeusen, 2014). Many adolescents do not eat breakfast (Mahoney et al., 2005), and many do not get anywhere close to the recommended intake of fruit and vegetables (Hoyland et al., 2009). Aside from nutrition, adolescents are often attending school while dealing with the symptoms of sleep deprivation (Baum et al., 2014), as well as not participating in enough physical activity to maintain healthy bodies and minds (Dunn & Weintraub, 2008; Hillman et al., 2008; Hortz & Petosa, 2006; van der na et al., 2010). Mental health issues and depression are major health issues for adolescents (Oddy et al., 2009). Adolescents are more likely to experience extreme positive and negative emotions (Padilla-Walker, 2008), yet have few emotional regulation strategies that they use (Zimmerman & Iwanski, 2014). Finally, with academic achievement being a cornerstone for success in a higher education driven society, adolescents need an understanding of how memory and its related cognitive functions work in order to succeed. In fact, working memory ability is more predictive than IQ when it comes to academic success (Alloway & Alloway, 2010).

This research demonstrates that adolescents are in need of access to education that helps them in learning about their brains and what they need to work at their best. Ellen Wartella and her colleagues (2016) found that 84% of 13 to 18 year olds reported receiving health information online during their lifetime. We know that adolescents are interested in going online to find information about their minds and bodies. Thus, podcasts provide an avenue through which our technologically savvy generation of adolescents can easily gain access to this education at no cost. In addition, the nature of podcasts as audio-only files increases accessibility by accommodating those with poor literacy skills.

It has been suggested through research that altering one's beliefs about their ability to make healthy lifestyle decisions can have implications for their motivation to participate in healthy behaviours (Kelly et al., 2011). Each podcast includes suggestions on ways to improve in each topic area, as well as thorough explanations of what the processes involve and current knowledge on the topic. By tailoring these podcasts to adolescents, they have the chance to learn about these topics as they relate to them, and can thus engage with the material in a more personal way. Adolescents are the future of our society: by generating resources that work to help them make a better life for themselves, we are also investing in future generations. If only one adolescent were to hear this podcast and make positive changes because of it, it would be worth the time in generating the resource.

Process of Development

This section will seek to explain the process by which each podcast was developed including topic selection, research, writing, recording, editing, and the methods used for evaluation.

Each topic was selected as a by-product of my academic background in human development and psychology. Topics such as memory and emotions were chosen as research topics from previous courses such as *Learning and the Mind* and *Social-Emotional Development*. Exercise and nutrition topics were chosen because of an increased interest in leading a healthy lifestyle, which led me to the knowledge about how it could be combined with neuroscience topics to improve the health of not only of my body, but also of my mind. In addition, the topic of sleep stemmed from personal interest in mastering this process, and unintentionally developing a vested interest in the role it plays in brain health. Finally, throughout my education, I have been fascinated with the brain and its many functions, leading to the interest in producing a podcast about the brain as a whole. Many of these topics were originally explored as a means of improving my own health and are topics that I consider key to understanding your own body and mind, and exerting some level of control over how you feel and think. Finally, these are all topics that I wish I had the knowledge about as an adolescent myself, potentially saving myself numerous sick days, emotional outbursts, anxiety, and more.

Each topic was thoroughly researched using peer-reviewed literature, textbooks, and other research. In order to properly research each area of interest, they were divided into specific topics and researched separately. Additional topics were added in order to compliment the use of podcasting, as well as analogical reasoning, as an effective

teaching strategy. Once each literature review was complete, it was forwarded to an academic advisor who approved the content. Once approved, each section of the literature that was chosen for podcasting was used to write a series of scripts. I chose to write the scripts to involve two participants. Many of the podcasts that inspired me towards creating this resource use this type of formatting, and there is a much potential for more engaging information presentation when it stems from a dialogue between two people rather than just one person.

Once the scripts were completed, each script was then recorded using audio editing software. Two condenser microphones were used to record the audio for each podcast. Once each podcast was completed, it was edited for sound by the co-host Adam Lachance. Upon completion of sound editing, the resource was forwarded to a music composer named Brian Case, who provided the music for each audio file. Upon completion of all sound and music editing, each podcast was transcribed thoroughly again in order to account for any deviations from scripts and to include times for ease of tracking content (Appendix A). Finally, the files were collected into a Google Drive folder in order to be accessed for feedback from both the academic advisor and evaluation participants.

Evaluation

This section will discuss methods through which feedback was generated for the resource, including teacher input and listener comments.

As a member of the Ontario College of Teachers, I have access to numerous personal acquaintances that are also certified teachers in Ontario. The objective was to use these connections to collect anecdotal evaluations through personal communication.

Once this feedback was generated, areas that received praise and areas that require improvement were highlighted, explained in Chapter Five.

Posting

Upon review and evaluation by fellow educators, the files may be uploaded to the Internet via http://www.podomatic.com. The files will be made accessible from a blog titled *TeenBrain* found at https://teenbrain.wordpress.com. Robin Crummy developed the site logo. From here, individuals will be able to see a description of the podcast, and have access to transcripts of the audio and references used. Using a blog format also allows for an introduction to my background and myself, and it is accessed easily via a link by anyone interested in listening. Blogs also allow users to leave comments, which will allow the feedback process to remain ongoing.

CHAPTER FOUR: PRODUCT

Podcasts can be found by clicking the following link below. Each podcast can be easily listened to or downloaded via Google Drive sharing. Transcripts for each podcast can be found in Appendix A.

https://drive.google.com/open?id=0B9HsCC1Al2Bzckdid1dRN0FTQWM

CHAPTER FIVE: SUMMARY, EVALUATION, IMPLICATIONS, AND RECOMMENDATIONS

Adolescence is a time of significant brain development, especially for the prefrontal cortex, a vital area for decision-making, rational thought, and impulse control (Baddeley, 2003). Unfortunately, adolescents do not make healthy choices when it comes to diet (Francis & Stevenson, 2013), exercise (Hillman et al., 2008), and sleep habits (Beebe et al., 2012). In addition, academic achievement is crucial to success in an education driven society, and mental health is a major health issue for adolescents (Oddy et al., 2009). Unfortunately, this age group may not have the information that they need to understand the importance of the aforementioned topics and their individual responsibility to take care of their brain to promote a healthy and adaptive lifestyle.

We know that adolescents are using the Internet to search for this type of information (Wartella et al., 2016). We also know from a cognitive behavioural point of view that changing or challenging one's thinking can have implications for behaviour, and that confidence in one's ability to engage in a healthy lifestyle is positively associated with intention to engage in behaviour that promotes a healthy lifestyle (Kelly et al., 2011). This information suggests that it is essential to develop resources that challenge and modify adolescents' thoughts on the importance of their brain health and understanding its functions. Tailoring resources to adolescents specifically may be an effective way to strengthen their relationship with the material and can potentially have implications for behaviour modification.

Summary of the Project

This project explored educational strategies, neuroscience, health, and well-being and their relation to adolescent development in service of developing an educational resource. The purpose was to develop a resource that was tailored to adolescent-related research, provided insights and knowledge about brain-based topics, and would pique the interest of teenage audiences. In order to accomplish these goals, a six-part podcast mini-series called *Teen Brain* was developed, and included episodes on the brain and its functions, sleep, diet, memory, exercise, and emotions (Chapter Four). The podcast includes the use of analogical reasoning and scientific evidence to foster interest in these topics.

A literature review (Chapter Three) was conducted to demonstrate the effectiveness of podcasting as a resource and analogical reasoning as an educational strategy. In addition, the literature review provided a thorough summary of the research in each area explored the podcast episodes. This information informed the development and creation of the podcast series. Finally, the podcasts were evaluated by teachers for effectiveness as a resource for adolescent audiences, which informed implications for research, practice and recommendations, all of which can be found in the subsequent sections of this chapter.

Evaluation of the Product

The podcasts were distributed to three qualified teachers, each of which is a personal acquaintance of the author. Each were given a link to the podcasts and asked to provide feedback on the effectiveness of the resource for the intended audience, as well as their opinions on the resource.

The *Teen Brain* series received much praise from the evaluators in regards to the quality and organization of the product. They found the language was articulate and clear and that the music created a professional feel. The breakdown of the podcast into succinct topics by episode was viewed as being positive because it made the purpose of each episode very clear. It was also remarked that the podcasts provided a large amount of content, although not overwhelming.

A few themes emerged from the feedback. One was that this type of podcast would be interesting and engaging for adolescents. With the information coming from two young voices and the use of personal anecdotes, one evaluator thought it would be more relatable to teens. Explanations were considered simple, clear, and articulate. One teacher believed that the podcasts were the perfect length, while the others did not comment on this area. It was also commented that teenage audiences might prefer this type of media product to a typical lesson format. Each evaluator addressed that the way the podcast is designed makes the science accessible and relates the science to real life situations that teenagers find themselves in. In fact, more than one teacher specifically mentioned the use of analogical reasoning as one of the keys to the success of the product, including mentioning that these explanations may help teens make sense of the material and connect with it easier.

Another theme was the effectiveness of using examples and giving strategies that teenagers can easily relate to. One teacher even commented that it works to give adolescents a name for the experiences they are having and an explanation of why they happen. Another enjoyed the real examples of how the brain affects their education and everyday lives. In addition, one evaluator thought that the practical strategies and tips

were the most effective part, and that the product has the potential to change someone's life if they see the value in it. Because the practical aspects could be easily applied, students can take the information and see results. In addition, the potential for the podcast to introduce teenagers to *metacognition*, or thinking about thinking, was evaluated as a positive asset of the product. An additional comment was that even if teens do not put all the information into practice, they would at least have a reference point.

This leads to the next emergent theme: the use of the podcast series as a classroom resource. Two teachers believed that adolescents might not be motivated or interested in seeking out these resources on their own and that the classroom would be an ideal place to introduce it. However, both believed that if teenagers were introduced to the product, they would find it interesting and valuable. One evaluator even commented that once they are introduced, students might be inspired to listen to more of the podcasts, look up related information, and build on the information provided. All teachers brainstormed educational themed ideas. One thought it would relate well to the health curriculum, especially Grade 7 to 8 where healthy choices are being discussed, and another evaluator thought it would be good to suggest it to students interested in science. Another thought it would be a great tool to help students add to their toolbox to improve study skills and learn hacks for their brains, especially the episodes on memory and emotions. One teacher even commented that after listening to the *Teen Brain* series, she started modifying her praise to students, such as saying, "That's good brain work." Finally, one evaluator believed that the podcasts would be better as shorter 5 to 7 minute audio files in the classroom setting, while another believed they would serve better as a homework-based tool.

The author's most poignant emergent theme from the feedback was that the product was not only interesting and useful for teenage audiences, but a range of audiences. All evaluators commented that they learned something new. One commented that a few of the podcasts were very relatable for her and expanded her knowledge in prior areas of interest. The introductory nature of the podcast led one evaluator to comment that, with a lack of science background, she still easily followed along and remained interested in the content. Finally, one teacher praised how episodes would reference material learned in previous episodes or to be learned in future episodes to help connect the information.

The final theme that emerged from the evaluation was implications for future research and practice. All evaluators commented that a website where educators and teens can access resources and additional information would be a useful tool for the podcast. Another suggested that including teens in the production of the product, such as by interviewing them as a part of the audio, might be an effective way to make it even more relatable to teens. Finally, one evaluator thought that the podcasts were more accessible to keen students because some of the material may require scaffolding for students who lack abstract thinking skills.

The feedback provided demonstrates that the *Teen Brain* podcast series will likely be a valuable resource for adolescents. All evaluators connected with the material and presentation of that material. Each teacher had different ideas about how the product could be used in the classroom, suggesting that, although not specifically designed for that purpose, the product may be an effective classroom resource. In addition, the teachers' comments that the podcast was relevant and relatable for teenage audiences,

and that listening to them may inspire behaviour modification, demonstrates that the goals of the resource were met. Finally, the fact that each listener stated that they gained new knowledge shows how this product can be effective as a learning tool, as well as being relatable to a wider range of audiences.

Implications for Practice

This podcast was designed to pique an interest in the functions of the brain and strategies for optimizing those functions in adolescent audiences. Each episode of *Teen Brain* was developed to present material in a creative way, and to encourage healthy lifestyle choices and/or the implementation of brain-based strategies. When qualified teachers evaluated the product, all three believed that the product was capable of capturing the interest of the target age group. Adolescents will be able to access the resource online at the website provided or through iTunes.

Cognitive behavioural theory suggests that the way in which we think about the world has implications for our behaviours (Kelly et al., 2011). The product is meant to encourage youth to think about the science behind daily experiences, and how our actions have consequences on the health of our brains. By conceptualizing these processes, we can attempt to introduce methods of taking control over them, and modifying our beliefs about them. By introducing these ideas, the teacher evaluators suggested that it might be a valuable tool to help adolescents think about and manage their experiences, such as through increased study skills or emotional regulation.

From the comments of the evaluating teachers, it is clear that this product would be appropriate as a classroom resource. Due to the nature of the feedback and material used in the podcasts, it would likely align with a health and physical education

curriculum best. Alternatively, certain episodes, including Memory and the Brain and Emotions and the Brain, may be good practical resources for adolescents' teachers to provide as a way to become more engaged with your brain.

Evaluating teachers suggested that although the product was developed to be explored by adolescents independently, the nature of the age group might make them unmotivated to search it out for themselves. Therefore, it also may be valuable to advertise the resource to parents and community organizations, or develop social media accounts in order to increase the likelihood of the adolescent coming into contact with the material.

Recommendations for Future Research

As demonstrated through the literature review and goals of the project, teenagers are not making healthy decisions about their brains. With the onset of three-quarters of psychiatric illnesses (Jacka et al., 2010), increased sedentary behaviours (van der na et al., 2010), and poor dietary habits (Oddy et al., 2009) all occurring during the adolescent years, it is clear that teenagers may be experiencing barriers to healthy decision making. In addition, adolescence is a highly emotional time (Padilla-Walker, 2008), yet teenagers have few emotional regulation strategies that they use (Zimmerman & Iwanski, 2014). Finally, as mentioned in the above summary, academic achievement is of high value in our education-driven society. This project worked to draw connections between these topics and point out to adolescents that understanding the inner working of the brain can have positive effects on the experiences of everyday life.

Research should focus on developing a greater grasp of adolescents' understanding of their bodies and minds and how they affect behaviour and wellness.

When taking into account the influence of parental knowledge and behaviour on healthy habits and adaptive behaviours of teens (Buckholt et al., 2014; van der na et al., 2010; Videon & Manning, 2003) it is important to note that parents may be lacking skills in various areas. Therefore, research should focus on if the delivery of resources, such as the *Teen Brain* podcast, would have implications for the development of knowledge and understanding of the importance of health behaviours.

The *Teen Brain* podcast was meant to pique interest in topics such as sleep, exercise, memory, diet, emotions, and the brain in general. Research should focus on whether or not exposure to media products such as these increases the likelihood of adolescents seeking out supporting information. When viewed through the cognitive behavioural theory lens, Kelly and colleagues (2011) suggested that our beliefs about our ability to participate in healthy lifestyle choices have implications for our intentions to enact those behaviours. Research in this area is needed to determine the effectiveness of different methods of delivering health and wellness information for behaviour modification in adolescence.

Adolescents are the future of our society. Improving research and education about healthy behaviour and adaptive strategies and finding ways to encourage that into practice will work to create a healthier generation. Developing resources such as the *Teen Brain* podcast and analyzing their effectiveness can increase our knowledge in this important research area.

Limitations

The completed *Teen Brain* project has a few limitations. First, due to the extensive nature of the topics covered, the literature review and the material presented in

the podcasts was not an exhaustive look at the research available in each area. In addition, there was no needs assessment used to determine an actual need for the product. Although the evidence surrounding adolescent behaviours suggests that interventions may be needed, there was no assessment to determine if these media product would be considered a useful addition to the field. Finally, there was also no formal evaluation of the product. Therefore, although evaluated by certified teachers, those teachers were personal acquaintances of the author and may present a biased report on the effectiveness of the product.

References

Abel, J. L., & Rissman, E. F. (2013). Running-induced epigenetic and gene expression changes in the adolescent brain. *International Journal of Developmental Neuroscience, 31*(6), 362–390. doi: 10.1016/j.idevneu.2012.11.002

Abt, G., & Barry, T. (2007). The quantitative effect of students using podcasts in first year undergraduate exercise physiology module. *Bioscience Education, 10*(1), 1–9. doi: 10.3108/beej.10.8

Alloway, T. & Alloway, R. (2010). Investigating the predictive roles of working memory and IQ in academic attainment. Journal *of Experimental Psychology*, *106*(1), 20-29. doi: 10.1016/j.jecp.2009.11.003. – 4.3 to 5.7 years at time 1 and 10 to 100.3 at time 2.

