WHAT IS THE AVERAGE LIFESPAN OF A PERSON WITH DYSLEXIA AND WHY IS IT IMPORTANT

Dyslexia: A Silent Threat to Life Expectancy

ABSTRACT

The purpose of this paper is to bring to light a study by the National Health Service in Great Britain, conducted by Gilbert et al. (February 2018) which found that the average lifespan of a male with poor reading skills is on average 26.1 years shorter than a male in England with average reading skills. The average life span of females with poor reading skills is 20.9 years shorter than that of females in Britain with average reading skills. Sally Shaywitz (2020) wrote that one can assume a native English speaker with poor reading skills should be considered to have dyslexia. Does that mean the average adult with dyslexia in Great Britain has a lifespan over two decades shorter than their non-dyslexic peers? No one has investigated this. As shocking as these revelations are, the North American research community has not attempted to replicate and/or investigate these findings. It is time for the research community to accept that the "reading wars" have been won by those whose research has undeniably shown that weaknesses in primarily phonemic processing, and possibly to some extent weaknesses in rapid automatized processing and poor orthographic processing, are the core symptoms of dyslexia.

It is time for North American scientists to accept that there is definitive evidence that synthetic multisensory phonics curricula are the way to address the academic fallout of dyslexia. Now it is time for North American scientists to investigate how having dyslexia affects major life activities and life spans. To not do so is possibly to condemn people with dyslexia to lives that are decades shorter than the general population and to unknown difficulties in major life activities. This author believes that it would be unprofessional, unethical, immoral, and inhuman.

Background

Over the last 60 years, the research concerning dyslexia has demonstrated causes, including genetics, and the altered neuroanatomy of the disorder, as well as how those differences relate to the symptoms that are observed when a person with dyslexia has problems reading. Today, we know dyslexia is a language disorder that is primarily due to the differences in the phonological processing areas of the brain, and we have excellent tools to diagnose this. A child born today with dyslexia is far more likely to receive excellent habilitation for their reading difficulties using one of the multisensory synthetic phonics curricula that are currently available than one born 60 years ago. There is much to be proud of and thankful for due to the research of those from the past. However, perhaps it is time to examine other aspects that those with dyslexia may experience during their lifetime, besides the academic difficulties.

Since the late 1990s and early 2000s, the scientific literature has been replete with unquestionable evidence that the primary symptoms of specific learning disorder-dyslexia are as follows (Lyon February 27, 2003; Lyon, 1999; Wolf and O'Brien, 2001; Roberts and Mather, 1997):

- **Poor/weak phonemic awareness**
- **Slow, rapid, automatized naming**
- **Weak/poor orthographic processing**

Since that time, the "Reading Wars" have ended. Occasionally, there will be a flare-up, but the above three symptoms again prove their accuracy (Hollingsworth, April 20, 2023). This author believes in the plethora of research findings that the above three symptoms are the core of the difficulties of specific learning disorder-dyslexia.

In addition, researchers from the Mayo Clinic (Author, No date) wrote that those with dyslexia often have social problems of withdrawal, low self-esteem, aggression, and behavior and anxiety problems. In addition, they indicated that the inability to read and comprehend could cause dyslexic children to grow into adults who cannot reach their potential. Reading and comprehension impairments can cause adverse long-term social, economic, and educational impacts.

Longitudinal studies from the *"Research Program in Reading Development, Reading Disorders, and Reading Instruction, Initiated in 1965"* (Lyon, February 27, 2003; Lyon,

1999) found children with dyslexia who were not habilitated prior to fourth grade never catch up to their nondisabled age-peers or their age peers with dyslexia who have been habilitated for their disorder. However, the journey of adults with dyslexia is not an area of research in the scientific community. Is this because adults with dyslexia, given extensive training in synthetic multisensory phonics, are "cured," and those who have not had such training are lost causes? Does reading habilitation in childhood and/or adulthood solve all dyslexia problems? The data describing the number of people in the United States who are poor readers is staggeringly high. Of those between the ages of 16 and 74, 54 percent read at the sixth-grade level or below. That is about 130,000,000 people (Schmidt, March 16, 2022; Rothwell, September 8, 2020). As Dr. Sally Shaywitz wrote (2020),

> **"Lack of literacy is a primary national concern. Thirty million (14 percent) in this country score *below* basic reading level in prose literacy skills—skills needed to comprehend and use connected texts—even though 45 percent graduated from high school. These adults are extremely inefficient readers, reading about sixty words a minute, a rate expected of first-to second graders. Surveys report that many limited readers perceive themselves as reading well." (p. 405)**

Shaywitz continued that most jobs require a twelfth-grade reading level in a few years. Most adult literacy programs believe they have been successful if they raise the reading level to eighth grade.

[Insert Figure 1 here]

[Insert Figure 2 here]

However, Shaywitz reported that employment applications are written at the ninth-grade level. Trade school manuals are on the tenth-grade level, as are most menus, ATM instructions, and IRS forms. Hence, reading activities of daily life are beyond many adults in this country. As Shaywitz wrote in an article (Shaywitz, January 2000), "Children with dyslexia neither spontaneously remit nor demonstrate a lag mechanism for catching up in the development of reading skills." Following up in 2020, she wrote, "Adults who are poor readers and for whom English is their first language are for the most part dyslexic." (p.406) To summarize, children with dyslexia who are not habilitated with synthetic multisensory phonics do not grow out of their dyslexia, and native English-speaking adults who are poor readers typically have dyslexia.

[Insert figure 3 here]

The three primary symptoms of dyslexia are poor phonemic awareness, slow, rapid automatized naming, and poor orthographic processing. Reading curricula strong in synthetic multisensory phonics is the best way to habilitate reading disabilities in children and adults with dyslexia (Author, Winter, 2024). There are secondary social difficulties that those with dyslexia often have. These can have negative impacts on the lives of adults with dyslexia. The scientific community knows very little about the day-to-day lives of

adults with dyslexia. We know that children with dyslexia have a significantly better outcome in adulthood if they are habilitated with synthetic multisensory phonics techniques before fourth grade. Those with dyslexia who are not habilitated with synthetic multisensory phonics curricula prior to fourth grade or never habilitated (e.g., with Orton-Gillingham curriculum) will not catch up to their nondisabled peers by age 18.

Approximately 130,000,000 people in the United States read at the sixth-grade level or less, and soon, the average American will need to be able to read at the twelfth-grade level in most jobs. However, adult literacy programs believe they are successful if they can help an adult learn to read at the eighth-grade level. Children do not grow out of their dyslexia, and a native English-speaking adult with difficulty reading often have dyslexia.

Question: Do people living the average lifespan in the USA spend most of their lives as children or adults? Question: Do people with dyslexia who live an average lifespan for a person with dyslexia in the USA spend most of their life as a child or as an adult? The answer to both questions is as an adult. Question: What do we know about adults with dyslexia in the USA? Pathetically little other than they have difficulty with the big three: poor phonemic awareness, slow, rapid automatized naming, and weak orthographic processing. Still, we know almost nothing about how this affects their day-to-day life.

What is the average lifespan of the "typical" American? It is as follows (Arias et al., August 2022):

- **Males: 73.2 Years**

- **Females: 79.1 years**
- **Overall: 76.1 years**

  (COVID-19 has done a "nice job" lowering life expectancy in our country.)

Why do People with Dyslexia have a Greatly Reduced Lifespan?

The National Health Service in Great Britain published a report in February 2018 on the research by Gilbert et al., which studied the significant impact of low health literacy on life expectancy. The study found that, "…43 percent of adults in England lack the literacy skills necessary to understand standard health information." Low literacy correlates with low health literacy; their results indicated that 75 percent of individuals with low health literacy have a significantly lower life expectancy than those with high health literacy. Those with lower health literacy tend to experience worse health, engage in poor health behaviors, and face a higher risk of a shortened lifespan.