Ambrosini, G. L., Emmett, P. M., Northstone, K., Howe, L. D., & Jebb, S. A. (2012). Identification of a dietary pattern prospectively associated with increased adiposity during childhood and adolescence. *International Journal of Obesity, 36*(10), 1299–1305. doi: 10.1038/ijo.2012.127

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience, 4*(10), 829−839. doi: 10.1038/nrm1201

Baker, B., Harrison, J., Thornton, B., & Yates, R. (2008). An analysis of the effectiveness of podcasting as a supplemental instructional tool: A pilot study. *College Teaching Methods & Styles Journal, 4*(3), 49–54. doi 10.19030/ctms.v4i3.5535

Baum, K. T., Desai, A., Field, J., Miller, L. E., Rausch, J., & Beebe, D. W. (2014). Sleep restrictions worsens mood and emotion regulation in adolescents. *The Journal of Child Psychology and Psychiatry, 55*(2), 180–190. doi: 10.111/jcpp.12125

Beebe, D. W., Difrancesco, M. W., Tlustos, S. J., & McNally, K. A. (2009). Preliminary fMRI findings in experimentally sleep-restricted adolescents engaged in a working memory task. *Behavioural and Brain Functions, 5*(9), 1–7. doi: 10.1186/1744-9081-5-9

Bellisle, F. (2001). Invited commentary: Glucose and mental performance. *British Journal of Nutrition, 86*(2), 117–118. doi: 10.1079/BJN2001407

Benton, D., & Jarvis, M. (2007). The role of breakfast and a mid-morning snack on the ability of children to concentrate at school. *Physiology & Behaviour, 90*(2,3), 382–385. doi: 10.1016/j.physbeh.2006.00.029

Blakemore, S. J. (2008). The social brain in adolescence. *Nature Reviews: Neuroscience, 9*(4), 267–277. doi:10.1038/nrn2353

Bondi, C. O., Taha, A. Y., Tock, J. L., Totah, N. K., Cheon, Y., Torres, G. E., Rapoport, S. I., & Moghaddam, B. (2014). Adolescent behavior and dopamine availability are uniquely sensitive to dietary omega-3 fatty acid deficiency. *Biological Psychiatry, 75*(1), 1–22. doi: 10.1016/j.biopsych.2013.06.007

Bourre, J. M. (2004). Roles of unsaturated fatty acids (especially omega-3 fatty acids) in the brain at various ages and during aging. *The Journal of Nutrition, Health, and Aging, 8*(3), 163–174.

Buckholdt, K. E., Parra, G. R., & Jobe-Shields, L. (2014). Intergenerational transmission of emotion dysregulation though parental invalidation of emotions: Implications for adolescents internalizing and externalizing behaviours. *Journal of Child and Family Studies, 23*(2), 324–332. doi: 10.1007/s10826-013-9768-4

Burnett, S., & Blakemore, S. J. (2009). Functional connectivity during social emotion task in adolescents and adults. *European Journal of Neuroscience, 29*(6), 1294–1301. doi: 10.1111/j.1460-9568.2009.06674.x

Burnett, S., Bird, G., Moll, J., Frith, C., & Blakemore, S. J. (2008). Development during adolescence of the neural processing of social emotion. *Journal of Cognitive Neuroscience, 21*(9), 1736–1750. doi:10.1162/jocn.2009.21121

Capaldi, V. F., Handwerger, K., Richardson, E., & Stroud, L. R. (2005). Associations between sleep and cortisol responses to stress in children and adolescents: a pilot study. *Behavioural Sleep Medicine, 3*(4), 177–192. doi: 10.1207/s15402010bsm0304_1

Chein, J., & Morrison, A. (2010). Expanding the mind's workspace: Training and transfer effects with a complex working memory span task. *Psychonomic Bulletin & Review, 17*(2), 193−199. doi: 10.3758/PBR.17.2.193.

Chuang, M. H., & She, H. C. (2013). Fostering 5th grade students' understanding of science via salience analogical reasoning in on-line and classroom learning environments. *Educational Technology & Society*, *16*(3), 102—118.

Conkin, H. M., Luciana, M., Hooper, C. J., & Yarger, R. S. (2007). Working memory performance in typically developing children and adolescents: Behavioural evidence of protracted frontal lobe development. *Developmental Neuropsychology*, *31*(1), 103−128. doi: 1080/87565640709336890

Cotman, C. W., & Engesser-Cesar, C. (2002). Exercise enhances and protects brain function. *Exercise and Sports Science Review*, *30*(2), 75–79.

Cotman, C. W., Berchtold, N. C., & Christie, L. (2007). Exercise builds brain health: Key roles of growth factor cascades and inflammation. *TRENDS in Neuroscience, 30*(9), 465–472. doi: 10.1016/k.tins.2007.06.011

Dahl, R. E., & Spear, L. P. (2004). Adolescent brain development: Vulnerabilities and oppourtunitiesopportunities. New York, NY: The New York Academy of Sciences.

Dahl. R. E., & Lewin, D. S. (2002). Pathways to adolescent health: Sleep regulation and behaviour. *Journal of Adolescent Health, 31*(65), 175–184. doi:10.1016/S1054-139X(02)00506-2

Danelli, L., Cossu, G., Berlingeri, M., Bottni, G., Sberna, M., & Paulesu, E. (2013). Is a lone right hemisphere enough? Neurolinguistic architecture in a case with a very early left hemispherectomy. *Neurocase, 19*(3), 209–231. doi: 10.1080/13554794.2011.654226

De Geus, E. J. C., & Moor, M. H. M. (2011). Genes, exercise, and psychological factor. In C. Bouchard & E. P. Hoffman (Eds.), *Genetic and molecular aspects of sports performance* (pp. 294–305). Oxford, UK: Blackwell Publishing.

Dharani, K. (2015). *Biology of thought: A neuronal mechanism in the generation of thought – A new molecular model.* San Diego, CA: Elsevier Inc.

Dunn, A. L., & Weintraub, P. (2008). Exercise in the prevention and treatment of adolescent depression: A promising but little researched intervention. *State of the Art Reviews, 2*(6), 507–518. doi: 10.177/1559827608323225

Evans, C. (2008). The effectiveness of m-learning in the form of podcast revision lectures in higher education. *Computers & Education, 50*(2), 491 – 498. doi:10.1016/j.compedu.2007.09.016

Eysenck, M., Derakshan, N., Santos, R., & Calvo, M. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion, 7*(2), 336−353. doi: 10.1037/1528-3542.7.2.336.

Fallone, G., Owens, J. A., & Deane, J. (2002). Sleepiness in children and adolescents: Clinical implications. *Sleep Medicine Reviews, 6*(4), 287–306. doi:10.1053/smrv.2001.0192

Field, F., Diego, M., & Sanders, C. E. (2001). Exercise is positively related to adolescents' relationships and academics. *Adolescence, 36*(141), 105–110.

Flanagan, B., & Calandra, B. (2005). Podcasting in the classroom. *Learning and Leading with Technology, 33*(3).

Florence, M. D., Asbridge, M., & Veugelers, P. J. (2008). Diet quality and academic performance. *Journal of School Health, 78*(4), 209–215. doi: 10.1111/j.1746-1561.2008.00288.x.

Francis, H., & Stevenson, R. (2013). The longer-term impacts of Western diet on human cognition and the brain. *Appetite, 63*, 119–128. doi: 10.1016/j.appet.2012.12.018

Freiedman, N. P., Corley, R. P., Hewitt, J. L., & Wright, Jr., K. P. JR. (2009). Individual differences in childhood sleep problems predict later cognitive executive control. *Sleep Problems in Childhood and Adolescence, 32*(3), 323–333.

Gligoroska, J. P., Manchevska, S., Dejanova, B., Petrovska, S., Todorovska, L., Petrova, V., Antovska, V., & Bozinovska, L. (2012). Influence of the physical activity on

the cognitive functions with people depending on their age. *Medical Archives, 66*(4), 271–275. doi:1.5455/medarh.2012.66.271-275.

Gradisar, M., Terrill, G., Johnston, A., & Douglas, P. (2008). Adolescent sleep and working memory performance. *Sleep and Biological Rhythms, 6*(3), 146−154. doi: 10.1111/j.1479-8425.2008.00353.x

Hancox, R. J., Milne, B. J., & Poulton, R. (2004). Associations between child and adolescent television viewing and adult health: A longitudinal birth cohort study. *Adolescence, 364*(141), 257–262.

Hanna, J. (n.d.N.D). *Choosing better proteins*. Retrieved from: http://web.standford.edu

Hasler, B. P., & Clark, D. (2013). Circadian misalignment, reward-related brain function, and adolescent alcohol involvement. *Alcoholism: Clinical and Experimental Research, 37*(4), 558–565. doi: 10.111/acer.12003

Hew, K. (2009). Use of audio podcast in K-12 and higher education: a review of the research topics and methodologies.*Education Technology Research Development, 57*(_), 333-357. doi: 10.1007/s11423-008-9108-3

Hillman, C. H., Erikson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heat: Cognitive effects of exercise on brain and cognition. *Nature Reviews, 9*, 58–66. doi: 10.1038/nrn2298

Hillman, C. H., Snook, E. M., & Jerome, G. J. (2003). Acute cardiovascular exercise and executive control function. *International Journal of Psychophysiology, 48*(3), 307–314. doi: 10.1016/S0167-8760(03)00080-1

Holmes, J., Gathercole, S., & Dunning, D. (2009). Adaptive training leads to sustained enhancement of poor working memory in children. *Developmental Science, 12*(4), 9−15. doi: 10.1111/j.1467-7687.2009.00848.x.

Hortz, B., & Petosa, R. (2006). Impact of "planning to be active" leisure time physical exercise program on rural high school students. *Journal of Adolescent Health, 39*(4), 530–535. doi: 10.1016/j.jadohealth.2006.03.015

Hoyland, A., Dye, L., & Lawton, C. L. (2009). A systematic review of breakfast on cognitive performance of children and adolescents. *Nutrition Research Reviews, 22*(2), 220–243. doi: 10.1017/S0954422409990175

Huppertz, C., Bartels, M., Van Beijsterveldt, C. E. M., Boomsma, D. I., Hudziak, J. J., & De Geus, E. J. C. (2012). Effect of shared environmental factors on exercise behavior from age 7 to 12 years. *Official Journal of the American College of Sports Medicine, 44*(10), 2025–2032. doi: 10.1249/MSS.0b013e3182d358e

Isaacs, E., & Oates, J. (2008). Nutrition and cognition: Assessing cognitive abilities in children and young people. *European Journal of Nutrition, 47*(3), 4–24. doi: 10.1007/s00394-008-3002-y

Jacka, F. N., Kremer, P. J., Leslie, E. R., Berk, M., Patton, G. C., Toumbourou, J. W., & Williams, J. W. (2010). Associations between diet quality and depressed mood in adolescents: Results from the Australian Healthy Neighbourhoods Study. *AustrailianAustralian and New Zealand Journal of Psychiatry, 44*(5), 435–442. doi: 10.3109/00048670903571598

Jarrett, C. (2015). *Great myths of the brain*. West Sussex, UK: Wiley Blackwell.

Jenson, E. (2008). *Brain-based learning: A new paradigm of teaching*. Thousand Oaks, CA: Corwin Press.

Kelly, S. A., Melnyk, B. M., & Jacobson, D. L. (2011). Correlates among healthy lifestyle cognitive beliefs, healthy lifestyle choices, social support, and healthy behaviours in adolescents: Implications for behavioural change strategies and future research. *Journal of Pediatric Health Care, 25*(4), 216–223. doi: 10.1016/j.pedhc.2010.03.002

Khurana, A., Romer, D., Betancourt, L. M., Brodsky, N. L., Giannetta, J. M., & Hurt, H. (2012). Working memory ability predicts trajectories of early alcohol use in adolescents: The meditational role impulsivity. *Addiction, 108*(3), 506–515. doi: 10.1111/add/12001

Klein, S. B. (2000). *Biological psychology*. Upper Saddle River, NJ: Prentice-Hall Inc.

Kypri, K., & McAnall, H. M. (2005). Randomized controlled trial of web-based primary care intervention for multiple health risk behaviours. *Preventative Medicine, 41*(3-4), 761-766. doi:10.1016/j.ypmed.2005.07.010

Laska, M. N., Murray, D. M., Lytle, L. A., & Harnack, L. J. (2012). Longitudinal associations between key dietary behaviors and weight gain over time: Transitions through the adolescent years. *Behaviour and Psychology, 20*(1), 118–125. doi: 10.1038/oby.2011.179.

Lewis, M. D., Lamm, C., Segalowitz, S. J., Steiben, J., & Zelazo, P. D. (2006). Neurophysiological correlates of emotion regulation in children and adolescents. *Journal of Cognitive Neuroscience, 18*(3), 430–443. dDoi:; 10.1162/089892906775990633

Luciana, M., Conklin, H. M., Hooper, C. J., & Yarger, R. S. (2005). The development of nonverbal working memory and executive control processes in adolescents. *Child Development, 76*(3), 697–712. doi: 10.1111/j.1467-8624.2005.00872.x

Mahoney, C. R., Taylor, H. A., Kanarek, R. B., & Samuel, P. (2005). Effect of breakfast composition on cognitive processes in elementary school children. *Physiology and Behaviour, 85*(_), 635–645. doi: 10.1016/j.physbeh.2005.06.023

Malik, V. S., Rimm, E. B., Fung, T. T., Rosner, B., van Dam, R. M., & Hu, F. B. (2012). Dietary patterns in adolescence and risk of type 2 diabetes in middle-aged women. *Diabetes Care, 35*(1), 12–18. doi: 10.2337/dc11-0386

McLaughlin, K. A., & Nolen-Hoeksema, S. (2012). Interpersonal stress generation as a mechanism linking rumination to internalizing symptoms in early adolescents. *Journal of Clinical Child & Adolescent Psychology, 41*(5), 584–597. doi:10.1080/15374416.2012.704840

McRae, K., Gross, J. J., Weber, J., Robertson, E. R., Sokol-Hessner, P., Ray, R. D., Gabrieli, J. D. E., & Ochsner, K. N. (2012). The development of emotional regulation: An fMRI study of cognitive reappraisal in children, adolescents, and young adults. *Social Cognitive, and Affective Neuroscience, 7*(1), 11-22. doi: 10.1093/scan/nsr093

Meeusen, R. (2014). Exercise, nutrition, and the brain. *Sports Medicine, 44*(1), 547–556. doi: 10.1007/s40279-014-0150-5

Mellanby, J., & Theobald, K. (2014). *Education and learning: An evidence-based approach*. West Sussex, UK: Wiley Blackwell.

Merhi, M. I. (2015). Factors influencing higher education students to adopt podcast: An empirical study. *Computers & Education, 83*(1). 32–43. doi: 10.1016/j.compedu.2014.12.014

Metz, S. M., Frank, J. L., Reibel, D., Cantrell, T., Sanders, R., & Broderick, P. C. (2013). The effectiveness of the learning to BREATHE program on adolescent emotional regulation. *Research in Human Development, 10*(3), 252–272. doi: 10.1080/15427609.2013.818488.

Michl, L. C., McLaughin, K. A., & Shepherd, K. (2013). Rumination as a mechanism linking stressful life events to symptoms of depression and anxiety: Longitudinal evidence in early adolescents and adults. *Journal of Abnormal Psychology, 122*(2), 339–352. doi:10.1037/a0031994

Monk, C. S., McClure, E. B., Nelson, E. E., Zarahn, E., Bilder, R. M., Leinbenluft, E., Charney, D. S., Ernst, M., & Pine, D. S. (2003). Adolescent immaturity in attention-related brain engagement to emotional facial expressions. *NeuroImage, 20*(1), 420–428. doi:10.1016/S1053-8119(03)00355-0

Morrison, A. B., & Chein, J. M. (2011). Does working memory training work? The promise and challenges of enhancing cognition by training working memory. *Psychonomic Bulletin & Review, 18*(1), 46–60. doi: 10.3758/s13423-010-0034-0

Nabkasorn, C., Miyai, N., Sootmongkol, A., Junprasert, S., Yamatoto, H, Arita, M., & Miyashita, K. (2005). Effects of physical exercise on depression, neuroendocrine stress hormones, and physiological fitness in adolescent females with depressive symptoms. *European Journal of Public Health, 16*(2), 179–184. doi: 10.1093/eurpub/cki159.

Nyaradi, A., Foster, J. K., Hickling, S., Li, J., Ambrosini, G. L., Jacques, A., & Oddy, W. H. (2014). Prospective associations between dietary patterns and cognitive performance during adolescence. *Journal of Child Psychology and Psychiatry, 55*(9), 1017–1024. doi: 10.1111/jcpp.12209

O'Conner, R. M., & Cryan, J. F. (2014). Adolescent brain vulnerability and psychopathology through generations: Role of diet and dopamine. *Biological Psychiatry, 75*(1), 4–6. doi: 10.1016/j.biopsych.2013.10.022

Oddy, W. H., Robinson, M., Ambrosini, G. L., O'Sullivan, T. A., de Klerk, N. H., Beilin, L. J., Silburn, S. R., Zubrick, S. R., & Stanley, F. J. (2009). The association between dietary patterns and mental health in early adolescence. *Preventative Medicine, 49*(1), 39–44. doi: 10.1016/j.ypmed.2009.05.009

Oenema, A., Brug, J., Dijkstra, A., de Weerdt. I., & de Vries, H. (2008). Efficacy and use of an internet-delivered computer-tailored lifestyle intervention, targeting saturated fat intake, physical activity and smoking cessation: A randomized controlled trial. *Annals of Behavioural Medicine, 35*(2), 125-135. doi: 10.1007/s12160-008-9023-1

Olds, W. (Eeds.). (2015). *Sleep, circadian rhythms, and metabolism: The rhythm of life.* Oakville, ON: Apple Academic Press Inc.

Padilla-Walker, L. M. (2008). 'My mom makes me so angry!': Aadolescent perceptions of mother-child interactions as correlates of adolescent emotions. *Social Development, 17*(2), 306–325. doi:10.111/j.1467-9507.2007.00426.x

Parson, V., Reddy, P., Wood, J., & Senior, C. (2009). Educating an ipod generation: Undergraduate attitudes, experiences and understanding of vodcast and podcast

use. *Learning, Media, and Technology, 34*(3), 215–228. doi: 10.1080/17439880903141497.

Passer, M., Smith, R., Atkinson, M., Mitchell, J., & Muir, D. (2008). Psychology: Frontiers and applications. Toronto, ON: McGraw-Hill Ryerson

Payne, J. (2014). *Change your brain, change your life (before 25): Change your developing mind for real-world success*. Don Mills, ON: Harlequin.

Pérez-Jiménez, H., Neveu, V., Vos, F., & Scalbert, A. (2010). Identification of the 100 richest dietary sources of polyphenols: An application of the phenol-explorer database. *European Journal of Clinical Nutrition, 64*(3), 112-120. doi: 10.1038/ejcn.2010.221

Piaget, J. (1972). Intellectual evolution from adolescence to adulthood. *Human Development, 15*(1), 1-—12. doi: 10.1159/000271225

Pinel, J. P. J. (2011). *Biopsychology: 8th Edition.* Boston, MA: Pearson Education, Inc.

Plankis, B., & Weatherly, R. (2008). Engaging students and empowering researchers: Embedding assessment, evaluation and history into podcasting. *Technology and Teacher Education, 19*(2), 1267-1274

Randall, D. (2013). *Dreamland.* New York, NY: W. W. Norton & Company

Ratey, J . J. (2008). *Spark: The revolutionary new science of exercise and the brain*. New York, NY: Little, Brown and Company

Reinsoso-Suárez, F., de Andrés, I., & Garzón, M. (2011). *Functional anatomy of the sleep-wakefulness cycle: Wakefulness.* New York, NY: Springer Inc.

Rekart, J. (2013). *The cognitive classroom: Using brain and cognitive science to optimize student success*. Plymouth, UK: Rowman & Littlefield Education.

Richland, L. E., & Burchinal, M. R. (2013). Early executive function predicts reasoning development. Psychological Science, 24(1), 87-—92. doi: 10.1177/0956797612450883

Richland, L., Morrison, R., & Holyoak, K. (2006). Children's development of analogical reasoning: Insights from scene analogy problems. *Journal Of Experimental Child Psychology, 94(*3), 249-—273. doi: 10.1016/j.jecp.2006.02.002 (3 to 14).

Romer, D., Betancourt, L. M., Brodsky, N. L., Giannetta, J. M., Yang, W., & Hurt, H. (2011). Does adolescent risk taking imply weak executive function? A prospective study of relations between working memory performance, impulsivity, and risk taking in early adolescence. *Developmental Science, 14*(5), 1119−1133. doi: 10.1111/j.1467-7687.2011.01061.x

Sacks, O. (1998). *The man who mistook his wife for a hat and other clinical tales.* New York, NY: Touchstone.

Sattlemair, J., & Ratey, J. J. (2009). Physically active play and cognition: An academic matter? *American Journal of Play, 1*(3), 365–374.

Savel, R. H., Goldstein, E. B., Perencevich, E. N., & Angood, P. B. (2007). The icritical care podcast: A novel medium for communication and education. *Journal of the American Medical Informatics Association, 14*(1), 94–99.

Silvers, J. A., McRae, K., Gabrieli, J. D. E., Gross, J. J., Remy, K. A., & Ochsner, K. N. (2012). Age-related differences in emotional reactivity, regulation, and rejection sensitivity in adolescence. *Emotion, 12*(6), 1235–1247. doi: 10.1037/a0028297

Smeets, T.. Kremers, S.P., Brug, J., & de Vries, H. (2007). Effects of tailored feedback on multiple health behaviours. *Annals of Behavioural Medicine, 33*(2), 117-123. doi: 10.1007/BF2879892

Sousa, D. A. (Eds.). (2011). *Educational neuroscience*. Thousand Oaks, CA: Corwin.

Thibaut, J. P., French, R., & Vezneva, M. (2010). The development of analogy making in children: Cognitive load and executive functions. *Journal of Experimental Child Psychology, 106*(1), 1-—19. doi: 10.1016/j.jecp.2010.01.001 (6, 8 and 23).

Tokuhama-Espinosa, T. (2011). *Mind, brain, and education Science: A comprehensive guide to the new brain-based teaching*. New York, NY: W. W. Norton Company INC.

Usyysal, N., Tugyan, K., Kayatekin, B.M., Acikgoz, O., Bagriyanik, H. A., Gonenc, S., Ozdemir, D…Semin, I., (2005). The effects of regular aerobic exercise in adolescent period on hippocampal neuron density, apoptosis, and spatial memory. *Neuroscience Letters, 383*(3), 241–245. doi: 10.1016/j.neulet.2005.04.054

Utter, J., Neumark-Sztainer, D., Jeffery, R., & Story, M. (2003). Couch potatoes or French fries: Are sedentary behaviors associated with body mass index, physical activity, and dietary behaviors among adolescents? *Journal of the American Dietetic Association, 103*(10), 1298–1305.

van der na, N., De Geus, E. J. C., van Beijsterveldt, T. C. E. M., Boomsma, D. I., & Bartels, M. (2010). Genetic influences on individual differences in exercise behavior during adolescence. *International Journal of Pediatrics, Article ID 138345*, 1–8. doi: 10.1155/2010/138345

Vandekerckhove, M., & Cluydts, R. (2010). The emotional brain and sleep: An intimate relationship. *Sleep Medicine Reviews, 14*(4), 219–226. doi: 10.1016/j.smrv.2010.01.002

Vendetti, M. S., Matlen, B. J., Richland, L. E., & Bunge, S. A. (2015). Analogical reasoning in the classroom: Insights from cognitive science. *Mind, Brain, and Education, 9*(2), 100—106. doi: 0.1111/mbe.12080 (children).

Videon, T. M., & Manning, C. K. (2003). Influences on adolescent eating patterns: The importance of family meals. *Journal of Adolescent Health, 32*(5), 365–373.

Wagner, C. A., Alloy, L. B., & Abramson, L. Y. (2015). Trait rumination, depression, and executive functions in early adolescence. *Journal of Youth and Adolescence, 44*(1), 18–36. doi: 10.1007/s10964-014-0133-8

Wartella, E., Rideout, V., Montague, H., Beaudoin-Ryan, L., & Lauricella, A. (2016). Teens, health, and technology: A national survey. *Media and Communication, 4*(3), 13–23. doi: 10.17654/mac.v413.515

Wesnes, K. A., Pincock, C., Richardson, D., Helm, G., & Hails, S. (2003). Breakfast reduces declines in attention and memory over the morning in schoolchildren. *Appetite, 41*(3), 329–331. doi: 10.1016/j.appet.2003.08.009

Yeager, D. S., Lee, H. Y., & Jamieson, J. P. (2016) How to improve adolescent stress responses: Insights from integrating implicit theories of personality and biopsychosocial models. *Psychological Science, 27*(8), 1078–1091. doi: 10.1177/0956797616649604

Zimmerman, P., & Iwanski, A. (2014). Emotion regulation from early adolescence to emerging adulthood and middle adulthood: Age differences, gender differences,

and emotion-specific developmental variations. *International Journal of Behavioral Development, 38*(2), 182–194. doi: 10.1177/0165025413515405

APPENDIX A

Teen Brain Episode 1 Transcript: An Introduction to the Brain and its Functions

[00:16] Sarah: Hi, my name is Sarah!

[00:19] Adam: And I'm Adam,

[00:20] Sarah: And you are listening to Teen Brain

[00:21] Adam: Now my sister has enlisted me to help her with this mini-series of podcasts about the brain and how it works. The only problem is, I don't know a lot about the structures of the brain and their jobs.

[00:30] Sarah: We are going to use this first podcast as an introduction to some key structures and functions of our brain and its systems so that both yourselves and Adam can get up to speed.

[00:39] Adam: Sweet!

[00:40] Sarah: We are actually going to start by talking about the nervous system. As some of you may know, our brain is part of the nervous system. The brain and spine's part of the nervous system is referred to as the central nervous system, the controlling system if you will. To begin our story today, we are going to be talking about the peripheral nervous system, to explain it, I would like you to think of yourself as a robot.

[01:01] Adam (robot voice): ok. I. Am. A. Robot.

[01:03] Sarah: Thank you for that. Now, if the human body was a machine like a robot, you can think of the central nervous system as the control center. In order to control the whole machine, a big task, it utilizes the peripheral nervous system, which consists of a large amount of wires called nerves. These nerves gather information from the body and bring it to the control center and bring orders from the control center to the body.

[01:25] Adam: So basically the Peripheral Nervous System is the control center's way of communicating with the body. Did I get that right?

[01:32] Sarah: Exactly. The peripheral nervous system has two systems of its own. System one is the somatic system. This system uses its nerves to bring all the sensory information, such as your sense of touch, from around the body to the control center, first through the spine, then to the brain. It also controls all your muscles through messages from the control center.

[01:51] Adam: Ok so system one is somatic and helps you be aware of the outside world and use your muscles. What would be system two?

[01:58] Sarah: The second system of nerves is the autonomic system, which works with your internal organs and the control center in order to keep your body functioning properly and prepare you physically for threatening situations. The autonomic system has two systems of its own.

[02:12] Adam: Wow, I feel like this is going to be a lot to remember.

[02:15] Sarah: If it helps you can think of these two new systems as a team. One team is responsible for getting your body active, and the other is responsible for calming it back down. System one is the sympathetic nervous system. This system is responsible for making sure that your body is prepared to keep you safe.

[02:29] Adam: So lets say I'm walking in the woods and I see a bear, how is the sympathetic system going to keep me safe?

[02:33] Sarah: Well your control center will yell "DANGER!" signaling the system to prepare you for something called fight or flight. This tells your sympathetic system to increase your heart rate in order to get more blood pumping to your muscles, take in more air into your lungs, trigger epinephrine which helps release stored energy into your blood and more, so that you can either run away or…

[02:53] Adam: fight a bear!?

[02:54] Sarah: Well, your sympathetic system isn't the one who decides whether you run from a bear or fight it, that's the control centers job; it just gets your body ready for whatever you decide to do.

[03:02] Adam: Ok ok, so system one is sympathetic to your situation and gets you prepared for survival, see what I did there.

[03:08] Sarah: Punny.

[03:09] Adam: Thanks. Ok what does system two do?

[03:11] Sarah: System two of the autonomic system is called the parasympathetic system. This system is what makes your body chill out after experiencing flight or flight. If you're still imagining your body as a robot, you can think of your robot as operating on a battery system. When the sympathetic system, or system one, sends the body into flight or flight, that battery starts to drain. It's the parasympathetic system's job to charge the

battery and make sure there's always enough for the sympathetic system to use it when needs it.

[03:38] Adam: How does it charge the battery?

[03:40] Sarah: It returns your body back to its normal state so it can conserve energy. It slows your heart rate back down, decreases your breathing because you don't need as much oxygen without your heart pumping so fast, and stores up energy so that it can be released again.

[03:51] Adam: That is interesting, so it's called the autonomic nervous system, maybe that is because you don't control it with your thoughts. It's like automatic almost.

[03:59] Sarah: I think you might be right about that. Imagine if every time you needed your heart to beat you had to think, "beat heart."

[04:04] Adam: Yeah it would be probably pretty tough to make it throughout a day. That would probably be all of our time.

[04:08] Sarah: Yeah, I think so. There's one thing I want to add about this system actually. From an evolutionary perspective, systems like this helped to prepare us for survival in dangerous situations, like running from a predator. However, a lot of the danger that we experience now is not as obvious as running away from an animal trying to eat us.

[04:24] Adam: Yeah, a lot of the things that we need to worry about now happen in our minds. I'm sure you've all heard the term stress.

[04:30] Sarah: Some stress is good for your body, it can help you to learn new things by making you more alert, or give the body the boost it needs to do well at your hockey game. However, when you experience too much stress or stress over long-periods of time, called chronic stress, then your body is always in the fight or flight response.

[04:45] Adam: So that must mean that your body's always prepared for danger, and the parasympathetic nervous system is not able to calm you body back down, like it's suppose to.

[04:54] Sarah: That's right, so if your body can't be calmed down, then you're always operating at less battery power than if the parasympathetic nervous system was able to charge it, and so, as you can imagine, operating with less battery power can have all sorts of effects on how well your body's able to function.

[05:08] Adam: We are going to be referring to the fight-or-flight response in many of the podcasts in this series.

[05:14] Sarah: That's right. It plays a big role in how we function in our everyday lives. Now we are going to dive into some of the areas of the control center, specifically the brain. Because the brain develops from back to front, we'll start at the back, a part of our brain that has a very important job. This area of the brain is called the brain stem and its job is to keep us alive. Damage to this area of the brain can have a range of consequences including coma and death.

[05:37] Adam: Ok so I'm looking at a list of a couple different parts of the brain stem here, can you tell me what they do?

[05:42] Sarah: Yeah, sure.

[05:45] Adam: Medulla Oblongata. Sounds like a spell in Harry Potter.

[05:48] Sarah: This is an important one, it takes all the messages from the Peripheral nervous system, which we just talked about, and tells it how to regulate our body's environment such as our temperature, heart rate, respiration and even digestion.

[05:59] Adam: The next one I see here is the Reticular Activating System.

[06:03] Sarah: Yes, this system tells your body how alert it needs to be. For example, lets say you are sitting at your desk in your bedroom; chances are your body is pretty relaxed. Now, let's say your mom were to bring in a stranger, your body would actually feel different because a stranger might be a threat. This system tells the sympathetic nervous system something's up. These two structures are a part of one of three sections of the brain referred to as the hindbrain. But the brain stem also includes some structures that are found in the midbrain.

[06:29] Adam: Ok, so where exactly are the hindbrain and midbrain?

[06:32] Sarah: The Hindbrain is the back of your head, so just above your spine, and the midbrain is located approximately between your ears and is responsible for all things related to your senses. Structures here collect information that you see and hear and relay it to the parts of your brain that turn the information into perceptions that we recognize. There's one specific part of the midbrain and brain stem that I want to mention. The reticular formation is responsible for your mind's level of consciousness.

[06:56] Adam: So how are we defining mind here?

[06:59] Sarah: When I refer to mind, I am thinking about our conscious brain, our thoughts and our feelings, rather than just the structures that function without us thinking about them.

[07:06] Adam: Wait a minute, didn't you just say that the reticular formation was responsible for your body's level of alertness.

[07:11] Sarah: Actually, that was the reticular activating system. The reticular formation is what controls our level of consciousness or our minds awareness of the world around us, while the activating system controls only our body's awareness.

[07:22] Adam: So that's the brain stem?

[07:24] Sarah: Yeah basically, I didn't tell you about every structure in this area of the brain, just like we are going to do with the other sections, I'm going to choose to highlight key areas that will help us understand how our bodies and minds work better. So now you know a little bit about how our brain works to keep you alive and connecting with your environment.

[07:39] Adam: Ok, I want to learn about how we move.

[07:41] Sarah: Yes, the cerebellum. This area of the brain's also found in the hindbrain, at the back of your head, and it is a big one. It accounts for 11% of the brain's total weight. Not only that, it has more neurons than all other part of the brain combined.

[07:55] Adam: Ok, I feel like I am going to need to know what a neuron is.

[07:58] Sarah: right, sorry about that. A neuron is a tiny cell that sends and also receives electrochemical signals. It uses a system a lot like the game telephone, where you whisper a message into someone's ear and they whisper it to the next person and so on.

[08:11] Adam: So neurons are whispering, is what I'm taking from this.

[08:15] Sarah: Well actually they fire; when they fire they release a neurotransmitter. Any neurons around them that have a receptor for that neurotransmitter will also fire, as so on and so on, so that messages in the brain get where they need to go. So it's like telephone except everyone is wearing headphones that only let him or her hear certain words. The neuron stands up and yells a word, and anyone who has the right headphones to hear it will also stand up and yell that word to the people who are further away.

[08:40] Adam: Ok, so neurons are tiny cells that send and receive these electrochemical signals when they fire. I got it.

[08:46] Sarah: Right, back to the cerebellum. It's big because it is responsible for coordinating approximately 700 muscles in your body, it's responsible for all the movement that you do. So as you can imagine, it takes a lot of brainpower to make our movements smooth. In order to help us do this, scientists believe that it stores some movements as automatic sequences.