A man living in an area of England with low health literacy can expect a life span that is 26.1 years shorter than a man residing in a high health literacy area. Similarly, a woman in a low health literacy area will have a life expectancy of 20.9 years shorter than one living in a high health literacy area. Shaywitz (2020) stated that adults whose native language is English and who have poor literacy skills are most considered dyslexic. Given the previously mentioned life expectancies of Americans, one might wonder if this means the average American male with dyslexia has a life expectancy of 47.1 years, and the average

life expectancy of an American female is 58.2 years. The answer remains unclear, prompting whether this issue should be examined.

[Insert figure 4 here]

The researchers (Gilbert et al., February 2018) reported that individuals with low health literacy are 1.5 to 3 times more likely to experience poorer health outcomes. They are 18 times more likely to take their prescription medications incorrectly and are significantly more likely to misunderstand the symptoms of medical conditions like asthma or diabetes. Furthermore, those with lower health literacy are more inclined to rate their health as "very poor" than those with higher health literacy.

Individuals with poor literacy skills are also more likely to be unemployed, which is linked to lower life expectancy. Moreover, low literacy complicates access to healthcare, further decreasing lifespan. Individuals with low literacy are twice as likely to smoke and consume excessive alcohol. There is also a connection between low literacy and the use of street drugs (Gilbert et al., February 2018). Additionally, poor literacy is associated with a lack of exercise, increased hospitalizations, more frequent emergency room visits, and lower compliance with prescribed medications, including difficulties in understanding medicine labels and health information and the use of illegal drugs (Gilbert et al., February 2018). Given the evidence suggesting significant reductions in life expectancy for people with dyslexia, it is essential to conduct further research into the issue.

Dyslexia and Comorbid ADHD

Now, when we consider that around 30 percent of those with dyslexia also have comorbid ADHD, the situation becomes even more concerning. On average, individuals with untreated ADHD can expect a significantly reduced life expectancy due to impulsive behaviors that neglect health-related issues. Research indicates that untreated ADHD can reduce life expectancy by 9.6 to 12 years compared to the general population (Barkley, January 14, 2018; Inewrro, January 18, 2018; Barkley, November 2022; Chau et al., November 18, 2017). Untreated ADHD lowers life expectancy 2.5 times more than the four leading causes of reduced life expectancy: obesity, smoking, diabetes, and poor diet. Those with ADHD generally exercise less, have poor sleep hygiene and nutrition, and face higher rates of obesity, substance use, sexual health issues, teenage pregnancies, antisocial behavior, and aggression compared to neurotypical individuals.

Considering these statistics, we might estimate that the average life expectancy of a boy with dyslexia and comorbid ADHD could be 38.8 years less than that of their non-affected peers, leading to an average lifespan of only 34.4 years. For a girl with dyslexia and comorbid ADHD, the average life expectancy might be 32.5 years less than that of her peers, meaning she could expect to live approximately 42.5 years. However, these figures remain speculative because the research has not been done. No one knows how much a person's life expectancy is reduced by having this comorbidity. It is a ratio of the above numbers, but again, no one knows.

[Insert Figure 5 here]

It is established that poor phonemic awareness, slow, rapid automatized naming, and inadequate orthography processing are significant factors contributing to dyslexia. The possibility that individuals with dyslexia might experience a lifespan drastically shorter than that of the general population merits serious attention.

Dyslexia Comorbid with Autism Spectrum Disorder

It is crucial to recognize that both autism spectrum disorder and dyslexia are lifelong conditions that can negatively affect individuals throughout their lives, regardless of intervention (Frith November, 2013). The co-occurrence of dyslexia and autism spectrum disorder has been found in about 6 to 30 percent of those with dyslexia (Stanborough, October 24, 2022).

In the United States, the mean age of death for individuals with autism spectrum disorder is approximately 36.2 years. Alarmingly, nearly 28 percent of those who die by that age do so due to accidental injuries. For individuals without intellectual disabilities, the average life expectancy may extend to about 53.87 years, and many who survive past age 65 tend to live longer, with a lifespan more akin to the general population (Krantz et al., February 2023). Yet, we still lack concrete data on the life expectancy of those with both dyslexia and autism spectrum disorder. It is a probability, not purely additive.

[Insert Figure 6 here]

Analysis

Interestingly, there is a wealth of information regarding the life expectancies of individuals with ADHD and autism spectrum disorder, yet there is comparatively little data about those with dyslexia. Scientists often prioritize lifespan research for the first two disorders rather than dyslexia. This discrepancy may stem from the perception that ADHD and autism spectrum disorder are pervasive neurodevelopmental disorders that affect all aspects of an individual's life. In contrast, many researchers consider dyslexia primarily a language disorder, not a pervasive developmental disorder. In this case, the goal is to habilitate individuals with dyslexia to improve their reading skills only. While some may go on to attend prestigious Ivy League universities and achieve notable success, these individuals are often exceptions rather than representatives of the average person with dyslexia.

The National Health Service (Gilbert et al., 2018) study underscores this reality. Many adults with dyslexia find themselves struggling to make ends meet, facing underemployment if they are fortunate, battling burnout, and trying to maintain their health, often with poor health practices and literacy.

Differences in the Dyslexic Brain

The author notes that even though one can be well habilitated for dyslexia with synthetic multisensory phonics and brain imagery, one can demonstrate pre- and post-changes in brain anatomy. However, this does not imply that years of exposure to synthetic multisensory phonics curricula will make a person with dyslexia's brain like a neurotypical's in all things. Shaywitz (2020) stated that the "brains of those with dyslexia continue to be significantly different from those of the general population" after such instruction. Hence, those with dyslexia who have been successfully habilitated for their disorder continue to have brains that are anatomically different from those of the neurotypical.

Research has shown that individuals with dyslexia exhibit significant differences in their brain structures compared to neurotypical individuals. Specifically, there are irregularities in the cellular architecture of the posterior planum temporale region of Wernicke's area, located in the left temporal lobe. Those with dyslexia tend to have higher occurrences of ectopias (the abnormal mixing of gray and white matter) and dysplasias (the irregular positioning of individual gray matter cells). Approximately two-thirds of individuals with dyslexia display an asymmetry in the planum temporale, with the left side larger than the right.

For individuals with dyslexia who also experience severe language delays, there is often a reversed parietal-occipital asymmetry, where the right planum is larger than the left,

contrary to the typical left-sided dominance. Additionally, adults with dyslexia tend to have larger right hemispheres than their left hemispheres and exhibit differences in their magnocellular visual pathways. Notably, there are also significant variations in cell size and distribution in both the posterior and anterior parts of the cerebellum. Finally, research has identified differences in brain structures between males and females with dyslexia. (Duane (1993); Riccio, and Hynd (1996); Fiedorowicz, et. al. (2001); Geshwin, 1979; Richardson (1994); Filipek, et.al. (1999); Livingstone (1999) Fawcett, and Nicolson (2001); Evans, et al (April 13, 2013).

Executive Function

Barkley (2012) defined executive function as "The use of self-directed actions so as to choose goals and to select, enact and sustain actions across time towards those goals usually in the context of others often relying on social and cultural norms for the maximization of one's long-term welfare as a person defines it to be" (p. 171). Barkley (2012) continued that the following brain structures are involved in executive function: prefrontal cortex, basal ganglia, amygdala, limbic system, and cerebellum.

Notably, those with dyslexia have central executive and phonological loop weaknesses. Spelling involves the phonological loop, visual-spatial sketchpad, and central executive. All of these are areas of weakness in those with dyslexia. Significant short- and long-term memory weaknesses are found in those with dyslexia. There are limited working memory resources for reading comprehension in those with dyslexia (Swanson & O'Connor,

September 10, 2009). Verbal working memory is a strong predictor of reading skills. However, visual-spatial working memory (a.k.a. visual-spatial sketchpad) is important in reading skills and comprehension (Pham & Hensson May 31, 2014). One can predict if a person has dyslexia by their working memory scores. Working memory predicts reading fluency and comprehension. However, Berg (November 12, 2014) noted that working memory is independent of IQ.