[09:04] Adam: So like what movements are we talking about?

[09:06] Sarah: Well Adam, do you remember learning to tie your shoe?

[09:10] Adam: Yeah, the bunny ears around the tree, simple.

[09:12] Sarah: Yeah, chances are though, when you were first learning how to tie your shoe it took all your concentration. But now you can probably tie your shoes and have a conversation at the same time, right?

[09:20] Adam: Definitely. I'm tying my shoe right now. So my cerebellum stored the movements of my muscles tying my shoes as one whole sequence?

[09:27] Sarah: Yes! If you think about how babies learn to move and walk, you can see that this area of the brain is practicing using all the muscles to make them smooth. They starts out as shaky and uncoordinated but then those movements become our everyday movements.

[09:39] Adam: Almost like someone trying to walk on a balance beam for the first time.

[09:42] Sarah: Trying to do anything for the first time.

[09:44] Adam: I think we're going to talk about this stuff in our podcast on memory, right?

[09:47] Sarah: Yes that's right, an interesting cerebellum hack involves visualizing. When you close your eyes and imagine yourself doing a complex movement, the same area of the brain fires neurons as it does when you actually do that movement.

[10:00] Adam: So my brain is working in the same way whether I am doing a movement or just imagining myself doing a movement, right?

[10:04] Sarah: Yeah, visualizing physical tasks is like a form of practice. Many professional athletes use this strategy.

[10:10] Adam: Ok so now we know that the back of our brain is responsible for movement and plays into that fight or flight response, right?

[10:17] Sarah: Yeah, and keeps us alive.
[10:19] Adam: But I'm guessing that, if you are anything like me, I'm not really thinking about this area of the brain when I imagine a brain. I'm imagining a grey wrinkly looking jello-like blob.

[10:29] Sarah: Yes, this is a great part of the brain. The third and final area for the brain is referred to as the forebrain, which is involved in everything cognitive, in other words everything you think and feel. It is divided into two hemispheres. The jello-like blob that you imagine is only a part of this area of the brain. Underneath the surface there are other structures that contribute to all the amazing things this area of the brain can do.

[10:49] Adam: One of these structures I know about is the thalamus. This area of the brain works kind of like the administrative assistant of the brain. It takes the messages from one area and delivers them to another. The thalamus is in the middle of your brain, above the midbrain, and it is surrounded on both sides by the limbic system.

[11:05] Sarah: What's interesting about the limbic system is that it actually is mirrored on both sides of the brain. So every structure has a matching part right across from it in the other hemisphere of the brain.

[11:14] Adam: And we use the limbic system for…

[11:16] Sarah: Our limbic system has a lot of different roles. A key area is the hippocampus. Basically the hippocampus takes information that you are working with and compares it to what you already have stored in your long-term memory so that you can remember it better.

[11:29] Adam: We're going to go deeper into this process in our podcast about memory.

[11:32] Sarah: Another important area in the limbic system is the amygdala. The amygdala is involved in the experience and production of emotions. Something we're going to talk about a lot in our emotions podcast.

[11:41] Adam: This is the area of the brain that signals that gut punch feeling you get when you remember that day you embarrassed yourself in class. Some scientists believe that the amygdala encodes emotions into your memories so that they store better in long-term memory.

[11:53] Sarah: The animated movie Inside Out is a perfect example of how this system might work. The memories as stores as large marbles, and then

when the character Sadness touches them, the memories turn blue. Then when the person falls asleep, all the marbles rush out and get stored in long-term memory.

[12:06] Adam: I love that movie.

[12:07] Sarah: Me too.

[12:08] Adam: It made me cry.

[12:09] Sarah: Me too.

[12:10] Adam: That's really embarrassing, I can't believe you just admitted that.

[12:12] Sarah: Actually tears just welled up, they didn't fall.

[12:14] Adam: My tears fell.

[12:15] Sarah: I was actually pretty proud, because it was very emotional.

[12:17] Adam: My tears fell, they fell down.

[12:19] Sarah: Ok anyways, another key part of this structure is the Cingulate Gyrus. The cingulate gyrus takes input from the limbic system and other parts of the forebrain and controls your attention. When this area of the brain is overactive, you may overthink certain upsetting situations over and over again; you can't seem to get your mind off what's bothering you. Over activity here is associated with anxiety and anxiety disorders such as Obsessive Compulsive Disorder, also known as OCD.

[12:44] Adam: Ok, so the person with OCD is not able to shift their attention away from their compulsive thoughts, right?

[12:50] Sarah: Exactly, you can think of this area of the brain like a lever with a position for each thing you need to think about. For a person with anxiety, this lever is stuck in one position. And last, but not least we have the hypothalamus. This area is responsible for the regulation of motivated behaviours, which means it regulates our sleeping, eating, and sex drives. It takes information from other parts of the brain, such as the brain stem, and helps to motivate you to get stuff done. This is the area of the brain that signals your stomach to growl when you're hungry. It takes note of the glucose levels in your blood and takes action.

[13:20] Adam: Tune into our podcast about sleep to learn how the hypothalamus helps to tell you when its time to go to bed.

[13:26] Sarah: Now that we have explored the structures beneath that, what did you call it?

[13:29] Adam: The jello-like blob.

[13:30] Sarah: Yes of course. A fun fact about those wrinkles that makes it so blob like is that they allow the brain to have more surface area without weighing too much. Lets say you were to take a piece of paper and write all the information you needed for your math test on both sides. If you crumple up that piece of paper into a ball, it would still have the same amount of information; it would just take up less space.

[13:48] Adam: Interesting, so it's not about the size of your brain, it's about how wrinkly it is.

[13:50] Sarah: Exactly. The forebrain has four lobes. The occipital lobe, analyzes visual information. This is the part that decodes all the information from your eyes that has come through other areas of the brain. The parietal lobe takes information from the brainstem about the body and analyzes it. The parietal lobe is responsible for your understanding of where objects are in space, including your own body.

[14:10] Adam: Ever weird that you need a part of your brain to tell you where your body is.

[14:15] Sarah: Yes, Oliver Sacks tells an interesting story of a patient that he examined. The man woke up in bed and discovered a leg in bed with him. He immediately threw the leg from his bed, only to find his own body tumbling onto the floor with it. Some scientists believe that this man may have had damage to his parietal lobe and he didn't recognize the position of his own leg. He didn't think it was his own leg.

[14:35] Adam: Doesn't the parietal lobe also analyze sensations from facial muscles?

[14:39] Sarah: Yeah, that's right, what's interesting about that is you can influence your brain by the expressions you put on your face. Smiling, even if it is forced, signals the parietal lobe that you're happy that can actually influence your brain.

[14:50] Adam: That's why I try and smile as much as I can, especially when I'm not the happiest.

[14:54] Sarah: Good plan.

[14:55] Adam: Yeah. The next lobe in the forebrain is the temporal lobe, I see here.

[14:57] Sarah: Yes, it can be found right behind your eyes, right in front of the midbrain actually. Scientists actually learned a lot about this area of the brain from a man who's referred to as H.M. H.M had a severe seizure disorder that led doctors to remove his temporal lobe. After the surgery, H.M was no longer able to form long-term memories. This case study helped scientists understand that this area of the brain contributes to long-term memory.

[15:19] Adam: It also is responsible for face and object recognition. And it analyzes auditory information, much like the occipital lobe analyzes visual information.

[15:29] Sarah: And last, but certainly not least, is the frontal lobe. This is of particular interest to adolescents or teenagers because it may not be fully developed until as old as 23 to 25. In fact, this lobe undergoes major development during the teenage years. Believe it or not, the frontal lobe plays a role in your ability to plan, evaluate the outcomes of behaviour, control your impulses, have good judgment, and use empathy.

[15:52] Adam: So basically everything adults say that teenagers suck at, right?

[15:55] Sarah: Yes. All those skills are still being developed through adolescence, which means sometimes it may be hard to make good choices. It's also the part of your brain that allows you to consider hypothetical questions, processes reading, music, speech, math and writing. Not to mention, it plays a large role in what makes you, well you. Finally, this area of the brain is important to our ability to produce speech.

[16:13] Adam: Man, it is quite interesting when you think about it how each area of the brain has so much power over our ability to live our lives.

[16:22] Sarah: Yeah, after hearing all of this it's hard to believe that people used to think we only used 10% of our brain's potential. In fact, our brains use up 20% of our whole body's energy consumption!

[16:31] Adam: oh man, there *have* been a lot of different understandings of how the brain functions. I read once that some ancient civilizations believed that our thoughts actually originated in our heart. This is actually where the phrase originates "off by heart." Like I learned the deck of cards off by heart.

[16:48] Sarah: I have an even weirder one for you. Some theorists used to believe that we were controlled by animal spirits moving around our bodies.

[16:54] Adam: Yeah that's animatism right? I think that might be legit still. Yeah that's definitely different.

[17:04] Sarah: In our teenage years, we become faster, stronger, and smarter than we've ever been before.

[17:08] Adam: With the major amount of development happening in the brain at this time, it becomes important to think about how you actually treat your brain.

[17:15] function at your best daily as well as have implications for how your brain's able to function in the future.

[17:22] Adam: Yeah think about it. You can run your brain so it just barely gets by or you can run your brain at peak performance and you can get the best out of yourself. You can tune into some of our other podcasts where you'll learn something interesting in each one about your brain that you probably didn't know!

[17:37] Sarah: thank you for listening to our podcast about the brain and its functions. I'm Sarah.

[17:40] Adam: And I'm Adam.

[17:41] Sarah: And this concludes our first episode Teen Brain.

[17:48] Sarah: I would like to thank Music Supervisor Brian Case for allowing us to use the song Belleville, which was performed and recorded by Joseph Perkins from London, UK. You can check out more of their stuff at braincase.ca or joeperkinsmusic.com. I would also like to thank Robyn Crummey for designing our logo. You can check out more of her awesome work on Instagram at @crummey_art. That's c-r-u-m-m-e-y_art. For those of you who didn't come across this podcast on the Teen Brain Blog please visit teenbrain.wordpress.com to learn more about the project and don't forget to leave a comment telling us what you thought of the episode. Alternatively, you can send an email to teenbrainpodcast@gmail.com. Thanks for listening.

Teen Brain Episode 2 Transcript: Sleep and the Brain

[00:16] Sarah: Hola, my name is Sarah!

[00:18] Adam: And I'm Adam,

[00:19] Sarah: And you are listening to Teen Brain. Today we are going to be talking about everything sleep!

[00:25] Adam: Oh my favorite subject. From why we sleep to when we sleep to dreams, we/re going to fill your brain full of interesting tidbits about those mysterious hours you can't remember.

[00:36] Sarah: So why do all humans naturally want to sleep at night and be awake during the day? As we all know, the earth rotates a full 365-degrees every 24 hours around the sun to mark a day.

[00:49] Adam: As long as living things have been on the planet, this has happened.

[00:53] Sarah: So naturally livings things began to predict that this 24 hours cycle was going to happen, this is referred to as a circadian rhythm.

[01:03] Adam: Yes, we predict this cycle because of the light from the sun. In humans for example, we have a tiny part of our brain that is found in the hypothalamus, located behind our eyes, called the suprachiasmatic nucleus that evolved to detect light from the sun.

[01:19] Sarah: Since the sun comes and goes on a regular basis, our bodies have adapted to functioning in a way that follows that cycle. Your body uses this time frame to know when to release certain hormones, including hormones that tell you when to sleep.

[01:32] Adam: When the sun goes down, your SNS detects less light, and it starts to secrete melatonin. Melatonin makes you tired, and eventually want to sleep.

[01:42] Sarah: When the sun comes back up, your SNS detects the light, light suppresses, or stops, the release of melatonin, and you wake up. The whole process is called the sleep-wake cycle.

[01:54] Adam: Ah, the Sleep-Wake cycle. It's got three main stages. Wakefulness, non-REM sleep, and REM Sleep. Wakefulness that one's obvious; this is every part of your day that you explicitly remember what we were doing.

[02:10] Sarah: non-REM sleep is dozing and light sleep. This type of sleep can make up sometimes 50% of the time you are asleep at night.

[02:19] Adam: and then there is the good stuff,

[02:20] Sarah: Oh yeah,

[02:22] Adam: This is the stuff I really enjoy. This is the REM sleep. REM stands for Rapid Eye Movement. Now this is the phase of your sleep when you actually dream.

[02:30] Sarah: Recently, I was on vacation with my mom and I happened to look over and notice her in this stage of sleep. I could see her eyes moving around behind her eyelids and even noticed small twitches in her hands.

[02:42] Adam: Was she dreaming?

[02:45] Sarah: I think so, when you enter this phase of sleep, your body has released a hormone that paralyzes your limbs so that everyone isn't jumping out of bed and acting out their dreams.

[02:57] Adam: But this system doesn't work perfectly or everybody though. Think about people who sleep walk, these people are not secreting enough of that paralyzing hormone in order to stay still while they are dreaming, so they get up and walk around.

[03:11] Sarah: Some people who sleep walk act out their dreams to the point where they have jumped out windows or tackled nightstands.

[03:18] Adam: Ouch.

[03:19] Sarah: Yeah, when we are asleep, our prefrontal cortex or the decision making part of the brain is asleep. We do not experience consciousness. So, for people with sleep disorders this can be very distressing.

[03:30] Adam: One man woke up in bed in the middle of the night to find he was developing frostbite on his feet. When his wife retraced his steps, she found footprints from his bare feet walking the three-block radius that they take to walk their dog every evening.

[03:44] Sarah: So, because he wasn't conscious, and his prefrontal cortex was asleep, he wasn't processing information from his body, so he didn't recognize or respond the pain that he was likely experiencing.

[03:54] Adam: Now scientists aren't exactly sure why we dream. What we do know is that when we are in REM sleep the brain produces images that the body reacts to as if they were really happening! Blood flows to the emotional and memory centers of the brain. Which is why you might find that your dreams often have settings and people that you recognize.

[04:15] Sarah: Some researchers believe that dreams are the body's way of practicing dealing with stressful situations.

[04:20] Adam: Another guy named Calvin Hall started collecting descriptions of dreams from 50 000 people. What he found was interesting, on average dreams tend to be negative, or have mean or aggressive characters in them.

[04:33] Sarah: So basically, your mind is taking any anxieties that you may have and acting them out using your own memories and emotions. It's basically a trial run for if those anxiety-provoking situations were to happen in real life.

[04:46] Adam: People who experience Post-Traumatic Stress Disorder, known as PTSD often have recurring negative dreams. The brain is not able to move past those anxieties that were experienced in the past.

[04:58] Sarah: Another dream theory has to do with the hippocampus. The hippocampus works with your memory to store information. Obviously your brain doesn't have enough room to store the mass amounts of information that you have to process every day.

[05:11] Adam: Therefore, dreams may be the result of your hippocampus working to organize information in your brain while you sleep.

[05:17] Sarah: This process of sorting your daily events while you sleep is very important to how we learn. One study asked participants to solve puzzles to get 6-digit codes. But the researchers were tricky; they made it so that in all the 6-digit codes, the last three numbers were a mirror image of the first three. So if the first three digits were 123 then the last three would be 321.

[05:39] Adam: The participants worked on the puzzles in three groups. One group worked on the puzzles and then went to bed for 8 hours. One group worked on the puzzles and was asked to leave, do their normal things, and come back 8 hours later but just not to sleep, the final group was kept awake and kept there for 8 hours at night, so they didn't get to sleep.

[06:01] Sarah: So, after whatever 8 hours they were assigned to the participants were asked to complete the puzzled again. The group who had slept was quicker to figure out the trick to the puzzles than any other group. In fact, the group who had been kept awake was more likely to never figure out the trick to the puzzles.

[06:19] Adam: This is just one piece of the large amount of evidence that shows that sleep can improve learning. This doesn't only apply to getting no sleep at night; even getting less sleep at night affects your ability to function. Teenagers who do not get enough sleep at night tend to do less well at school,

be less concentrated in class, tend to be more emotional and are more likely to miss school.

[06:42] Sarah: One study by Beebe, Rose, and Amin conducted in 2010 took two groups of students, aged 13 to 17. They let one group get a normal nights sleep, the other group was only allowed to sleep 6 and a half hours. After 2 weeks of doing this, they asked the teenagers to complete a task on a computer screen. The group that only slept 6 ½ hours a night spent more time looking away from the screen, showing more sleepy behaviours such as rubbing or closing their eyes, and putting their head down on the desk.

[07:12] Adam: I'm sure we all know it can be hard to concentrate when you are tired, but 6 ½ hours of sleep doesn't seem like sleep deprivation. That is like going to bed at 12:30 in the morning and waking up at 7 am for school, which I did all the way through high school.

[07:26] Sarah: That is what a lot of people think, but believe it or not, teenagers need 9 to 10 hours of sleep a night. When you aren't getting enough sleep it can create a lot of problems.

[07:35] Adam: For one, you may find that you are much more emotional. Lack of sleep can cause the amygdala to fail, make it more difficult for you to control your emotions. These are the days that you blow up over the smallest thing, or find yourself crying during the credits of American Idol, right Sarah?

[07:52] Sarah: That was one time. I felt really bad for all the people who had their dreams crushed that day.

[07:58] Adam: Very personal to you,

[08:00] Sarah: Yeah, had I had gotten enough sleep the night before, I probably would have been able to say "that sucks" and move on, but without enough sleep I was sitting there crying my eyes out.

[08:09] Adam: Those were the gory days.

[08:11] Sarah: Yeah pretty much,

[08:13] Adam: Ruben Studdard, Ruben Studdard!

[08:15] Sarah: Yeah the campaign I had?

[08:16] Adam: Yeah

[08:18] Sarah: Ruben is still putting out gospel albums.

[08:20] Adam: Not enough sleep also affects your ability to make good decisions. Part of that is due to something called reward responsiveness.

[08:29] Sarah: Reward responsiveness is how your brain reacts to rewards. Normally your brain reacts by producing dopamine, which makes you happy. But you need melatonin to make dopamine in the brain, and when you aren't sleeping you aren't getting as much.

[08:42] Adam: So you have to do things that are much more exciting in order to get the same amount of dopamine in your brain to have that same happiness effect. These new, more exciting things have a tendency to be risky or dangerous, like drinking alcohol or doing drugs.

[08:57] Sarah: Think of it this way, let's pretend that you post a photo on your Instagram account and you get 50 likes. When you have enough sleep you think, "sweet, I got 50 likes." When you don't get enough sleep your brain is like whatever 50 likes is boring, not exciting at all. So you post a more risky photo in order to get 100 likes, and the thrill of posting the risky photo and the 100 likes only gets you as excited as 50 likes got you the first time.

[09:23] Adam: Oh my gosh, but if you were sleeping enough, you could just be happy with your 50 likes and move on with you life.

[09:30] Sarah: Exactly. One group of researchers including Capaldi, Handwerger, Richardson, and Stroud conducted a study back in 2005 where they took adolescents ages 10 to 17 and asked them to complete a questionnaire about their sleep habits. Participants were then asked to complete a stressful task, which including either public speaking, a mental math test, and a mirror drawing test where mistakes made a loud buzzer go off, kind of like Operation. They collected a saliva sample from each person before and after the stressful event.

[10:03] Adam: What they were looking for was the levels of cortisol in their saliva. When we experience stress, our body releases cortisol. Interestingly, what they found was that adolescents who had reported more sleep problems had less cortisol in the saliva then those who hadn't reported sleep problems. They showed less stress response to stressful events than those who had no sleep problems.

[10:27] Sarah: So the researchers hypothesized that sleep may make it more difficult for the body to respond appropriately to stress. In other words, it's harder to care or give your attention to the stress, and therefore your mind does not give the body the signal it needs to prep you for stressful events, and one of those ways is releasing cortisol.

[10:45] Adam: You may be thinking, wow, less sleep means less stress. This isn't the case; you aren't experiencing any less exposure to stressful situations you just don't care as much. So that includes tests at school, job interviews, sports. A little bit of stress can help you work at your best in these situations. It pushed you, you know. Decreasing your stress response to these situations can have consequences for your ability to achieve.

[11:10] Sarah: Ok, so now we know that sleep is important. But, you probably know, it isn't the easiest thing to come by.

[11:18] Adam: That's right, you might be saying great, I would love to get 10 hours of sleep a night but when it comes time to go to bed I'm just not tired.

[11:24] Sarah: What is interesting about that is after we hit puberty our body does something really cruel to us. It pushes our sleep-wake cycle off by approximately 3 hours. A typical adult will naturally hit peak wakefulness or alertness around 9 am, they will have a dip around 2 pm where they may want to take a long for a nap, they'll have another wakefulness boost around 6pm and around 10 o'clock at night their body is ready to prep them for sleep.

[11:48] Adam: Unfortunately, as any teenager knows, if you are let to sleep as long as your please, 9 am is not going to be when you feel the most awake. And 10 pm is not a sleepy time for you at all.

[11:59] Sarah: This is referred to as delayed circadian preference. The hours that you prefer to be awake are later than what is typical of an adult.

[12:07] Adam: However, because society still expects you to be up for the first period bell, this can create a problem. So what an adult feels like at 10 pm, you're basically feeling like at 1 am. So when adults expect you to be at school in the morning this creates something called circadian misalignment.

[12:25] Sarah: Yes, your sleep schedule does not match with the demands of your social schedule. So basically you are experiencing jet lag. Which is associated with difficulty falling asleep and waking up, and even being tired during the day

[12:38] Adam: Night after night of staying up late and having to wake up early take a toll on a person. And this toll is called sleep debt, something I have been in debt to for years.

[12:46] Sarah: Like any debt, sleep debt needs to be paid. Every hour of sleep that you miss out on adds up. You may notice this effect on the weekend or school holidays.

[12:57] Adam: Oh, that's why I slept 14 hours straight on the weekend in high school. That makes a lot of sense.

[13:02] Sarah: Yeah exactly. Your body needs to make up for lost hours of sleep somehow, and a lot of time weekends may be your only opportunity. Unfortunately, this has consequences of it's own.

[13:13] Adam: Ah, You can't win here.

[13:16] Sarah: But don't fret there is a way to overcome it. As anyone who has experienced jet lag will tell you. You need to become accustomed the time zone that you are living in. The best way to do this is to keep a consistent sleep schedule. When you go to bed and wake up at the same time everyday your body adjusts appropriately and it becomes easier to fall asleep and wake up when you need to.

[13:35] Adam: So, when you stay I stay up even later and sleep in on the weekends, I'm resetting my sleep cycle and making it even harder to wake up for school during the week.

[13:45] Sarah: Yeah.

[13:48] Adam: This just reminds me of when I would always be lying in bed at a decent time thinking, yeah that is what I need to do, but very few things would bring on sleep any quicker. Knowing this doesn't let me sleep.

[13:59] Sarah: Yeah, basically knowing all this is really fine and dandy, but it can still be hard to actually fall asleep when you want to.

[14:06] Adam: Yeah,

[14:08] Sarah: For one, our emotions play a big role in our ability to sleep. When we experience stress or worry our brains can get pushed into hyper drive and we can't stop thinking about what's bothering us.

[14:19] Adam: It can be hard to turn off your inner voice in order to fall asleep. It just keeps talking to you.

[14:23] Sarah: Yeah, from an evolutionary standpoint, humans used to need to feel safe in groups order to experience REM sleep. Because your body paralyzes you in REM sleep, it makes you pretty vulnerable to predators.

[14:35] Adam: We needed to be able to rely on our group to protect us. When we experience social stress, our body does not believe we are safe enough to sleep.

[14:44] Sarah: As teenagers, you are especially susceptible to social stress. Tune into our podcast about emotions to learn about how the emotional centers of your brain are undergoing major developmental changes during adolescence.

[14:56] Adam: These changes to our emotional centers can make it hard for us to deal with emotional issues and bedtime can be an especially difficult time not to think about those situations that have been bothering us all day.

[15:07] Sarah: There are tons of strategies out there to help you fall asleep. Literally Google "how to fall asleep" and you will be confronted with over 40 million results.

[15:16] Adam: So I should just follow what they say on yahoo answers.

[15:20] Sarah: Find what works for you, try some different things and you'll see.

[15:25] Adam: If you remember from earlier, sleep is when your hippocampus works to sort through the information you processed all day. Sleep actually helps us process those negative experiences.

[15:35] Sarah: I myself am a pretty big worrier, I have the most difficult time falling sleep and so there are a few strategies that I use to help me. First, I remember the information that we just told you. I think about how sleep will actually help me feel better about my worries. So I relax my body, especially my face, and I focus on breathing. I breathe in to the count of seven and I breathe out to the count of seven. I do that over and over again and eventually I'm asleep. It is really hard to talk to yourself when you are counting, so it gives my mind that little bit of relaxation it needs to fall asleep.

[16:05] Adam: I do pretty much the same thing, I didn't know that you did that. I do almost like a meditation to help my body and my mind relax. But I count all the way up to 100, just one after another. One… relax… two… relax… three, I've never made it to 100.

[16:24] Sarah: That's good then, it works. These aren't the only strategies you can use to help you fall asleep. Because your sleep-wake cycle is determined by light, it can also be thrown off by artificial light. Exposure to artificial light, especially light that is tinted blue like television, computer, or phone screens, can trick your suprachiasmatic nucleus into thinking its sunlight.

[16:48] Adam: If your SNS believes that the sun is still shinning, it doesn't give the cue to release melatonin. When melatonin isn't released, you aren't feeling tired.

[16:58] Sarah: So if you know that you need to be in bed by a certain time, you can help yourself out by limiting your exposure to artificial light before bed. Playing on your phone or tablet in bed actually makes it harder for you to fall asleep.

[17:10] Adam: That's right now that I think about it there is blue light in my phone that I look at. Now, you can also use this artificial light to your advantage. My bedroom is in the basement in my house, and because of that, the amount of natural light I get down there is limited. Therefore it makes it harder for me to wake up in the mornings because my SNS doesn't have that sunlight coming in.

[17:31] Sarah: So I thought about this, and being the thoughtful sister that I am, I bought him a special alarm clock for Christmas that shines a big light when it goes off so that his brain will think it's sunlight and make it easier to wake up.

[17:42] Adam: So far so good, if your bedroom's not in a dark basement you can make this way easier to wake up by letting your SNS be exposed to the natural sunlight that comes out in the morning. Open your window. Instead of sleeping with dark curtains, try letting natural light in, lighter curtains, just pulling the curtains back, you might be surprised how much easier it is to wake up.

[18:05] Sarah: Yes, or you can use the artificial light on your phone or tablet to help you wake up. Sometimes I need to wake up before the sun for work, I will go on my phone for 5 minutes when it is time to get up and that little boost of light can help me get out of bed in the morning and feel even more awake.

[18:19] Adam: Now we hope you know a little bit more about why humans need sleep and how important it is.

[18:25] Sarah: Not to mention a couple tips on how to trick your body into getting the sleep you need.

[18:30] Adam: Tune into more of our podcasts to learn some other great hacks for your brain!

[18:34] Sarah: I'm Sarah,

[18:36] Adam: And I'm Adam,

[18:37] Sarah: And this concludes Episode 2 of Teen Brain.

[18:37] Sarah: I would like to thank Music Supervisor Brian Case for allowing us to use the song Belleville, which was performed and recorded by Joeseph Perkins from London, UK. You can check out more of their stuff at braincase.ca or joeperkinsmusic.com. I would also like to thank Robyn Crummey for designing our logo. You can check out more of her awesome work on Instagram at @crummey_art. That's c-r-u-m-m-e-y_art. For those of you who didn't come across this podcast on the Teen Brain Blog please visit teenbrain.wordpress.com to learn more about the project and don't forget to leave a comment telling us what you thought of the episode. Alternatively, you can send an email to teenbrainpodcast@gmail.com. Thanks for listening.

Teen Brain Episode 3 Transcript: Diet and the Brain

[00:16] Sarah: Hi, my name is Sarah!

[00:18] Adam: And I'm Adam,

[00:19] Sarah: And you are listening to Teen Brain. Today we are going to be talking about our favorite subject.

[00:24] Adam: FOOD.

[00:25] Sarah: Yes, and how the food that we eat affects our brains.

[00:18] Adam: In an earlier podcast we talked about the body as a machine and the brain as the control center for that machine. Well, like any machine, the body needs fuel. Certain kinds of fuel make the machine run excellently. However, there are other types of fuel that still allow the machine to run, but have effects on how it runs as well and how long it is able to run for.

[00:51] Sarah: Today we are going to be talking about that fuel, and obviously by fuel we mean…

[00:55] Adam: FOOD.

[00:56] Sarah: Yes we know you love food Adam.

[00:57] Adam: Food. In order to have the best fuel for our bodies we need a balance of a few different things. Carbohydrates, protein and fat.

[01:04] Sarah: First and foremost we need carbohydrates for energy. Carbohydrates are digested easily by our body and provide glucose to our blood stream. Glucose or sugar is critical for energy.

[01:15] Adam: But not all carbohydrates in our diet are the same. Food that contains lots of added sugar causes our blood-glucose level, or the amount of

glucose in our blood stream to spike. This spike, however, doesn't last, even though we're eating foods with lots of sugar, our overall level of glucose in our blood is lower, and we have less energy.

[01:34] Sarah: If you aren't sure if you are eating the right carbohydrates, you can look up a food's glycemic index. Glycemic index ranks food on a scale of 1 to 100 according to how they influence your blood-glucose levels. Foods that are high on the glycemic index are the ones that Adam just mentioned, the ones that spike your blood-glucose level initially, but overall give you less glucose in your blood. Examples are French fries which have a glycemic index of 75, white bread has a glycemic index rating of 70, and crackers have a rating of 87. Now, if crackers have a rating of 87 imagine where candy falls?

[02:11] Adam: Mmmm, candy falling. Sounds delicious. Foods that are low on the glycemic index like sweet potatoes which rank at 44, peak our initial glucose level less but allow for a more steady level in our bloodstream, actually giving us more energy that lasts longer.

[02:30] Sarah: Not to mention, carbohydrates that are low on the glycemic index make you feel full for longer.

[02:35] Adam: If glucose is like sugar and is needed in the body for energy, why are people always saying that we need to eat less sugar?

[02:41] Sarah: Well first of all the kind of sugar you need to avoid is added sugars and artificial sweeteners. They give you less energy overall to start. This happens because they are metabolized quickly so the blood glucose they provide does not last. But more importantly too much sugar in your diet has implications for your physical and mental health.

[02:58] Adam: That's right, sometimes our body produces free radicals. Free radicals are uncharged molecules that are missing electrons. So basically these free radicals stomp around the body stealing electrons from other molecules to make themselves whole, leaving destruction in their path, a process called oxidation. When we eat unhealthy food, such as fried foods, our body produces more free radicals.

[03:20] Sarah: When our bodies are healthy, we are able to counteract these free radicals and detoxify their harmful effects. But when we have too much sugar in our diet we experience something called oxidative stress, which basically means that we don't have the ability to manage the damage done by these free radicals.

[03:37] Adam: Think of oxidative stress like this. Imagine a kindergarten classroom, lets pretend there's 20 kids, ok. Every kid in the class is playing with a toy expect five. Those five kids need a toy to play with so they walk

around yanking toys from the hands of the other 4 and 5 year olds. Anyone else who has a younger sibling or cousin knows that this is the natural progression, when their toys get taken from them they likely start to cry.

[04:00] Sarah: When we are not experiencing oxidative stress it is like having 10 adults in the classroom who can go around and make every kindergartener feel better, give them a hug and tell them its going to be ok. Oxidative stress would be the equivalent of having one teacher in a kindergarten room full of crying children. He can only help one at a time, so by the time he has helped one kid to stop crying, the toy stealer has struck again and more kids are crying now. It becomes impossible to manage the damage that those 5 students are doing in his classroom.

[04:29] Adam: You may be thinking, why doesn't the teacher stop the 5 disruptive kids first. The truth is that there is a way. Remember, remember that the students in this example are molecules and the teacher is our ability to clean up after damage caused by these reckless free radicals.

[04:44] Sarah: We can reduce the number of free radicals, or toy stealers, in our system, as well as work to decrease their damage, by eating antioxidants.

[04:53] Adam: I see Anti- Oxidants. Because it prevents oxidation.

[04:56] Sarah: Yeah, antioxidants can be found in fruits, vegetables, nuts, grains, poultry, and fish. Some even say that antioxidants help to keep the brain and body young. This is because they help to prevent the damage caused by oxidation.

[05:08] Adam: Another group of nutrients called Polyphenols also act as antioxidants. In doing so they help protect the brain against damage done by neurotoxins, they promote learning, they promote memory and cognitive function, and they also decrease cell degeneration, which can lead to dementia.

[05:24] Sarah: You can find polyphenols in plants and foods that are made from plants. Examples include cocoa powder, seasonings such as oregano, celery seeds, peppermint, cloves, rosemary and thyme, and fruits such as cherries, strawberries, and raspberries. Not to mention, many different kinds of seeds, vegetables, and cereals. In fact, one study recently investigated and created a list of 100 of the most polyphenol rich foods.

[05:47] Adam: Ok, we need carbohydrates for our brain fuel, and antioxidants can help to prevent and manage damage. What else do we need?

[05:54] Sarah: We also need good fats, these good fats are called Essential Fatty Acids. Essential fatty acids are called essential because of body needs

them to function. These fatty acids are important to keep the membranes or walls of our cell intact.

[06:08] Adam: Since our cells are responsible for making up who we are, I'm sure you would appreciate if all their pieces stayed inside of them. And because they maintain cell membranes they also play a role in helping nutrients get inside of our cells.

[06:19] Sarah: These essential fatty acids, and especially Omega-3 Fatty Acid, use their skills to help with brain development, they decrease the likelihood of getting cardiovascular disease, and they help to prevent destruction of cells which can lead to dementia, schizophrenia, and depression.

[06:34] Adam: Unfortunately, in our society we don't get enough essential fatty acids. As a whole, in western culture there is a tendency for diets to lack fruit and vegetables, and have high amounts of saturated, or bad, fats, and high sugar intake.