One needs good working memory for reading comprehension. As Dehn (2014) wrote, "Reading comprehension relies heavily on working memory and thus requires sufficient working memory resources…A reader using working memory to decode words usually does not have enough working memory capacity remaining to devote to comprehension" (p. 52). Hence, it is reasonable to assume if a person has trouble decoding words that will not have the working memory to use for comprehension.

Farah and colleagues (August 32, 2021) found that those with dyslexia have abnormalities in their neurological and behavioral domains related to executive functions that persist into adulthood. The researchers found that early evaluation and treatment in children with dyslexia for executive function difficulties help them with future lifetime success. Protopapa et al. (September 2022) added that adults with dyslexia have impairments in memory and attention not caused by ADHD, which causes them significant difficulties in daily functioning, education, and work settings.

The Cerebellum, Developmental Coordination Disorder, and Dyslexia

Developmental Coordination Disorder (DCD), also known as dyspraxia, affects approximately 10 percent of the general population and is a lifelong condition. There is no cure for DCD (Pietrangelo, May 24, 2023). It is characterized as a sensorimotor disability often accompanying cognitive difficulties (Deng et al., November 5, 2013).

Individuals with DCD struggle with rapidly adapting their movements in changing situations, maintaining balance, coordinating their body movements, predicting the outcomes of their actions, learning new movements and procedures, and solving motor-related tasks. They frequently have trouble sequencing their movements correctly (Tamplain, February 2024; Tamplain, No Date). Those affected by DCD often have significantly lower physical fitness levels and higher body mass indexes (BMIs) than the general population, increasing their risk of obesity. Longitudinal studies indicate that individuals with DCD exhibit decreased physical flexibility, muscle strength, endurance, and core strength. Additionally, they have reduced lung capacity and significantly lower cardiovascular fitness compared to their nondisabled peers. DCD is a chronic disability that persists throughout an individual life (Cacola, October 24, 2016).

Adults with DCD exhibit the aforementioned deficits along with issues related to executive functioning, increased anxiety, depression, and lower self-esteem compared to the general population. They also face challenges with driving, organizing daily life, and living and working independently (Author, no date). Research shows these individuals often struggle

with controlling a vehicle, judging distances, and parking (Kirby et al., September 11, 2011). DCD can adversely affect daily living activities and employment throughout a person's lifespan (Steenbergen et al., January 31, 2024).

There is a high rate of comorbidity between dyslexia and DCD, estimated at around 80 percent (Fawcett & Nicolson, 2001). This rate is five times higher than expected in processing and attentional difficulties associated with dyslexia, as well as visuospatial processing challenges linked to DCD. Additionally, memory weaknesses are common in both disorders. Individuals with comorbid dyslexia and developmental coordination disorder demonstrate clinically significant symptoms of both disorders (Downing & Caravolas, December 2020).

Moody (2014) stated that the dyspraxia seen in adults with dyslexia is not seen as poor motor coordination. Such adults have practiced for years to overcome their coordination difficulties, and their primary difficulties with dyspraxia are cognitive. They struggle with social interaction, timekeeping, organization skills, sequencing motor activities, and structuring information. They also have difficulty with phonemic awareness, slow reading, auditory working memory, and visual processing.

The rate of comorbidity between ADHD and developmental coordination disorder is about 50 percent (Lino et al., July 21, 2022). The comorbidity rate between Autism Spectrum Disorder (ASD) and developmental coordination disorder ranges from 60 to 90 percent (Ringold et al., August 28, 2022).

Adults with developmental coordination disorder have difficulties in their daily life activities that go far beyond academic problems. "Adults with developmental coordination disorder (DCD) experience difficulty coordinating gross and fine motor movements. These difficulties can lead to challenges in performing daily activities such as climbing stairs, bathing, dressing, and using tools. Tasks like food preparation can be complicated, and they may struggle with participating in sports, driving safely, and managing fatigue. In addition, they may face speech articulation issues, poor hand-eye, and eye-foot coordination. Adults with the disorder tend to be accident-prone, bumping into people and objects frequently". (Author, no date, Dyspraxia DCD America).

Other adult symptoms include difficulties with learning new skills, remembering information at home or work, and manipulating small objects (e.g., tying shoelaces) (Author, October 1, 2023). Pietrangelo (May 24, 2023) identifies additional challenges, such as abnormal posture, gait abnormalities, and difficulties with grooming. DCD is 3 to 4 times more common in males than in females, and it often co-occurs with dyslexia, ADHD, autism spectrum disorder, apraxia of speech, and dyscalculia (Pietrangelo, May 24, 2023).

The cerebellum is believed to be the primary region of the brain responsible for motor control and learning. It is also believed to be the main area affected in individuals with developmental coordination disorder.

Research by Allen (March 11, 1998) indicates that the cerebellum plays a crucial role in several cognitive functions, including:

- Attention

- Learning processes

- Memory tasks

- Management of conditional anxiety

- Complex reasoning and problem solving

- Sensory and motor tasks

Allen also noted that impairment in the cerebellum could negatively affect a person's ability to:

- Plan

- Reason

- Shift cognitive sets

- Name fluently (which includes Rapid Automatized Naming, or RAN), a symptom of dyslexia)

- Utilize working memory

- Recalling learned information

Furthermore, damage to the cerebellum can lead to behavioral issues such as aggression, emotional expression deficits, impulsivity, and inappropriate behaviors.

Brown (2013) elaborated on how, besides controlling motor functions, the cerebellum is essential for processing emotions, language, working memory, and executive functions. Ratey (2001) emphasized the cerebellum's importance in social interactions, stating,

> **"The cerebellum has only recently been implicated in the normal functioning of social behavior. New research shows that the cerebellum is crucial as a mediator in cognition. To perceive an object or event, we must integrate various sensory qualities and relevant memories or thoughts in a carefully timed manner. The cerebellum assists in regulating attentional states and coordinating associations, which are vital for entering into relationships with another human being. Communication, conversation, and graceful social interaction all depend on being able to pay attention to another person and to one's own internal states and to alternate easily back and forth between them." (p. 305)**

When a person's cerebellum is damaged, they may experience several symptoms, including disturbances in balance and posture, muscle rigidity, loss of muscle tone, a noticeable decline in coordination, impaired ability to plan movements, and reduced automaticity (Fawcett & Nicolson, 2001).

Overall, understanding the intersection of dyslexia, ADHD, and associated conditions requires comprehensive research to explore their combined impacts on life expectancy and overall well-being.

Default Mode Network

Automaticity is linked to the brain's Default Mode Network (DMN), which allows us to perform automatic behaviors like driving a car while simultaneously thinking about other matters, like vacation planning. For most individuals, driving under typical conditions becomes an automatic action managed by the cerebellum. As we practice this skill repeatedly, the neural pathways related to driving become well established. These neural pathways enable us to stop the vehicle without consciously considering how much pressure to apply to the brake pedal. While learning to drive requires active thought about these actions, they eventually become automatic with practice. This automation frees up cognitive resources, allowing us to engage in silent thinking and internalized speech, such as planning vacations (Gillespie, Szabo, & Nemeroff, 2020).

The Default Mode Network enables individuals to:

- Make self-referential judgments

- Engage in social cognition

- Create episodic memories

- Comprehend language and semantic memory

- Appreciate visual aesthetic beauty

- Process one’s own emotions as well as those of others (empathy)

- Allow for mind wandering (Menon, April 2023; Crawford, July 1, 2021).

Key brain regions involved in introspection include the anterior medial cortex, posterior cingulate cortex, and angular gyrus (Gillespie, Szabo, & Nemeroff, 2020). The cerebellum is crucial in planning and coordinating these automatic behaviors (Barkley, August 28, 2018; Balsters & Ramnani, February 9, 2011; Fawcett & Nicolson, 2001).