[06:48] Sarah: Good fats, or again, essential fatty acids can be found in avocados, nuts, salmon, mackerel, olive oil, canola oil, and peanut oil. You can also get fatty acids by taking a fish oil vitamin every day.

[07:01] Adam: One interesting study found that our consumption of essential fatty acids can have impacts on the lives of our future children.

[07:08] Sarah: A researcher named Bondi and his colleagues conducted a study in 2014 on rats. They fed some rats a regular nutritious diet and some rats a diet that was deficient in essential fatty acids.

[07:18] Adam: What they found was that the kids of the rats who didn't get enough fatty acids had more behavioural issues, were more anxious, and were more likely to be hyperactive. Not only that, they were slower at learning tests, and had a hard time with tasks that required them to use their short-term memory.

[07:35] Sarah: So when you are thinking about what fuel to put into your body, it isn't just you that you need to think about. Food can influence the lives of our future children as well.

[07:42] Adam: I think we are getting ahead of ourselves a little bit here. Speaking of fuel, are there any other parts we need?

[07:47] Sarah: Yes the final ingredient for the perfect body fuel is protein. Your body needs protein in order to form new cells and repair old ones. Part of that role is repairing and building muscles mass, which is why you see very muscular individuals on protein powder containers.

[08:02] Adam: It that how it works?

[08:04] Sarah: It makes you muscly, so they want you for their advertisements.

[08:06] Adam: It also provides the body with energy.

[08:08] Sarah: In fact, when you eat your carbohydrates with protein you are mixing the perfect energy cocktail.

[08:14] Adam: Carbohydrates give the body an amino acid called tryptophan. Your brain needs tryptophan in order to make serotonin.

[08:21] Sarah: Lack of serotonin in the brain is actually associated with disorders such as depression and anxiety.

[08:26] Adam: That's right. So when we get that tryptophan from carbs, and it makes the serotonin. That serotonin makes us feel calm and relaxed. However, that feeling can also lead to fatigue and decreased alertness.

[08:37] Sarah: Therefore, when you eat you carbohydrates with protein you get an interesting reaction. Proteins contain tryptophan themselves but they also contain another amino acid called tyrosine, Tyrosine is needed in order to make dopamine and norepinephrine. Dopamine is the boss of the pleasure centers of our brain and norepinephrine is a part of the fight or flight response.

[08:56] Adam: So it allows more oxygen into the brain, increase heart rate, releases stored glucose into the blood stream. So when we get these types of effects combined the calming and fatiguing effects of tryptophan, we end up increasing alertness and reaction time, and decreasing the negative effects of stress, while improving cognitive performance.

[09:14] Sarah: So, when we're looking for high protein foods that have the tyrosine that we need to help us feel more alert we can look at foods such as soy produces, chicken, fish, turkey, peanuts, almonds, avocadoes, milk, cheese, yogurt, and sesame seeds.

[09:27] Adam: So those are the 3 key ingredients to healthy fuel for your body. However, these nutrients are only a few nutrients that you can incorporate into your diet in older to have a healthy and long-lasting brain.

[09:28] Sarah: For example, lycopene is what makes tomatoes and other red fruit red. This is another thing that can help reduce oxidative stress, which we talked about earlier.

[09:46] Adam: And another, leafy green vegetables prevent inflammation or swelling in the brain that is associated with the symptoms of depression. They are also high in folate, which increases cognitive development.

[09:57] Sarah: Before we started researching this podcast, Adam and I knew very little about what it takes to eat good brain food. But there are lots of good resources available, go online and look for information, to help you eat better.

[10:08] Adam: Even changing one unhealthy eating habit can help reduce the symptoms of depression.

[10:13] Sarah: Yes, and healthy eating can also help to prevent obesity and other diseases such as diabetes and cardiovascular disease to help you stay healthy longer.

[10:21] Adam: It is easy to talk about eating healthy, but it is a lot harder to actually do it. Did you know that foods that are high in sugar and full of bad fats actually create the same reaction in the brain that people have to addictive drugs such as cocaine, heroine, and alcohol.

[10:35] Sarah: That's right, a lot of the foods that we eat such as confectionary items, which are candy, chocolate bars, and other sweets, are like drugs to our brain.

[10:42] Adam: Teenagers are the biggest culprits for eating confectionary items. In fact, one study found that ¼ of what teenagers eat is in the form of snacks and confectionary items, and those are often eaten in place of meals.

[10:55] Sarah: Videon and Manning, a pair of researchers, asked all students in the U.S in 2003, in grade 7 to 12 how often they ate certain foods. What they found was that 70% of the students they asked had not eaten at least two veggies the day before, and 55% and had not eaten at least 2 fruit.

[11:13] Adam: Wow. Fruit and vegetables are the most important contributors to good fuel for your brain and body. They have all the nutrients that you need.

[11:20] Sarah: When we are eating diets high in refined sugar and fat and are not also getting enough fruits and vegetables and the nutrients that they provide, there are long-term impacts that this can have on the brain.

[11:30] Adam: For one it can reduce the abilities of your cognitive functions such as memory, attention, and inhibition.

[11:35] Sarah: It also makes us want to eat more. When we have a more difficult time remembering what we last ate, which makes us more likely to eat again. In our podcast about memory we are going to discuss a patient refereed to as H.M who lost his ability to form new memories. Even if he had just ate, if someone offered him a plate of food, he would eat again, having no memory of just eating.

[11:55] Adam: And finally, it affects our mood. A researcher named Oddy conducted a study in 2009 where he asked students to fill out a survey about their eating habits and a questionnaire that gave them a rating about their mental health. Early adolescents who scored poorly on the mental health scale were more likely to eat high saturated fat and refined sugar diets including fast food, red meat, and confectionary items.

[12:17] Sarah: So students who eat unhealthy diets are more likely to be depressed?

[12:21] Adam: That's what it seems to point to. Another interesting food fact is that people who eat breakfast are more likely to have a healthy body weight and make healthier lifestyle choices than those who do not eat breakfast.

[12:33] Sarah: Unfortunately, 42% of adolescents skip breakfast.

[12:36] Adam: But breakfast is the most important meal of the day.

[12:40] Sarah: I know! In fact one study used a few different interesting tests to prove that eating breakfast is good for your brain. Mahoney, a researcher, and his colleagues got together 30, 9 to 11 year olds back in 2005. These kids were assigned to one of three groups. One group ate oatmeal with is a food that's low on the glycemic index, one group ate cereal, which is high on the glycemic index, and one group ate no breakfast at all.

[12:03] Adam: All three groups took some cognitive function tests. One test tested spatial memory. The researchers gave the participants a fake map that had 4 fake continents. All the countries on the map had fake names that were either colour, nature-related names, or animal names.

[13:19] Sarah: Participants could look through the countries one at a time on a computer, there were 24 countries in total and they had 8 minutes to study them. Then they were given a map and asked to fill in as many countries as they could remember without being able to look back at the study materials.

[13:33] Adam: The kids who had eaten oatmeal for breakfast labeled most of the countries, those who ate cereal left more countries unlabeled, and those

who ate no breakfast left even more countries unlabeled than the other two groups.

[13:43] Sarah: In another test the kids were given very complex pictures and asked to try and draw them without tracing. Almost an hour later, they came back and were asked to try and draw them again but this time from memory. This test is used to assess visual perception.

[13:56] Adam: The kids who ate breakfast, whether it was oatmeal or cereal, were able to copy the image from memory with greater accuracy than those who didn't eat breakfast.

[14:06] Sarah: One more test was used to look for auditory or hearing attention. Students listened through headphones for 10 minutes with random words being read. Whenever certain combinations of words were read, the kids had to press a space bar on a computer.

[14:18] Adam: Those who ate breakfast, again whether it was oatmeal or cereal, were less likely to press the space bar when they were not supposed to, something that researchers refer to as a false alarm.

[14:28] Sarah: This study demonstrates that eating breakfast, even if it isn't the healthiest choice, can have an impact on how your brain performs in various situations.

[14:35] Adam: Breakfast however, is not the only important meal. Research has shown that teenagers who eat meals with their families are more likely to eat fruit and vegetables.

[14:44] Sarah: That's right, plus what your parents know about healthy eating can have a big impact on the kind of food that you eat.

[14:48] Adam: For example, Sarah and I didn't grow up eating healthy foods.

[14:52] Sarah: I had pizza for pretty much every meal.

[14:54] Adam: Yeah I had pizza for lunch every day throughout high school, and I think that might be partially why we spent a lot of time being sick and emotionally drained.

[15:03] Sarah: When we started to learn about how to eat healthier, we noticed that we started to feel much better and we shared that knowledge with our parents.

[15:10] Adam: You can do the same; family meals are not all your parents' responsibility. If your parents are like ours, and don't know a lot about eating

healthy themselves. Their parents didn't show them that either. You can go online and find healthy recipes to make as a family or for your family, this is something they might not have had when they were kids. You can be the person who helps to make sure that everyone in your family has a healthy brain.

[15:33] Sarah: That is right, you are the person who is the most responsible for making sure that your body has the right fuel it needs to make you happier, healthier, and keep your brain working at its best.

[15:43] Adam: Tune into more of our podcasts to learn even more ways to make your brain happy!

[15:48] Sarah: I'm Sarah,

[15:49] Adam: And I'm Adam,

[15:50] Sarah: And this concludes Episode 3 of Teen Brain.

[15:55] Adam: It's Episode 3.

[16:05] Sarah: I would like to thank Music Supervisor Brian Case for allowing us to use the song Belleville, which was performed and recorded by Joseph Perkins from London, UK. You can check out more of their stuff at braincase.ca or joeperkinsmusic.com. I would also like to thank Robyn Crummey for designing our logo. You can check out more of her awesome work on Instagram at @crummey_art. That's c-r-u-m-m-e-y_art. For those of you who didn't come across this podcast on the Teen Brain Blog please visit teenbrain.wordpress.com to learn more about the project and don't forget to leave a comment telling us what you thought of the episode. Alternatively, you can send an email to teenbrainpodcast@gmail.com. Thanks for listening.

Teen Brain Episode 4 Transcript: Memory

[00:16] Sarah: Hi, my name is Sarah!

[00:18] Adam: And I'm Adam,

[00:20] Sarah: And you are listening to Teen Brain. Today we are going to be talking about my personal favorite subject, which is memory.

[00:25] Adam: From an evolutionary perspective, being able to remember which animals might eat you or which berries made you sick the day before could have helped humans survive everyday life.

[00:34] Sarah: Our memories are key to learning. Lets say you ate poison berries and they made you sick, if you woke up the next day and you couldn't remember eating the berries or being sick, you would never learn to avoid eating those berries.

[00:44] Adam: Although we don't often need our memory for the same types of things we may have in the past, it is still a very important process to our every day lives including our ability to do well at school.

[00:54] Sarah: Not to mention, our memory makes us who we are, all of your past experiences play a role in how you act and the decisions that you make.

[01:01] Adam: Humans use three different kinds of memory: sensory memory, short-term memory, and long-term memory. But for the sake of this podcast we are going to focus on short- and long-term memory.

[01:10] Sarah: When we receive information from the outside world, our body converts that information into sensations, such as vision or touch, which the neurons in our brain turn into perception. Perception is our ability to become aware of something through our senses.

[01:23] Adam: Two things can happen to these perceptions, they can be forgotten or ignored, or they can be acknowledged in our short-term memory.

[01:29] Sarah: Information in our short-term memory is held for 10 to 12 seconds. Humans have the ability to remember 7 plus/minus 2 items at any given moment.

[01:38] Adam: Think of short-term memory like a bookshelf that's only big enough to hold between 5 and 9 books. If the shelf is full and you add another book, one or more of the books will fall off.

[01:47] Sarah: So when we add new information to our short-term storage, other items need to be forgotten in order to make room.

[01:54] Adam: But, there is a way that you can use your short-term memory storage better. It's a strategy called chunking.

[01:58] Sarah: Chunking involves combining information into parts in order to hold more information. For example if you need to remember a 4-digit number such as 4-8-6-2 that would take up 4 items in your short-term memory. However, if you think of that number as 48 and 62, you are only using two items in your short-term memory.

[02:19] Adam: Short-term memory processes happen in the prefrontal cortex.

[02:23] Sarah: When you need more memory space and duration to perform a complex task such as multitasking, you use something called working memory.

[02:30] Adam: Working memory is where our perceptions are stored in an organized fashion in order to allow us to complete tasks. This system is what makes humans skilled workers.

[02:38] Sarah: A good example of the working memory system at work is when you are taking notes in class. In order to take notes in class you need to be able to listen to the teacher, read off the board, and write your notes. Working memory helps you manage all the different sensory signals and motor skills needed to complete this task.

[02:55] Adam: It is also the system that allows you to apply strategies to information such as with math problems. Your short-term memory introduces the information and then your working memory manipulates it.

[03:04] Sarah: One theory of working memory suggests that it can be divided into three separate systems. One system is the boss system; it is referred to as the central executive. The other two systems are the phonological loop and the visuospatial sketchpad.

[03:19] Adam: The central executive directs and inhibits our attention. It helps us to determine which of the two other systems to send information to. It lets us focus our attention on a task by shifting our attention to it, and it lets us keep our focus on a task by facilitating inhibition. Inhibition is your ability to resist reacting to distractions.

[03:38] Sarah: The phonological loop uses the brain centers that are associated with language. It is used for processing and manipulating spoken language and written language.

[03:47] Adam: Some researchers refer to this loop as the “mind’s voice” because they believe that this system provides the voice you hear in your head when you talk to yourself.

[03:55] Sarah: Speaking of talking to yourself, this is also the system that is in play when you use articulatory rehearsal. Articulatory rehearsal is a memory strategy where you repeat information to yourself over and over in your head in order to remember it better.

[04:10] Adam: Such as when you friend tells you their phone number and you are trying to find a pen or open your contacts to write it down.

[04:15] Sarah: The last system in working memory is the visuospatial sketchpad. This is the area of the brain responsible for processing and manipulating visual or spatial information.

[04:25] Adam: If I asked you to describe the layout of your bedroom, this would be the area of the brain you would use to imagine what it looks like and then describe it.

[04:31] Sarah: When we are under 8 years old this is the system that we use to solve math problems. We visualize, which could explain why, when we are first learning how to do math, we often use manipulatives, such as counters, to help us understand concepts.

[04:44] Adam: Or fingers right?

[04:45] Sarah: Or counting on your fingers.

[04:47] Adam: Once we turn 8 we begin to use the phonoarticulatory loop in order to solve math problems, meaning we talk ourselves through the problems.

[04:54] Sarah: There is a downside to this, as we discussed earlier our short-term memory only has room for 5 to 9 items. Therefore, if you are talking yourself through a math problem and somebody starts to talk to you, the information that they are saying overtakes other items in your memory, and you will likely have to start over.

[05:10] Adam: That is the worst. The effect is also something to keep in mind when we use our phones while we study. If our memory can only work with about 5 to 9 pieces of information and you are getting notifications on your phone, each time you look away from your work, you are replacing something in memory with that information.

[05:25] Sarah: How useful your working memory is and how long information stays in short term memory all depends on how much attention we give it.

[05:32] Adam: When we really give something our full attention it gets transferred to long-term memory. Long-term memory can store information anywhere from a day to a lifetime.

[05:40] Sarah: Working memory works with long-term memory. In our example about remembering the layout of your bedroom, you had to pull a

memory out of your long-term memory and manipulate it in order to answer the question.

[05:50] Adam: Having clear memories of the past is what makes people so smart.

[05:53] Sarah: It is also what forms our personality.

[05:54] Adam: There are two kinds of long-term memories. Oh, the first are explicit memories.

[05:58] Sarah: You are totally aware of your explicit memories, this type of memory encompasses your day-to-day activities, you can recall them, appreciate them, and easily describe them.

[06:07] Adam: These are the memories that you are aware of remembering or may even have memorized on purpose. This is also the easiest form of memory for everyone to use.

[06:14] Sarah: There are two different types of explicit memories. Episodic memories and semantic memories. Episodic memories are called autobiographical memories because they're like watching episodes from your own life.

[06:25] Adam: If I asked you what you ate for breakfast, your answer would be an episodic memory.

[06:29] Sarah: The hippocampus is important for these type of memories and they tend to be emotionally driven. In fact, the more emotionally driven they are the more likely you are to remember them. This happens because the hippocampus is connected to the limbic system.

[06:40] Adam: As you may remember from our podcast on the brain and its functions, the limbic system is responsible for this emotional response. The connection between the hippocampus, which is the long-term memory coordinator, and the emotional centers of the brain allows us to encode emotional information with our memories.

[06:53] Sarah: The second kind of explicit memories are semantic memories. These are our memories for facts and knowledge. This is the memory that helps us know and understand the meaning of words.

[07:06] Adam: That way when someone is talking to us we don't have to stop and think about every word they are saying and what it means.

[07:10] Sarah: This happens in the temporal lobe. Without this type of memory, words would just be gibberish to you; you wouldn't be able to remember anything about what they mean.