Automaticity and Dyslexia

Individuals with dyslexia encounter considerable challenges in mastering new behaviors to the point of automaticity, particularly when compared to their non-impaired peers. They require significantly more time to learn new procedures until they can execute them without conscious thought or needing internalized speech. As Nicolson explained (Nicholson & Fawcett, 2000),

> **"If a task takes four hours for a non-dyslexic child to learn, it will take eight hours for a dyslexic child. However, this isn't linear. A task that takes 100 hours might take 1,000 hours for a dyslexic child. For a task requiring 10,000 hours, it would take 100,000 hours, and so on. Consequently, skills like reading, writing, and spelling, which require hundreds of hours of practice, are particularly challenging for children with dyslexia."**

[Insert figure 7 here]

Fawcett (2004) elaborated on this concept by introducing the "square root rule." This rule describes the additional time it takes for a dyslexic child to learn a new procedure to the point where it becomes automatic, compared to a neurotypical child. Fawcett stated, “The extra time needed for a dyslexic child to master a task is proportional to the square root of the time a non-dyslexic child takes” (Slide 45). What does this mean?

According to Isla Rowntree (Carlton, May 12, 2022), the average child aged 4 to 6 requires about 45 minutes of practice to learn how to ride a bike at an automatic level. While some children may take longer, others may need less time. Using Fawcett's (2004) "square root rule," we can calculate the learning time for children with dyslexia. If the average child takes 45 minutes to achieve this skill, we find the square root of 45, approximately 6.708. Multiplying this result by 45 gives us 301.905 minutes. This indicates that, on average, a child with dyslexia in this age group takes about 5.03 hours to learn to ride a bike at the same automatic level.

[Insert Figure 8 here]

What does this mean? If a non-dyslexic child learns to ride a bike six times faster than a child with dyslexia does, this difference can significantly affect the dyslexic child's emotional well-being. Furthermore, it raises concerns about the dyslexic child's coordination skills, as studies show that 80 percent struggle with coordination. Imagine how a child might feel if none of their peers want them on their team simply because they are “clumsy."

Nicolson and Fawcett (2008) discussed the dyslexia automaticity deficit (DAD dyslexia automaticity deficit), which indicates that individuals with dyslexia often get fatigued more quickly than their peers when learning new skills. This deficit in automaticity can affect activities such as riding a bike, reading, driving a car, or operating new machinery. Although it may not appear that individuals with dyslexia take longer to master these skills, they frequently depend on "conscious compensation" through internalized speech (controlled processing) for tasks that would be automatic for most people.

[Insert figure 9 here]

Furthermore, Nicholson and Fawcett (November 14, 2014) noted that individuals with dyslexia typically take longer to "unlearn a procedure" than those without dyslexia, primarily due to an automaticity deficit. For example, imagine someone who has driven internal combustion cars with manual transmissions for 40 years and then decides to switch to an electric vehicle. Electric cars lack gears to shift and do not require a clutch. During the transition to the new vehicle, this person may find himself or herself instinctively trying to shift gears, which can lead to anxiety while driving. Additionally, the electric car's quicker acceleration and regenerative braking system may contribute to their discomfort, as they are still adjusting to the behaviors associated with a traditional car (Author, November 19, 2024).

Imagine a person with dyslexia taking six times longer to become comfortable driving an electric car due to difficulties with automaticity. Would this person feel more anxious and fatigued than someone without dyslexia learning to drive the exact vehicle? The answer is yes!

Understanding the Basics of Human Memory Systems and Their Relation to Dyslexia

The human brain has two primary memory systems: declarative and procedural. The declarative system is responsible for recalling facts and events, such as remembering that Columbus sailed the ocean blue in 1492 or recalling personal life events like graduating from college on the same day Mount St. Helens erupted. In contrast, procedural memory pertains to knowing how to perform specific tasks, like riding a bicycle (Censor et al., November 6, 2006; Karni November 3, 2004; Kari et al., 1994).

When learning a new skill and encoding it into procedural memory, individuals often see the most significant improvement after training concludes. Research indicates that when teaching a new skill, it is beneficial for a teacher to have the student practice it until their performance plateaus. At that point, the teacher should pause the training and allow the student to get a good night's sleep. The rest is essential, as sleep, helps solidify new procedural memories. The following day, after a good night's sleep, the student should be assessed to gauge their proficiency in the new skill. Typically, the student's performance will be notably better than the day before when they plateaued, with significantly fewer

errors. Why does this happen? One function of sleep is to enhance new procedural memory consolidation.

Two key sleep functions include helping us retain and process new skills and memories (Strickgold, February 2013). Lack of sufficient sleep can hinder improvements in new skill acquisition (Winerman, January 2006). Sleep has a more pronounced effect on procedural than declarative memory (Strickgold, 2005). Strickgold (December 16, 2022) stated, "Over the last decade, it has become increasingly clear that the processes of learning and memory consolidation and integration can occur over extended periods, measured in days or even years. Concurrently, evidence has continued to support an important role for sleep in at least some aspects of these processes." Proficient reading relies on procedural memory. Once reading becomes automatic, particularly at or above the fourth-grade level, it transitions into a tool for learning, becoming effortless.

Sleep and Dyslexia

Approximately 50 percent of those with dyslexia have failures of overnight sleep procedural memory consolidation of even simple motor skills (Nicholson et al., August 2010). Bruni (2009) and colleagues discovered that people with dyslexia have irregular EEGs during non-REM sleep that appear to be related to their disability. They found that the hippocampus is involved in this difference. The hippocampus allows learning and encodes long and short-term, visual-spatial, verbal, and declarative memory (Author May 5, 2024).

People with dyslexia were found to have differences in their sleep patterns and sleep-dependent memory consolidation processes (Reda et al., December 31, 2020). These sleep problems may be related to the cognitive impairments that those with dyslexia have in working memory, problem-solving strategies, and procedural memory (Smith-Spark et al., 2022). Again, the above seems to indicate that people with dyslexia have significant difficulties with automaticity and how it can affect their everyday lives.

Perhaps, one of the next steps in treating dyslexia is studying possible interventions that will help memory consolidation during sleep. Hedenius et al. (2021) wrote,

> **"These findings suggest that the procedural learning problems previously observed in children with developmental dyslexia may be related to the overnight consolidation phase rather than the initial learning phase. Understanding which aspects of learning are particularly challenging in this condition (sic. and) is crucial to developing effective intervention."**

Over 50 percent of those with ADHD have sleep disorders, and this exacerbates the symptoms of ADHD and can significantly reduce academic and employment outcomes. (Barkley 2012; Craig et al. February 2020). Additionally, 64 to 93 percent of those with autism spectrum disorder have sleep disorders (Singer et al., April 1, 2023). What does this mean for those who have dyslexia comorbid with ADHD and/or autism spectrum disorder regarding sleep impairments? We do not know.

[Insert Figure 10 here]

Clark et al. (October 17, 2017) reported that those with Parkinson's disease, specific language impairment, dyslexia, schizophrenia, and developmental coordination disorder appear to have similar impairments in procedural learning and memory. Hence, cerebellar function impairment is associated with neurodevelopmental disorders and other diseases and disorders.

Social Interaction

Semrud-Clikeman (2007) indicated that 75 percent of individuals with learning disabilities struggle with social interaction. Those with learning disorders often exhibit lower social competence and are less well-liked (Wren, 2000). Patterson and Pennington (January 14, 2015) noted,

> **"At the brain level, dyslexia is associated with aberrant structure and function, particularly in left hemisphere reading/language networks. The neurocognitive influences on dyslexia are multifactorial and involve phonological processing deficits and weaknesses in oral language skills and processing speed."**

These difficulties could understandably influence social interactions for individuals with dyslexia.

Over the years, several studies have found that people with dyslexia and/or ADHD often have trouble recognizing emotional facial expressions (Most & Greenbank, 2000; Brown, 2001). Additionally, individuals with dyslexia may struggle with recognizing faces (Sigurdarottir et al., February 2015). Research by Irish scientists revealed that young adults with dyslexia (average age 25) exhibit mild impairments in visual processing for non-reading tasks, such as face perception (December 15, 2021).

Fatigue, anxiety, and exhaustion appear to be another area of study to fully understand and treat dyslexia. Roffman (2000) noted, "One final ongoing issue that is worthy of mention for many with learning disabilities (LD) or ADHD is the problem of fatigue. The extra effort required to cope with the ongoing social and academic demands of schooling can be chronically exhausting" (p. 217). She continued, "Adults with LD/ADHD often experience pressure as they work to manage their symptoms. Anxiety can develop from everyday occurrences, such as the loss of yet another set of keys..." (p. 49). This social and situational anxiety can cause significant additional fatigue and social difficulties.

These challenges can significantly affect daily life, social interactions, and employment opportunities for those with dyslexia throughout their lifespan.

Should Two Symptoms be Added to the List for Dyslexia?

Given the above, should poor automatization and coordination be added to the existing list of symptoms of dyslexia? Such a list would look as follows:

- **Poor phonemic awareness**
- **Slow rapid automatized naming (RAN)**
- **Poor orthographic processing**
- **Slow atomization of new behaviors**
- **Poor balance/coordination**

These are "new" symptoms of dyslexia. Additionally, the author believes these two "new symptoms" can account for much of the heartache and shortened lifespan of adults with dyslexia. Hence, about major activities of daily living outside of academic life, clinically significant difficulties with slow automatization of new behaviors and poor coordination can be just as debilitating as poor phonemic awareness, slow rapid automatized naming, and orthographic processing in educational settings. This is not to say that the more academically relevant symptoms of dyslexia do not affect other major daily life activities. They do, but not to the extent that poor automatization and coordination do. Concurrently, poor automatization and poor coordination can negatively affect academic life, but not as much as poor phonemic awareness, slow rapid automatized naming, and poor orthographic processing affect academic life. The point is to consider fully the effect of the symptoms of dyslexia on an individual's life in academic environments and beyond. One must include the symptoms of poor automatization, poor coordination, and academic symptoms.

It is established that individuals with dyslexia can experience different levels of impairment from each of their symptoms. Not all those with dyslexia are alike. Some experience severe impairment from all symptoms of their disorder, while others may have significant difficulty with just one. This difference in severity of symptoms can be due to remediation, the severity of original symptoms, compensation, and other factors (Reid, November 11, 2006). The same can be said of the two "new symptoms."

Driving While Dyslexic

Learning to drive with dyslexia is much more difficult than for the average person. Those with dyslexia struggle to quickly find right versus left and read wordy road signs. It can also affect the ability to produce behaviors in the proper sequence using your hands and feet at the same time and using short-term memory (Author February 18, 2021).
Those with dyslexia were found to have the most significant difficulty with driving situational awareness. They are also slow to comprehend and be aware of road signs, which could significantly impair their ability to drive safely (Taylor et al. 2016). When people with dyslexia drive and come across road signs, their vehicle's speed varies significantly. This does not happen in areas where there are no road signs. As a result, they cannot drive fluidly while reading road signs (Tejero et al. 2019).

Driving while Dyslexic and ADHD

There have been no studies of dyslexia and comorbid ADHD driving skills. However, again, 30 percent of those with dyslexia have ADHD. There is a plethora of research on the driving records of those with ADHD. Barkley (1998; 2008) stated that those with ADHD should be considered 30 percent less mature than their nondisabled age peers in their ability to control impulsivity, hyperactivity, and inattentiveness. This immaturity is called the "30 Percent Rule." Many 16-year-old adolescents with ADHD want their driver's license. However, under this rule many may be functioning with regard to their ability to control impulsivity, hyperactivity, and inattentiveness at the level of an 11-year-old. No one would think it would be appropriate for an 11-year-old to drive. Adults with ADHD are more likely to drive a car in traffic prior to getting their license. They use poor driving habits. They receive significantly more traffic tickets, especially for speeding. They are four times more likely to be in a serious accident if they are driving without medication for their ADHD. They handle a car as well as a person who is legally intoxicated with alcohol when not medicated (Barkley 2006).

Approximately 25 percent of those with ADHD have their license revoked compared to 5 percent of the general population. About 17 percent of those from the general population have accidents with injuries compared to 60 percent of those with ADHD. Those with ADHD rate themselves as being significantly worse driver than their nondisabled peers. The same is true of the parents and driving instructors of those with ADHD (Barkley 2012).

Employment and Dyslexia

Brown and Gerber (1994) believed there were three types of adults with learning disorders in the work play. They were those whose disability did not interfere with their work, those who struggled long hours to overcome their disabilities in the workplace, and those who were chronically unemployed. Mcloughlin et al. (1994) wrote that for those with mild disabling conditions, reading and writing can make the workplace overwhelming. McGrady et al. (2001) indicated that a person with a learning disorder must work much harder than neurotypicals on the same tasks. As Roffman (2001) quoted Betty, an adult with a learning disorder in the workplace, says, "You are always compensating and you're tired a lot" (p. 261).

Many adults with learning disorders have social skills deficits that cause them to fail at office politics. Many such individuals reach a career plateau they cannot advance beyond because of poor social skills. Lacking social skills is the prime reason adults with learning disorders are underemployed (Brown & Gerber, 1994; McLoughlin et al., 2001). Brown and Gerber (1994) indicated that 41 percent of those with learning disorders have significant difficulty completing a job application and passing job placement assessments. In April 2016, the British Dyslexia Association estimated there were 6.2 million adults with dyslexia in Great Britain who were unemployed or "economically inactive."

Goodacre et al. (January 3, 2020) found that 70 percent of adults who had experienced homelessness in Great Britain were dyslexic. In the United States, MacDonald and colleagues (2016) found that adults with dyslexia are overrepresented in the homeless population. They also have an increased risk of mental health disorders, mood and anxiety disorders, and suicide attempts. Adults with dyslexia worry about obtaining a job and keeping it. Over their lifespan, their disability negatively affects all domains of human functioning (De Beer et al., January 24, 2014). Finally, adults with dyslexia were found to face significant challenges in employment due to their disability, such as excessive mental exhaustion, fatigue, and a high risk for burnout (Wissell et al., June 18, 2022).

Employment Dyslexia Comorbid ADHD

To date, no one has studied employment issues of those with dyslexia comorbid with ADHD. However, there is plenty of research into the work histories of those with ADHD. Recalling that 30 percent of those with dyslexia have comorbid ADHD, how would it complicate their employment? The main reason those with ADHD lose their jobs is due to social interaction problems (Ratey and Griffth 1998). At any one time, one-half of those with ADHD are unemployed (Biederman October 27, 2006). A 33-year follow-up of boys with ADHD found they were 6 times more likely to be homeless than the general population. About a quarter of homeless people have ADHD (Murillo et al., November 2016).

Workers with ADHD make significantly lower salaries, are absent from work more, and are far less productive than non-ADHD workers. They have more accidents on the job and make an average of $10,000 less per year than those without ADHD (Ramsey 2010).

Conclusion: The Lifetime Toll of Dyslexia

If a person has a neurodevelopmental deficit (i.e., dyslexia), they must create software to compensate for it. That is hard and takes time and energy. It also takes an action that is, for most people, unconscious and makes it conscious. Hence, it will never be as "automatic and efficient" as an ability. Such compensation skills divide attention and make tasks, which are naturally not conscious, more onerous and less efficient, creating frustration. When additional stimuli are added on an unpredictable basis, this requires a cognitive shift, and these learned skills tend to break down, which may lead to a feeling of vulnerability and anxiety. People with such disabilities tend to fatigue faster and perform cognitively less efficiently when engaged in their "skills" compensations. Those with neurobiological deficits are at risk of not being aware of and/or sensitive to cultural norms and symbols as well as their importance in social interaction. This unawareness may cause significant social rejection, anxiety, and frustration for these individuals. An additional source of frustration and anxiety for individuals with these deficits is that most people's behaviors are automatic. Thus, they frequently do not understand the struggles of those who must function on a cognitive level.