[07:17] Adam: Implicit memory is the next form of long-term memories and their job is an interesting one.

[07:22] Sarah: In fact, you probably aren't even aware when this memory's at work.

[07:26] Adam: These are your automatic memories, like riding a bike. When you get on your bike, you likely don't think right foot petal, left foot pedal, I move my legs, you just do it.

[07:35] Sarah: In an earlier podcast we talked about typing your shoes and how the brain stores movements as sequences so that it can use less resources to do this task. This is the same example.

[07:44] Adam: When you first learned to tie your shoes you needed the hippocampus to help you store the sequence in long-term memory.

[07:50] Sarah: Over time your hippocampus began to train your cerebral cortex or the movement boss to take over the task. This leaves your hippocampus free to work on other things while your movement centers make the actions happen. In order to store new things more easily in long-term memory, the hippocampus groups it with past experience or knowledge. A little further on we are going to get to examples of how you can capitalize on this relationship to make your memory work even better for you.

[08:14] Adam: Long-term memory is something that we take for granted. When people develop Alzheimer's disease they slowly lose their long-term memory skills. It makes it hard for them to use language, make perceptions, and even think.

[08:24] Sarah: In fact, scientists don't even know what area of the brain long-term memory occurs in. Although we know that the hippocampus helps create long-term memories, we know that it doesn't store them.

[08:34] Adam: In order to make the most of your memory, you need to know factors that affect its ability to do its job, and ways that you can use those factors to your advantage.

[08:42] Sarah: Very true, for example our memory is highly influenced by our emotions.

[08:46] Adam: Negative emotions, such as stress, worry, or sadness, can be detrimental to memory. When we are experiencing negative emotions, our central executive shifts our attention to that emotion in order to help us experience and understand that emotion.

[08:59] Sarah: When our attention is not on the task at hand, we are using up our short-term and working memory capacities. This is also true of test anxiety.

[09:06] Adam: If you or a friend feel really anxious about taking tests, you've probably noticed that it seems to take you forever to answer even a single question, even though you're really concentrating.

[09:16] Sarah: This happens because having anxiety over the test is taking up memory space, leaving you with less space to work on the actual test at hand.

[09:24] Adam: Not to mention, when you are experiencing negative emotions, you are more likely to pull memories tied to negative emotions from your long-term memory.

[09:31] Sarah: Have you even noticed when you are feeling sad, you start thinking about other sad experiences, like when you get into an argument with your parents, afterwards you are in your room and you think about the day you got in trouble at school, or when your girlfriend or boyfriend broke up with you.

[09:43] Adam: Usually we get over the sadness and can return to think about happy thoughts and memories. However, people who are depressed aren't able to break this sad cycle as easily, and can't stop only thinking about these sad things.

[09:54] Sarah: Positive emotions have the opposite effect on our memories.

[09:58] Adam: Activities that are new and exciting and peak your curiosity actually cause the body to produce some stress hormones. These stress hormones shift your attention over to the new experience or learning. When you give situations your attention you are more likely to remember them.

[10:10] Sarah: Sometimes in class it can be difficult to get excited about learning because of something called habituation.

[10:16] Adam: If your teacher uses the same kind of lessons everyday, it can be hard for your brain to give its full attention.

[10:20] Sarah: However, it's likely that if your teacher always teaches things the same way, they aren't going to change now.

[10:25] Adam: So one thing you can do is try and experiment with making the material exciting for yourself. There is another option though that can help you learn more.

[10:30] Sarah: This strategy is called priming and it involves introducing yourself to material before it's taught.

[10:37] Adam: We are going to tell you why you should listen to your teacher when they tell you to read a chapter before class.

[10:41] Sarah: Even if you don't take notes on it, you will still learn more if you introduce yourself beforehand to the information you're going to learn.

[10:47] Adam: This happens because of how we store long-term memories.

[10:50] Sarah: When our brains are storing new memories, they compare them to old memories and decide where they best fit.

[10:55] Adam: Think of a long-term memory like a library. As you know, books in the library are sorted by the Dewey Decimal system, which makes sure that books about the same topics are shelved together. The hippocampus is like the librarian and new memories are like a stack of books to put away. The librarian has to go around and find where each book goes.

[11:13] Sarah: When you look at information you will learn ahead of time, your brain gets a head start finding all the places it needs to for the new information. So when the time comes to actually learn the material, it is like the librarian holding up a book and a sign popping up that says "HEY! THAT BOOK GOES OVER HERE."

[11:26] Adam: This way we save our brain energy by making it work more efficiently. The hippocampus has already decided what memories this new information will fit with, so it's easier to draw connections that relate your own experiences.

[11:38] Sarah: We can also use this relationship with long-term memory to help with other memory strategies.

[11:42] Adam: We probably already know a few strategies that use information from our long-term memory to help us memorize or learn new information.

[11:48] Sarah: Think about pneumonic devices. These include acronyms, which involves using every letter of a word as a clue to a piece of information.

I'm sure you all have heard Every Good Boy Deserves Fudge to remember the notes on a Treble Clef.

[12:00] Adam: A method that I use is creating mental pictures.

[12:03] Sarah: Yes that's right, you are really good at that.

[12:05] Adam: So, what I do is I think about a concept that I need to learn and I take all of its parts and I turn it into a strange picture in my head, something silly.

[12:13] Sarah: One year me and Adam were in the same class and I got him to tell me about all about his strange mental pictures that he made up to help him study for the exam and I ended up knowing a lot of the answers because of them.

[12:23] Adam: This strategy works in a few ways. First I connect the information from my own memory. So in this case I know I need to remember the name Leon Festinger, he's a famous social psychologist. Now I have a friend named Leon, so I put his body on a man who is dressed quite festively. Now, I just need to get the rest of the name in there, so he's pointing with his finger, up in the air. Leon Festinger. Now its no longer hard to remember this social scientists name, I just got to remember my friend Leon dressed festively, pointing at the sky. As we mentioned earlier, the more attention you give something the more likely you are to remember it. The more ridiculous the device is I create, the easier it is to remember.

[13:04] Sarah: This doesn't only work for mental images, you can come up with you own ways of creating elaborate stories about information. You never know it just might stick with you forever. The class where we discussed Leon Festinger was over 5 years ago and we still remember him and his work.

[13:17] Adam: Festive Leon finger in the air. Coming up with mental strategies isn't the only way to improve memory. Getting enough sleep is important to ensure that your brain is operating at it's best and it able to give the proper attention to learning tasks. You can listen to our podcast on sleep and the brain to learn more about how great sleep is for your mind.

[13:33] Sarah: Eating healthy is another good way to improve memory. Protein builds new cells; therefore having a balanced diet can help you to make new cells that will hold the new information.

[13:42] Adam: These aren't the only tricks to take control of your memory. Hop online and good memory strategies and find what works for you.

[13:47] Sarah: Don't be afraid to try different strategies, that is what we did and that is how we got interested in making this podcast in the first place.

[13:53] Adam: Tune into more of our podcasts to learn more hacks to help your brain work at its best.

[13:58] Sarah: I'm Sarah,

[13:59] Adam: And I'm Adam,

[14:00] Sarah: And this concludes Episode 4 of Teen Brain.

[14:06] Sarah: I would like to thank Music Supervisor Brian Case for allowing us to use the song Belleville, which was performed and recorded by Joeseph Perkins from London, UK. You can check out more of their stuff at braincase.ca or joeperkinsmusic.com. I would also like to thank Robyn Crummey for designing our logo. You can check out more of her awesome work on Instagram at @crummey_art. That's c-r-u-m-m-e-y_art. For those of you who didn't come across this podcast on the Teen Brain Blog please visit teenbrain.wordpress.com to learn more about the project and don't forget to leave a comment telling us what you thought of the episode. Alternatively, you can send an email to teenbrainpodcast@gmail.com. Thanks for listening.

Teen Brain Episode 5 Transcript: Exercise and the Brain

[00:16] Sarah: Hi, my name is Sarah!

[00:18] Adam: And I'm Adam,

[00:19] Sarah: And you are listening to Teen Brain

[00:20] Adam: Teen Brain. Today we are going to be talking about how getting your blood pumping with exercise makes our brain work at its best.

[00:25] Sarah: That's right, exercise isn't only great for physical health of your body by increasing cardiovascular, or heart, health, decreasing the risk of some types of cancers, increasing bone density, and decreasing the risk for stroke or diabetes.

[00:40] Adam: No, it's also amazing for the physical health of your brain. Just a few reasons to mention, it decreases depression and anxiety, helps the brain recover from injury, it also helps to delay or even prevent the onset of diseases that affect brain cells such as Alzheimer's disease and Huntington's disease.

[00:58] Sarah: When we exercise, we place good stress on our brains. When our brains put in the work to recover from that stress, we're training them to adapt and grow. They're able to function better, and it also gives them the tools to handle other types of stress. When we are talking about exercising we don't mean going out and running a marathon everyday or lifting hundreds of pounds worth of weights.

[01:17] Adam: We will mostly be discussing anaerobic exercise, which is any sustained activity that increases your heart rate and increases the body's need for oxygen.

[01:24] Sarah: This could be running, jogging, hiking, swimming, rowing, kayaking, biking, playing sports, or even just walking.

[01:32] Adam: The more we participate in these kinds of activities, the better our body gets at doing them and the better we become at using oxygen in our bodies.

[01:40] Sarah: Exactly, so the more you exercise the more efficiently your body uses the oxygen that it has, and the slower your heart can beat while you do them.

[01:46] Adam: The more efficient your body is, the more calories it burns.

[01:49] Sarah: Not to mention the more efficient your body is, the better you can adapt to stressful situations.

[01:54] Adam: One researcher asked students to participate in one session of aerobic activity. After only the one session they biopsied, or took a little piece of their muscles. What they found was that those muscles had more proteins that are important for synthesizing, or burning, fat!

[02:09] Sarah: So after just one day their muscles were better able to burn fat.

[02:12] Adam: Yeah imagine the results after more than one session. Burning fat, although very healthy for your, isn't the only good outcome that they have found in exercise research.

[02:21] Sarah: Exercise increases tryptophan in the brain, which if you remember from our podcast on diet, is needed for the brain to make serotonin. Serotonin influences mood and impulsivity. When we don't have enough of it, we may even experience depression.

[02:34] Adam: That is one of the reasons exercise make you less prone to react out of proportion to any given situation and it overall makes you less irritable.

[02:42] Sarah: Studies have found that over time exercise can make more dopamine receptors in your brain. If you remember from our first podcast, dopamine is vital to the reward system. It is what makes us motivated to do things and makes us satisfied with our life.

[02:54] Adam: When you have more places for dopamine to plug into, you are more motivated and happier.

[02:58] Sarah: No wonder studies have found that people who voluntarily choose to exercise tend to be less neurotic, have higher vigor, which means more physical strength and good health, have lower levels of anxiety, depression, and tension, have higher self-esteem, are more satisfied with their lives, are happier, and have less fatigue.

[03:17] Adam: Less fatigue, that's interesting considering you are exercising more right, and that makes you tired.

[03:20] Sarah: You would think, but the truth is when you exercise regularly, you actually have more energy.

[03:25] Adam: Plus, if you are someone who is having a really rough time and are really low on overall well-being, aerobic exercise had been scientifically proven to improve your mood, improve coping behaviour, and decrease depression and anxiety.

[03:38] Sarah: That's not all, lets talk about the hippocampus. If you remember from our memory podcast, the hippocampus is the gatekeeper to our memories. It places our experience into long-term memory so that we can access them again.

[03:48] Adam: Exercise actually increases the number of cells in this area of the brain, increasing synaptic plasticity, which is the strengthening of connections between the neurons in our brain, and improving memory, which improves your ability to learn too.

[04:00] Sarah: That is pretty interesting considering people used to believe that we were born with all the brain cells we could ever have. Now you are telling me that exercise can help you grow new neurons?

[04:09] Adam: Yep! It happens through a type of protein that John Ratey refers to as Miracle Grow for the brain called Brain Derived Neurotropic Factor.

[04:17] Sarah: When we exercise we get more of this BDNF in our brains. Not enough BDNF if our brain is associated with depression and other mood disorders. Proteins such as this are important for cell growth and repair.

[04:30] Adam: Cotman and Engesser-Cesar did an interesting study with rats in 2007. One group of rats was the exercise group, who had access to a running wheel; the other group did not. And in case you didn't know, rats love to run on a wheel, if you put it in there they are going to run on it. The other group did not. What the scientists did was place the rats into a water maze that had 4 rooms. The water level was high enough that the rats had to swim throughout the maze.

[04:54] Sarah: There was a catch; in one quadrant of the maze there was an escape platform. If the rat found it he could stand on it and would not have to swim anymore.

[05:02] Adam: After a few rounds of going through the maze the researchers took away this escape platform. The rats who had been in the exercise group were more likely to swim straight for the place where the escape platform had been and then spend more time exploring the quadrant where it was when they couldn't find it.

[05:16] Sarah: This suggests that exercise might actually increases spatial memory and learning ability since the exercised rats knew exactly where to look for the platform and looked all around the place where they had found it before, even when it wasn't there.

[05:28] Adam: In people, it has been found that physically fit individuals actually have bigger dorsal stratum. Dorsal Stratum is an area of the brain located in the frontal lobe that helps with inhibition and cognitive control. You may remember from our podcast on memory, got to hope right, that inhibition is the ability to resist reacting to something.

[05:45] Sarah: They actually did a cool study where they took a group of first year university students and asked one group of them to participate in bouts of aerobic exercise and the other group didn't exercise. Then they sat them down in front of a computer. On the computer screen, short letter sequences flashed for less than a second. If the letter sequence had a certain letter they were looking for, they pressed a button with their left hand. If it had a different letter they were told to look for they pressed a button with their right hand.

[06:11] Adam: As I'm sure you can guess, the group who participated in exercise did better on this task. They were also better able to slow down after they had made a mistake.

[06:20] Sarah: This suggest that exercise may help us focus more. For some people on these types of tasks, once you make a mistake you can get frustrated and start reacting more quickly, but the exercise group actually slowed down to try and do better.

[06:31] Adam: This might happen because exercise increases norepinephrine in the brain, which helps with attention, perception, and motivation. Besides making you better at tasks like these, more fit children score higher on intelligence, math, and verbal tests and one study even showed that high school students who participated in high levels of exercise had higher grade point averages.

[06:52] Sarah: Besides all of that, exercise increases you immune function, or your body's ability to fight illness. So you are less likely to get sick. So if exercise is so great, why are adolescents some of the least active people?

[07:04] Adam: A lot of it has to do with their leisure time activities, according to the research. If after school and on the weekends you tend to watch a lot of TV, or do activities where you sit around a lot you are not giving enough time to exercise.

[07:17] Sarah: It can also be hard if you think you need to go to the gym to exercise. I love exercising but I never go to the gym. Websites such as Pinterest or even Google are a great place to look for exercise routines that you can try at home that need no equipment.

[07:30] Adam: I don't go to the gym either; I get my exercise taking martial arts classes in Brazilian Jiu Jitsu.

[07:34] Sarah: So remember that the gym is only one way of getting exercise. For adolescents especially going to the gym can be discouraging. You may feel the need to lift heavier weights than is good for you or push yourself harder than you need to because of the way people are working out around you.

[07:47] Adam: This just leaves you feeling sore and possibly embarrassed because you don't feel like you know what you are doing.

[07:53] Sarah: Some people have a natural affinity for exercise and naturally excel at physical activities because of their genes, these are the people who are most likely to exercise. But everyone can find a type of exercise that they like to do.

[08:04] Adam: Yeah, even if you don't identify as someone who is good a exercising or sports. That doesn't mean that you can't go for a walk every day

or take the stairs instead of the elevator, you're already treating your body to the exercise it needs.

[08:16] Sarah: If you dedicate 6 hours a week to exercise, your brain will thank you for it. Even after a week you can start to feel better. One of the best ways that you can exercise is running or jogging. From an evolutionary point of view, our ancestors used to have to chase animals in order to catch them or kill them for food. Our bodies are made to run. Getting into running, or any exercise, can be hard. When I first started running I would get up and commit to going outside for 20 minutes. I didn't run all that time, in fact for the first two weeks I hardly ran at all. Then one day I felt like I could run a little farther, so I decided to run between two stop signs on every street I went down and I walked in between. In the next two weeks I could run through two stop signs before stopping for a break, and I didn't feel as anymore tired. After a month I was able to run for 20 minutes straight and eventually I could run 5k.

[09:05] Adam: It is about finding what works for you. Aerobic exercise is important but so it strength training to some degree. When we work on building up our muscles we are also protecting our joints. Not to mention, strength training has been shown to decrease anxiety, improves mood, and increases confidence.

[09:20] Sarah: When we say strength training you are probably thinking about huge men that you see at the gym lifting weights that weight more than you. However, using moderate weights that aren't as heavy are effective for your brain

[09:29] Adam: One of the best weights to use is your body. Exercises like push-ups work a number of different groups in your body. Go online and find body weight exercises that you can do at home.

[09:37] Sarah: Another factor that influences your likelihood of exercise social support. Often times when we undertake exercise programs alone we tend to give up.