People with dyslexia are far more at risk of having comorbid ADHD, developmental coordination disorder, executive function weaknesses, poor procedural and short-term memory, problems with the automatization of new behaviors, significant difficulties with sleep, difficulties with social interaction, problems with balance and coordination, alterations in their default mode network, difficulties with employment, and problems with activities of daily living when compared to neurotypicals. Is it reasonable to ask if someone with dyslexia may have a shorter life expectancy? Additionally, when adding the already accepted "core symptoms" of weak phonemic awareness, slow rapid automatized naming, and poor orthographic processing to the list of difficulties those with dyslexia experience, would it not be prudent to investigate if the above significantly shortens the lifespan of those with dyslexia? If follow-up studies related to the National Health Service's (Gilbert et al. 2018) findings fail to be replicated, then there is no reason to be concerned about it. However, if they are replicated, the scientific community would be committing a significant, detrimental ethical and moral oversight in not investigating ways to mitigate why people with dyslexia live significantly shorter lives.

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Figure 1

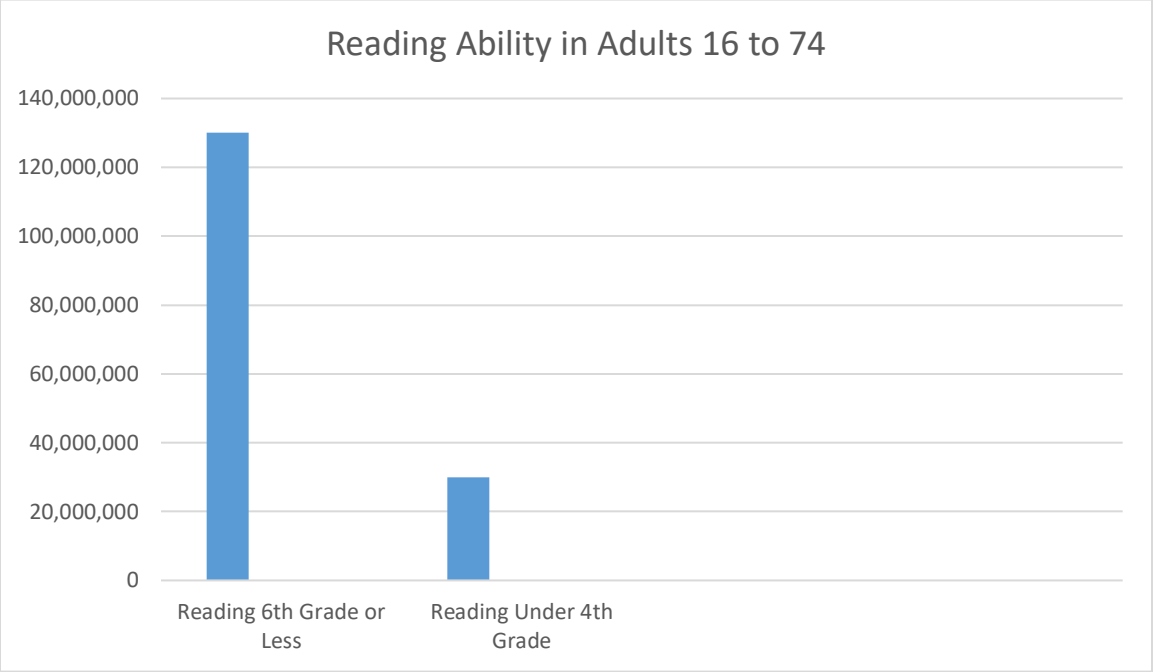


Figure 2

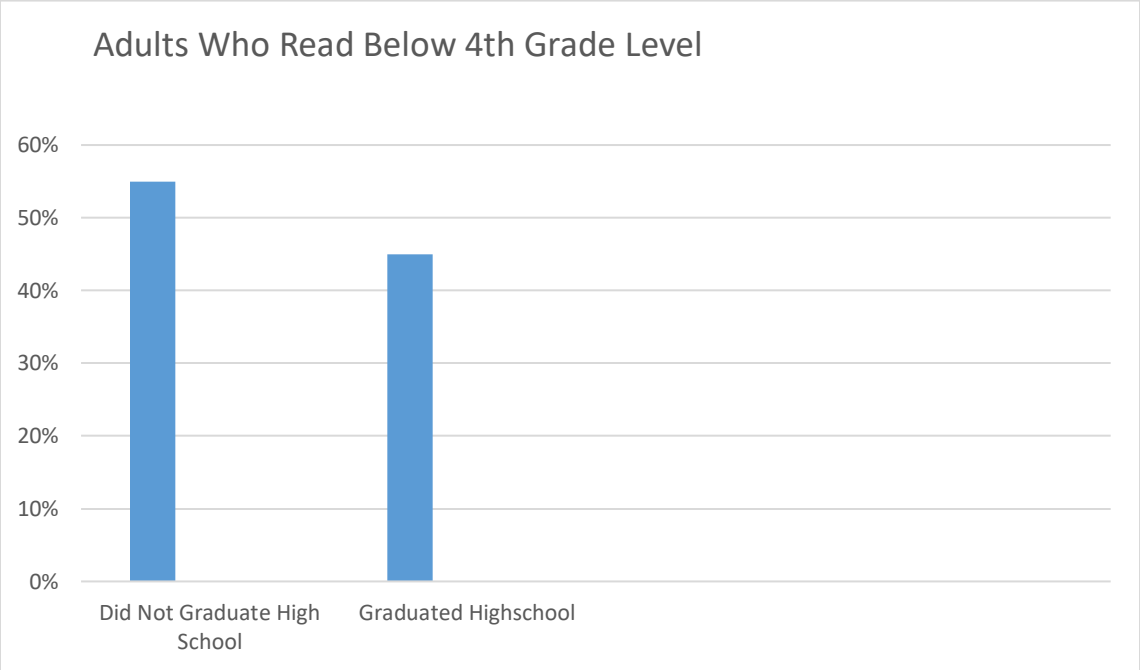


Figure 3

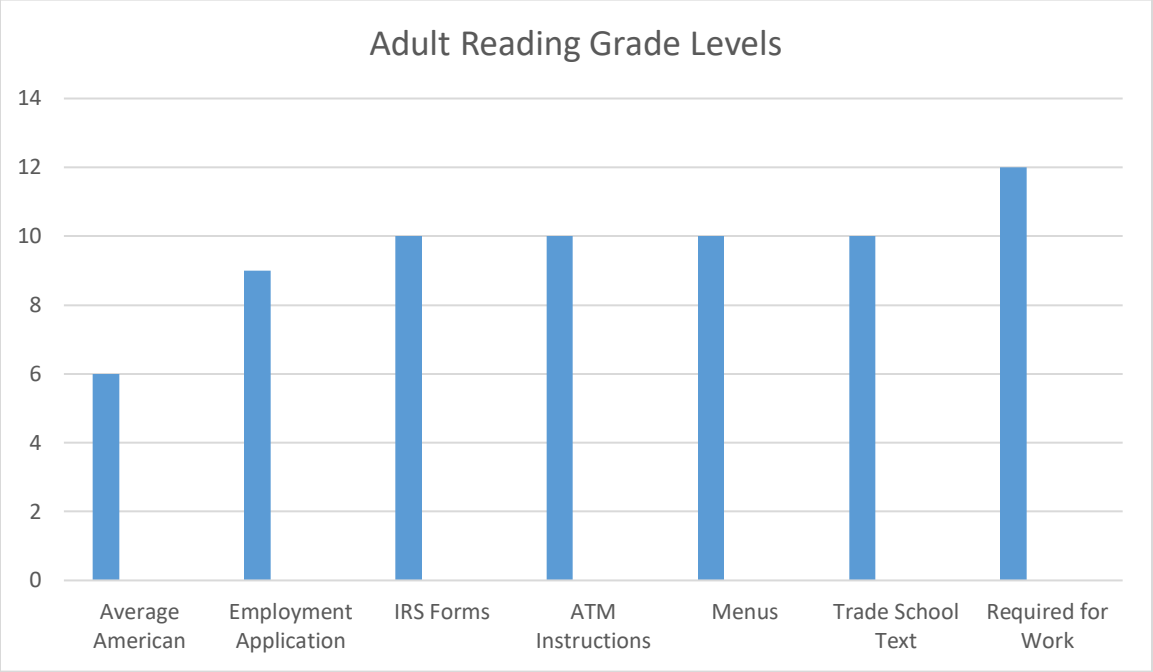


Figure 4

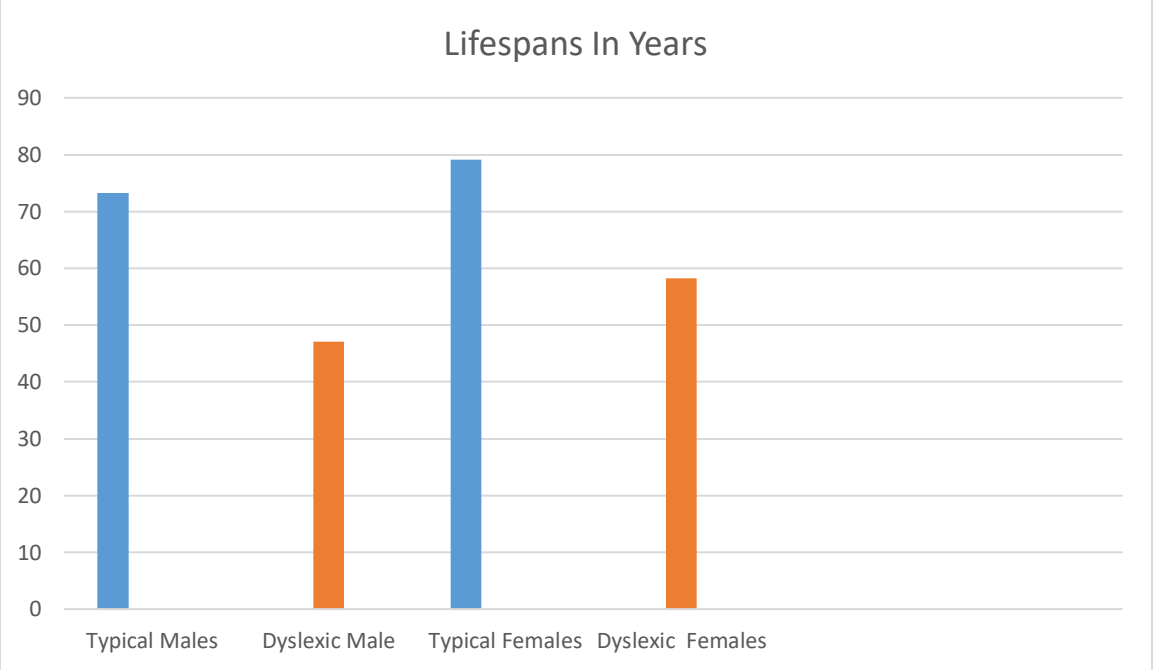
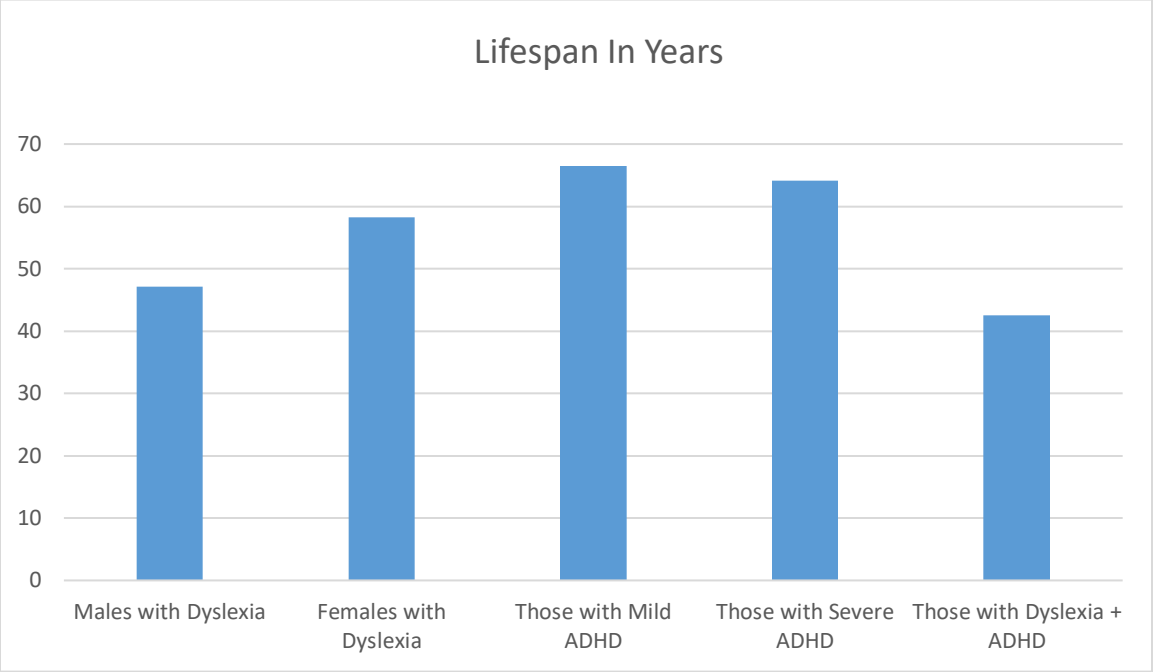


Figure 5



*Please note: The lifespan of those with dyslexia comorbid with ADHD is the sum of the number of years each disorder reduces lifespan. No research indicates this.

Figure 6

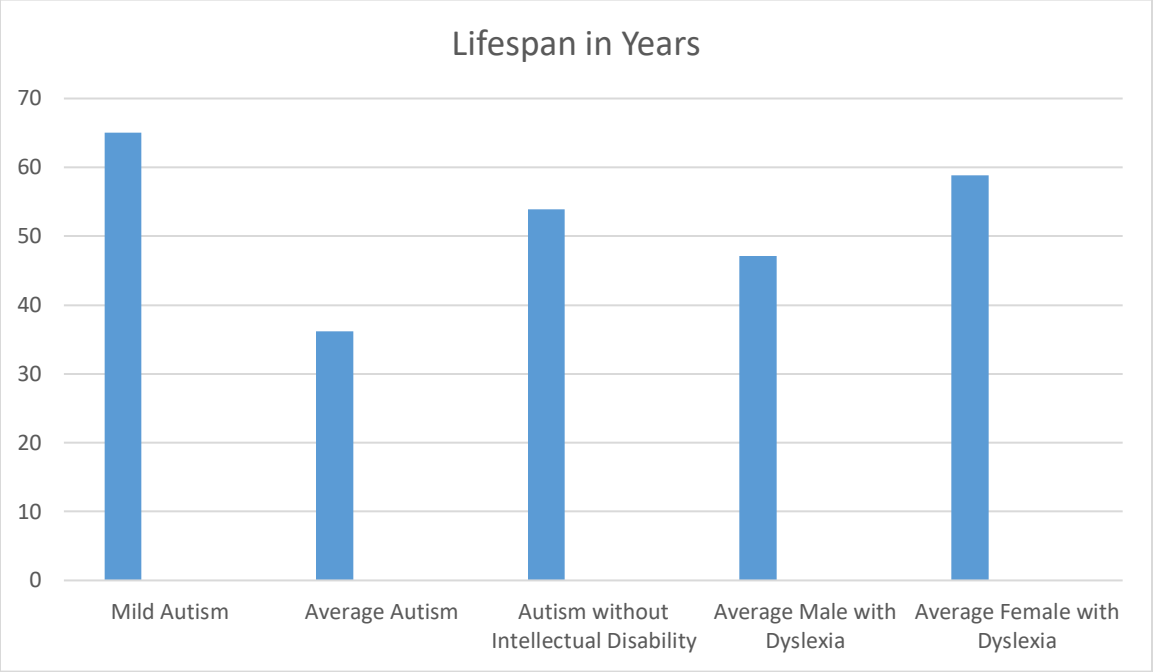


Figure 7

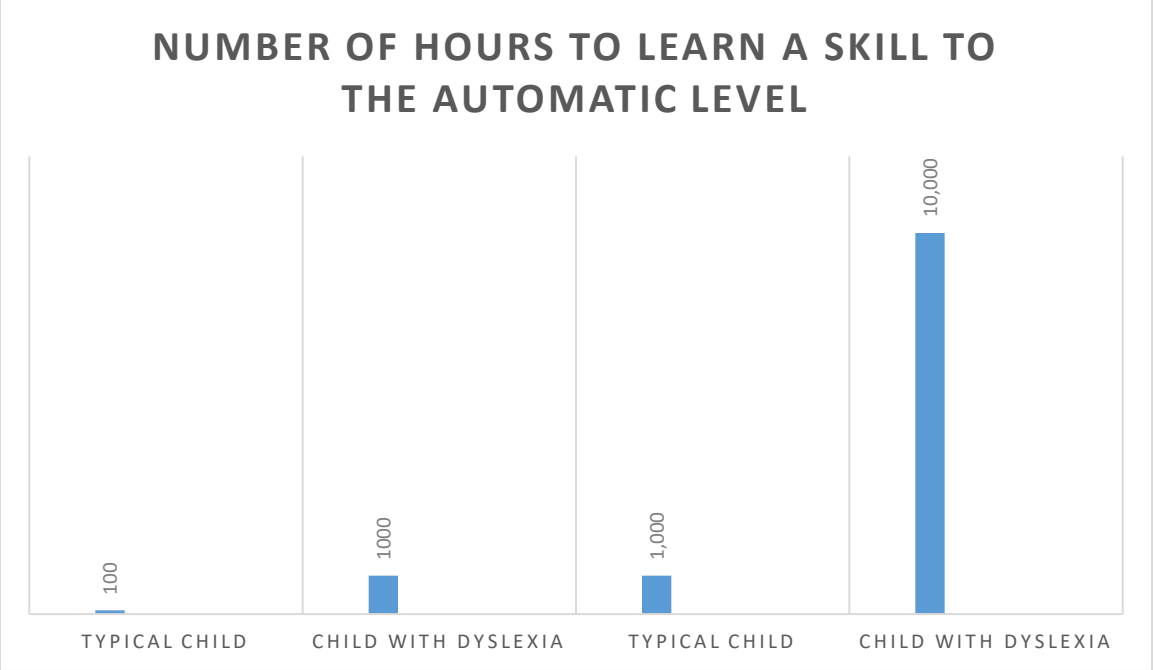


Figure 8

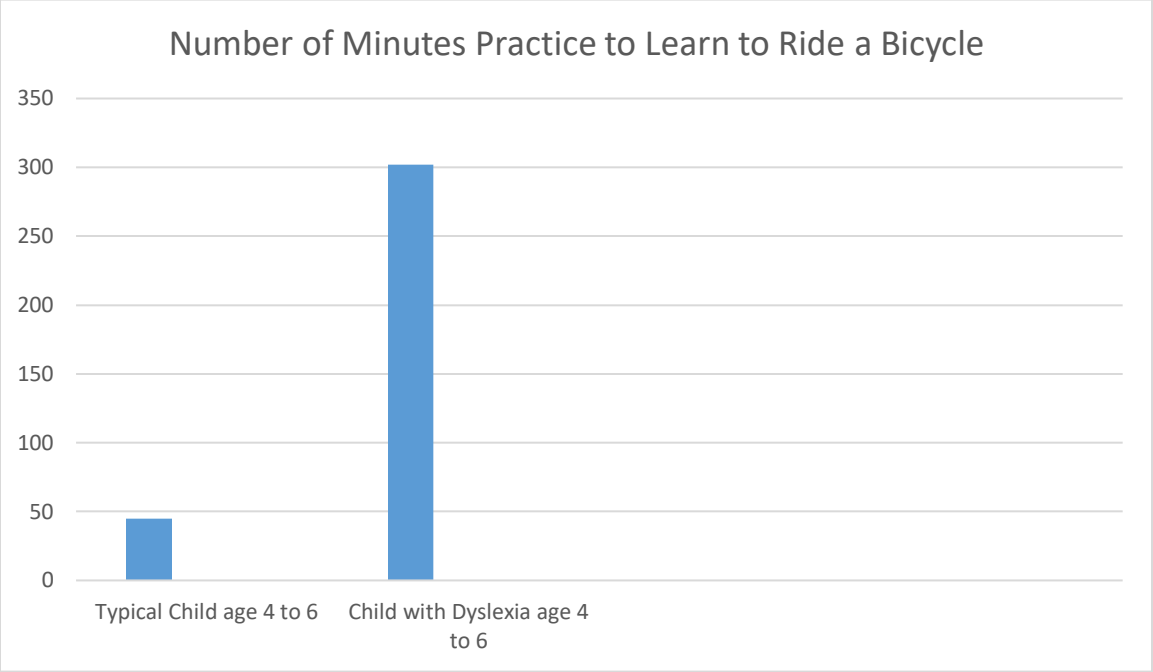
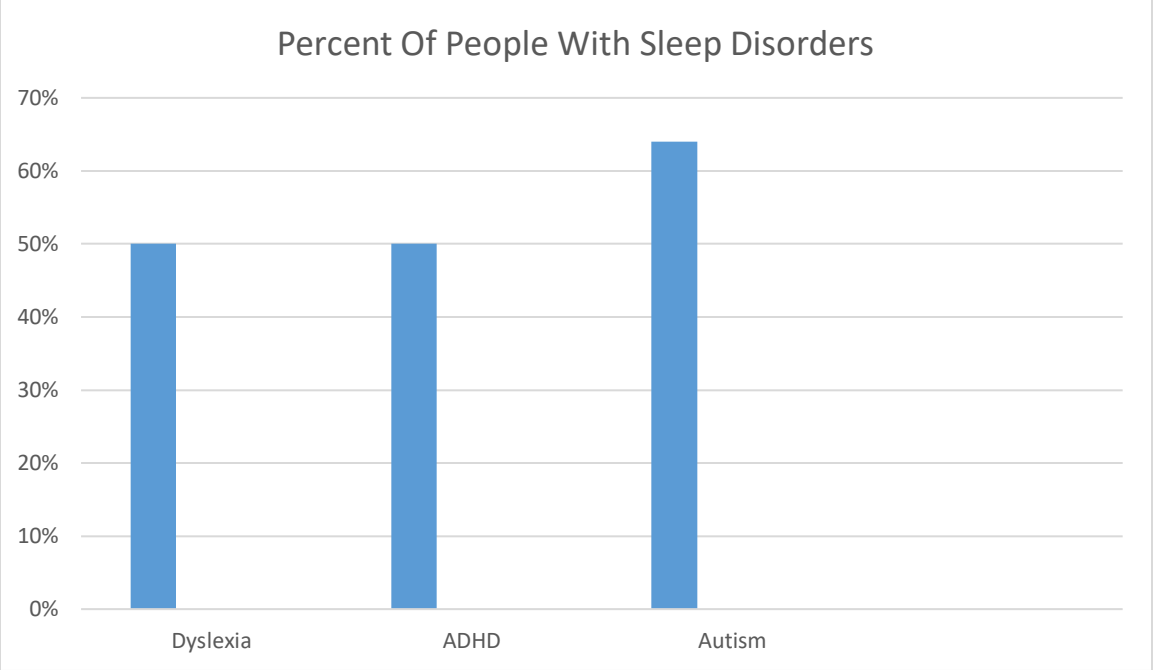


Figure 9



Please note: The percentage of those with autism spectrum disorder with comorbid sleep disorder represents the low range of the estimate. The upper range reaches 93 percent.