[09:45] Adam: Finding a friend who is interested in getting healthy too can be a huge motivator! You are less likely to cancel on a workout date with a friend then you are on yourself. Plus you can both talk to each other about different exercises or activities that you've tried and have someone else with you so you don't feel as silly trying new things.

[10:03] Sarah: Overall when it comes to exercise, you should commit 45 minutes to an hour a day to your body and brain. The more you work on your heart and the brain, the better they become at helping you stay healthy.

[10:12] Adam: As we mentioned earlier, even 6 hours a week has been shown to make a healthier brain. So that's all it takes.

[10:22] Sarah: And with that we will conclude our 5th episode of Teen Brain.

[10:23] Adam: Listen to our other podcasts to learn more ways to make your brain function at its best.

[10:27] Sarah: I'm Sarah

[10:28] Adam: And I'm Adam

[10:29] Sarah: And we'll see you next time.

[10:35] Sarah: I would like to thank Music Supervisor Brian Case for allowing us to use the song Belleville, which was performed and recorded by Joseph Perkins from London, UK. You can check out more of their stuff at braincase.ca or joeperkinsmusic.com. I would also like to thank Robyn Crummey for designing our logo. You can check out more of her awesome work on Instagram at @crummey_art. That's c-r-u-m-m-e-y_art. For those of you who didn't come across this podcast on the Teen Brain Blog please visit teenbrain.wordpress.com to learn more about the project and don't forget to leave a comment telling us what you thought of the episode. Alternatively, you can send an email to teenbrainpodcast@gmail.com. Thanks for listening.

Teen Brain Episode 6 Transcript: Emotions

[00:16] Sarah: Hi, my name is Sarah!

[00:17] Adam: And I'm Adam,

[00:19] Sarah: And you are listening to Teen Brain

[00:20] Adam: Today we are going to be talking all about emotions, what they are, why we have them, and even what you can do to control them.

[00:25] Sarah: Emotions are interesting in that they are always responses to our perceptions or what we encounter in the world.

[00:31] Adam: Emotions are universal! Everybody has them. All around the world people make similar faces to the same emotional situations. For example, cross culturally people show similar reactions to sadness, joy, fear, anger, disgust, shame, guilt, you can be all the way across the world and recognize these things.

[00:49] Sarah: Even with children who are born blind, they make the same emotional expressions as children who aren't, despite never seeing a person make that expression in their life.

[00:58] Adam: We all have them. Knowing this is the first step to understanding them and dealing with them.

[01:00] Sarah: So what are emotions?

[01:03] Adam: Emotions are feelings that differ from your normal state.

[01:05] Sarah: They also have three features. First, they cause a change in our physiological state, like when you experience fear and your body goes into fight of flight, causing your heart to race.

[01:16] Adam: They also evoke a feeling for us that we can give a name to such as sadness, happiness, and anger.

[01:22] Sarah: And finally, emotions motivate our behaviour. Feeling sad may cause you to seek out a friend or anger may motivate you to yell at somebody.

[01:29] Adam: Understanding our emotions and regulating the effects that they have on us is important for your well-being, academic performance, and positive adjustment in life.

[01:36] Sarah: You have likely already learned a lot of basic emotional regulation, if you hadn't you might find yourself like a two-year-old going into hysterics over not getting your favorite cereal.

[01:45] Adam: Unfortunately, as we get older, our lives get more complicated than just what kind of cereal eat in the morning, and as it does so do our emotions.

[01:51] Sarah: If you are a teenager, one of the trickiest pars of emotions is that you can't just ignore them. Your brain is still learning how to stay on track with tasks or goals when there is highly distracting emotional stimuli around.

[02:03] Adam: This can have an effect on your ability to accomplish tasks, such as homework, or dedicate your attention to situations, such as your teacher writing on the board.

[02:10] Sarah: As we learned in the podcast on sleep, teenagers don't get enough sleep and lack of sleep can have an effect on your emotions. Besides making you more fatigued, it affects your overall mood, increases your

tension and anger, makes you more irritable, and makes you more likely to have emotional outbursts.

[02:25] Adam: Like when Sarah used to freak out at me at the breakfast table because she didn't like the sound of my chewing. Talk about irritable and emotional outburst.

[02:31] Sarah: Yeah the night before I probably stayed up till 1 in the morning on the computer and had to get up at 7:30 for school. But to be fair, your chewing is really annoying…

[02:40] Adam: As teenagers even with the appropriate amount of sleep, our brains aren't capable of performing at their emotional best.

[02:46] Sarah: This is because when we enter adolescence the area of our brain that controls our emotions, as well as the portion of our brain that allows us to use logic to control how we behave, is undergoing major developments.

[02:58] Adam: These areas of the brain are still working; they just aren't able to work as well as if your brain has is fully matured. This is why you might think back on how you acted when you were feeling emotional and regret the way you handled a situation. You are still able to look at things logically, but it can be hard to practice those skills in the moment.

[03:14] Sarah: And that is entirely your brain's fault. This is even true when it comes to understanding the emotions of others. One study by Burnett and his colleagues that was conducted in 2008 attached 10 to 18 year olds to fMRI machine, which detects where there is activity in your brain by measuring where blood is flowing to.

[03:31] Adam: While they were hooked up, they were asked to read various situations and think of them from their point of and then from their mother's point of view.

[03:37] Sarah: They asked them some questions about embarrassing situations, such as "you were quietly picking your nose and a friend saw you," they were asked about some guilty situations such as "you laughed at a quiet girl you know and you made her sad," they were asked about some disgusting situations such as "your dad told you your refrigerator as infested with maggots," and finally they were asked about fearful situations, such as "an angry dog is barking and running towards you."

[04:00] Adam: When they studied their brain activity when the teens were thinking about themselves in those situations, and also in the situation from their mother's perspective, they found that the prefrontal cortex was more

active and that the activity was stronger in adolescents' brains than it was in adults' brains.

[04:17] Sarah: This means that adolescent brains need to work harder to do the same job. The emotions that were studied in this research were called social emotions. Social emotions are more complicated emotions that require you to understand your own mental state and understand other people's mental states. So you need to be able to think about how you feel, as well as have ideas about how other people feel. Examples of these emotions are guilt, pride, shame, and embarrassment.

[04:40] Adam: For example, when you feel embarrassed for a class presentation, it is probably because you think that your classmates think you look silly, or will have negative opinions about that presentation.

[04:49] Sarah: Or you are worried about how the opinion of the teacher will affect your mark. Your thoughts about what others' are thinking and feeling consequently affect your own feelings.

[04:58] Adam: Basic emotions are a little easier and only require you understand your own mental state; these are emotions such as sadness, happiness, or surprise.

[05:05] Sarah: Not only is adolescence a time of increased brain growth in the social brain, it is also a time of changing social environments and relationships.

[05:13] Adam: Making the move to high school or university can be a difficult time socially. You may have to make all new friends, interact in a new social situation, and deal with more independence.

[05:22] Sarah: It can be hard not to feel alone when we first make transitions. Research has shown that adolescence is a time when we begin to rely more on peer relationships, while also tending to have more conflict with our parents. We tend to believe that our parents aren't as supportive of us as they were when we were kids.

[05:37] Adam: The trouble with peer relationships is that they can sometimes be unstable. We've all seen examples of a romantic relationships that is on-again-off again and constant drama, or a group of friends that seems to hate each other one week but they are inseparable the next. These are just realities of being a teenager.

[05:54] Sarah: So as our focus shifts to relationships with peers more than family, we may find ourselves in more social situations and feeling more self-

conscious. Some people may find themselves experiencing something called rejection sensitivity.

[06:06] Adam: Rejection sensitivity is when people worry about being rejected, or tend to think that they are being rejected.

[06:11] Sarah: When you are worried that you will not be welcomed by others, or reading into every situation that people don't like you, it makes you less likely to put yourself in social situations and that can influence the way that you interact with people all the time.

[06:23] Adam: We all worry if people will like us, but most times we are able to overcome those thoughts and feelings. People who experience rejection sensitivity feel very anxious in all social situations, they often have a more difficult time regulating those emotions.

[06:37] Sarah: This brings us back to our conversation about emotional regulation, which is the ability to control the impulses and instincts that accompany our emotions.

[06:44] Adam: Teenagers are already at a disadvantage when it comes to regulating these emotions. First of all, we are prone to more extreme positive and negative experiences of emotions.

[06:54] Sarah: Think of the stereotypical teenagers in movies weeping about a break up, or when you see a group of teenagers in the mall acting overly excited.

[07:00] Adam: This also plays a role in peer pressure. If you have ever experienced peer pressure, which we all have, you probably realize that you willingly participated without actually being forced by your friends.

[07:10] Sarah: Peer pressure happens because our emotions get the best of us. When we are with a group of friends, we get excited and it becomes more difficult to control our impulses, we also all have an ingrained desire to fit in social groups and impress other people.

[07:22] Adam: This may lead to you to actually convincing yourself to try things you swore in health class you would never do.

[07:26] Sarah: One study used an interesting test to demonstrate that it is harder to control yourself when you 're feeling emotional.

[07:30] Adam: Lewis and colleagues, some researcher, took 5 to 16 year olds and asked them to play a game on a computer to win a prize. The game was divided into three blocks. In each block the participants had to push a button

each time a certain letter appears on the screen. The participants earned points towards the prize every time they correctly pushed the button.

[07:51] Sarah: In the first block they all played and earned points. However, in the second block the researchers rigged the game so that the participants lost all their points. What they found was that when they began to lose their points they became more likely to click on the wrong letters, suggesting that anger and frustration was making it more difficult to control their responses to the different letters.

[08:11] Adam: Now being the nice researchers they are, they ensured that everyone got points in the third round and everyone received a prize.

[08:16] Sarah: Besides experiencing stronger emotions, and lack of sleep, which we already talked about, another factor in how you regulate emotions is how you think about yourself and others.

[08:25] Adam: If you are the kind of person who believes that we are who we are and you can never change that , you are more likely to belief that when you have a negative social experience it is due to who you are as a person. So if you believe that you are not good in social situations or in dealing with emotions, then when you approach these situations you're not going to be prepared to handle them in a healthy way.

[08:44] Sarah: Not to mention, this causes your body to get ready for a stressful experience and can cause a lot of stress itself. However, if you are the kind of person who believes that people have the potential to change, you likely see social failures as experiences that you can overcome.

[08:57] Adam: When you approach situations with this second point of view, you're more likely to believe that you can have control or the resources to cope with situations, and your body doesn't feel the same kind of stress.

[09:08] Sarah: Between 12 and 17 years old, we also become more likely to participate in a negative emotional regulation strategy called rumination.

[09:15] Adam: Rumination is basically think about something that is upsetting you over and over and over and over, and being unable to get over the feelings that those thoughts give you.

[09:25] Sarah: This actually makes your depressed feeling last longer and feel worse.

[09:39] Adam: Some researchers believe that this happens because negative events in our lives can mismatch with how we feel about ourselves. Thinking

about them over and over is your brain's way of trying to make sense of them.

[09:40] Sarah: However, when we can't overcome those feelings it can have effects on our ability to direct attention, which can affect how we do in school and life. For me, I tend to ruminate before I fall asleep while I'm lying in bed.

[09:52] Adam: Me too, if you want to check out our sleep podcast to might be able to learn some strategies to make falling asleep easier.

[09:58] Sarah: Finally, how your parents deal with their own emotions and your emotions also play a role in how you are able to regulate your emotions.

[10:03] Adam: I'm sure you know we learn a lot about life from our parents, and emotions aren't an exception to that rule. It is important to know that parents aren't always perfect, and emotions are one thing that a lot of people have a difficult time with, after all their parents taught them.

[10:16] Sarah: Not to mention when you become a teenager you tend to have more fights with your parents, and those fights tend to be more emotional than they were when you were a kid.

[10:23] Adam: We are going to give you some strategies that can help you manage your emotions better, and when you are able to control the side effects of these emotions better, you may just find you have an easier time communicating with people like your parents.

[10:33] Sarah: The first strategy is called reappraisal.

[10:35] Adam: Reappraisal involves changing your thoughts about a situation in order to change your feelings about that situation. Just like with other emotional tasks, teenagers' brains are more active when using this strategy then they are for adults.

[10:47] Sarah: All this means is that our brains are still learning how to use these skills. In order to reappraise a situation you need to be able to understand your feelings and that they aren't healthy for you.

[10:56] Adam: Once you have figured out that you want to feel better, you can take the negative situation and put a different spin on it that will make you feel better about it.

[11:03] Sarah: For example, Adam and I moved to a new city when we were in grade 8 and grade 9. Being the new kid in a big school, it can be really hard to make friends. There was one girl that I started hanging out with often, but sometimes she would totally forget about plans we had made. At first I got

really upset and I felt like she was ditching me on purpose. Having those thoughts affected the way that I acted towards her. I would wait until the last minute to ask her if we were still hanging out and then be really mad when she had forgotten. Even at school I felt upset with her.

[11:29] Adam: So what did you do?

[11:30] Sarah: I changed schools [laughing]. Well I changed the way I thought about the situation. I told myself maybe she's just forgetful and she isn't trying to hurt my feelings on purpose. She probably doesn't even realize how I'm feeling about it. Changing those thoughts helped me feel better. I started making sure that my plans with her will well organized beforehand, and I would even ask her a couple days beforehand if she still wanted to hang out.

[11:50] Adam: That's awesome, is this the girl that you are still friends with today that I'm thinking of?

[11:55] Sarah: Yeah, we've been friends for almost 10 years now and that just shows that sometimes it can be your own negative or misleading thoughts that cause you to view situations in ways that bring you down.

[12:04] Adam: Changing the way you think can help you look at something from a new perspective and come up with strategies that could make you feel better.

[12:11] Sarah: Another strategy that is very effective is called mindfulness. Research has shown that mindfulness programs have been very effective in helping teenagers regulate their emotions.

[12:18] Adam: Mindfulness has 2 parts. First you need to be able to direct your attention to the emotions you're feeling including how they make you feel mentally and physically. Once you can actually recognize your emotions as they're happening, you can start to think about them objectively. This means that you don't feel bad about them or good about them. You accept them for what they are. They're there.

[12:38] Sarah: When you are aware of your emotions coming on or when you are experiencing them and you are able to think about them as an experience that happens to you, you are better able to cope with your emotions and your actually less likely to have emotional outbursts.

[12:48] Adam: Yes I actually use this strategy a lot when I'm training Jiu Jitsu. When you're practicing Jiu Jitsu sometimes a person holds you down where they're lying on top of you, using various strategies to try and make you feel extremely uncomfortable. One of them is called the mount position. In Jiu Jitsu you learn how to escape this mount position, so you're basically trying

to use all kinds of different moves to try and get the other person off of you. But sometimes the other person is bigger and sometimes they're even better than you, so these things don't really work. So these moments can cause a lot of stress and it can be very difficult. Sometimes you may even start to panic.

[13:22] Sarah: Yeah, I tried Jiu Jitsu too before and it made me panic. My heart would race and I would feel like I was being crushed.

[13:27] Adam: That used to happen to be too. But then I started using mindfulness techniques; I realized that I was starting to panic. I could feel it coming on. I could feel my breathing getting more labored, my heart beating faster, the panic was making itself very hard to ignore. My body and my mind were just reacting naturally to the situation. Once I was able to thank about my panic in that way, as just an emotion, I was able to calm myself down and direct my thoughts elsewhere.

[13:50] Sarah: Didn't you used to say to yourself "you are not dying."

[13:52] Adam: Yes I did, I thought that in my head though, not out loud. I used my awareness of my emotions to overcome my panic inside my head and now I've had guys who are a hundred pounds heavier than me holding me down and I can even get out sometimes.

[14:05] Sarah: Dealing with our emotions, especially the overwhelming ones like Adam's panic or my frustration with my friend, can be as simple as understanding them for what they are.

[14:13] Adam: They are just your mind and body reacting to experiences as they think is best. You have the power to change how your emotions affect you.

[14:19] Sarah: If you remember from our first podcast about the brain and it's functions, we told you that the brain is like the control center of the body, you can use your thoughts alone to take control over how your emotions make you feel and act.

[14:28] Adam: This is our final podcast in the series, if you haven't already tuned in and listened to some of the other episodes, please check them out, you might even find more to ways you can take control over your brain.

[14:38] Sarah: I'm Sarah,

[14:39] Adam: and I'm Adam,

[14:40] Sarah: And that concludes Episode 6 of Teen Brain

[14:48] Sarah: I would like to thank Music Supervisor Brian Case for allowing us to use the song Belleville, which was performed and recorded by Joseph Perkins from London, UK. You can check out more of their stuff at braincase.ca or joeperkinsmusic.com. I would also like to thank Robyn Crummey for designing our logo. You can check out more of her awesome work on Instagram at @crummey_art. That's c-r-u-m-m-e-y_art. For those of you who didn't come across this podcast on the Teen Brain Blog please visit teenbrain.wordpress.com to learn more about the project and don't forget to leave a comment telling us what you thought of the episode. Alternatively, you can send an email to teenbrainpodcast@gmail.com. Thanks for listening.