Dyscalculia: Disability of Mathematics

Randall Hall
GLOBAL LIFE SCIENCES INSTITUTE

Summary

The purpose of this white paper is to furnish Global Life Sciences (GLSI) with a literature review of the current research for possible treatments of dyscalculia and to recommend an avenue of a future treatment model along with providing research that could potentially benefit the health of millions of people worldwide. Dyscalculia, a learning disability similar to dyslexia but with numbers, can create equity issues both in and out of the classroom. People who have dyscalculia can quickly become frustrated by learning arithmetic or just by numbers in general. This frustration can lead to a high number of people disliking numbers because they are unable to perform arithmetic as easily as others. As a result, people will give up too easily and grow to hate mathematics.

An individual with dyscalculia realizes five plus three equals eight, but they may not realize that three plus five equals eight. Even though the two expressions equal each other, they may not realize that addition is commutative and so that the order of the numbers does not matter. The commutative property is just one example of an abstract concept that not everybody may get at first, but when concepts such as commutatively is explained using manipulatives or visuals, individuals pick abstract concepts up quickly.

Dyscalculia is primarily an issue in education but can indirectly cause issues in the lives of children and adults. The prevalence of developmental dyscalculia may be equivalent to that of dyslexia, posing an important challenge for effective educational provision (Devine et al. 2013). Dyscalculia is an issue because it creates a student equity issue within the classroom. Dyscalculia leaves the child very confused when they perform mathematical operations leaving them unable to grasp the concept despite how hard they try.

Dyscalculia affects anywhere from 3.5%-6.5% of the student population (Morsanyi et al. 2013). Treatment helps people with the disability to become less frustrated at numbers and helps them become less likely to make mathematical mistakes in disciplines such as finances, science, etc. The success rate of the current models used are moderate; therefore, there is a greater need for research in current ways to help reach success. The higher the success rate of dyscalculia treatment, the more positive effects the individual can have in their life and their education.

When an individual has dyscalculia, the individual may feel like no matter how hard they try; they do not feel that they are looked upon as smart and able to perform at the same level that the rest of society is. When this happens, the individual may show signs of frustration and anger that contribute to the mentality that they should give up because they cannot easily grasp a mathematical concept. People with dyscalculia especially exhibit these thoughts when they are in a group. This happens because the general opinion of a person with a learning disability is that they are not smart and capable of being a contributing member of the group (Grover 1994).

Arithmetic involves recognizing numbers and symbols, memorizing facts, and understanding abstract concepts like place value and fractions. Any of these may be difficult for children with developmental arithmetic disorders, also called dyscalculia. Problems with numbers or basic concepts are likely to show up early.

Background

Dyscalculia, a learning disability involving numbers that is similar to dyslexia, can cause education difficulty in any sort of class where any abstract topic of mathematics is involved. Dyscalculia is defined as the impaired ability to learn grade-appropriate mathematics. Dyscalculia comes from Greek and Latin which means: “counting badly.” The prefix “dys” comes from Greek, which means “badly” and “calculia” comes from Latin “calculare,” which means “to count.” Moreover, dyscalculia is a specific learning disability involving innate difficulty in learning or comprehending arithmetic. Furthermore, since dyscalculia is innate,|it is difficult to understand numbers, how to manipulate numbers, learning math facts, and various other analogous symptoms.

Dyscalculia is generally defined as a disability in mathematical abilities presumed to be due to a specific impairment in brain function (Kosc, 1974; Shalev & Gross-Tsur, 1993, 2001). Additionally, dyscalculia is often existent with no indication of any other learning disabilities being present (Ashkenazi et al. 2013). Math disabilities often are present in children with generally low Intelligence Quotients (IQs); however, dyscalculia can also occur in people with IQs that cover the whole IQ range. People with any IQ often suffer from having difficulty with time, measurement, and three-dimensional space reasoning but this is not always the case. People with dyscalculia have difficulty grasping math concepts and solving simple math problems despite adequate education. Furthermore, the individual has an impaired ability learning grade-appropriate mathematics. A person who struggles in mathematics does not imply that they have dyscalculia. All people are born with different strengths and weaknesses; just because a person struggles in a certain area does not mean they have such an impairment associated with a particular area. Mathematics is a discipline that takes time and practice for problems involving formal math procedures to make practical sense to people. Everyone struggles with something, and you cannot gauge someone’s ability to do something based on how fast or how slow they perform at something.

State of the Science

With every condition that affects a human being, there are several warning signs that a person who exhibits dyscalculia shows or has at different age levels. If a young child has difficulty learning to count and trouble to recognize printed numbers; difficulty relating together the idea of a number to how it exists in the world, or they have trouble organizing things in a logical way then most likely they have dyscalculia. If a student that is of age to be in school has trouble learning math facts and difficulty developing problem-solving skills; a poor memory for math functions, not familiar with math vocabulary, or avoid games that require strategy then they probably have dyscalculia. If a teenager or an adult have trouble estimating costs like groceries, difficulty learning abstract math concepts; reduced ability to budget, trouble with mental math and abstract concepts then they probably have dyscalculia.

Identifying a child who has dyscalculia can be incredibly difficult because a student who has difficulty learning math skills does not necessarily mean that the child has a learning disability. Everyone learns at a different pace; it takes time and practice for people for formal math procedures it makes practical sense especially for young people. In light of the notion that identifying a child with this condition is quite difficult, a person may benefit from additional help and may have dyscalculia if the individual exhibits any of the following:

- Good at speaking, reading, and writing, but slow to develop counting and math problem-solving skills.
- Good memory for printed words, but difficulty reading numbers, or recalling numbers in sequence.
- Good with general math concepts, but becomes frustrated when specific computation and organization skills need to be used.
- Encounters trouble with the concept of time-chronically late, difficulty remembering schedules; trouble with approximating how long something will take.
- Poor sense of direction, easily disoriented and easily confused by changes in routine.
- A reduced long-term memory of concepts, in other words, can do math functions one day but is unable to repeat them the next day.
- Poor mental math ability – trouble estimating grocery costs or counting days until vacation.
- Some difficulty playing strategy games like chess, bridge or role-playing video games.
- Some difficulty keeping score when playing board and card games.

This list is not comprehensive and in no way should be used to diagnose a child because every child has their strengths and weaknesses. Furthermore, just because a student struggles with a math concept does not mean that they have dyscalculia. Moreover, a person only has dyscalculia if they show clear signs that they cannot retain a procedure to do a math problem on a day-to-day basis or they struggle with an abstract concept; however, the above list should be used as a guideline to see if an individual needs to seek additional help.

Identification of Dyscalculia

A learning disability is usually hard to identify; however, an individual is usually tested for a learning disability by a teacher or a trained professional. That said, it is difficult and ill-advised for a person who does not teach nor have any qualifications in the field of educational psychology to test an individual for a learning disability. Furthermore, a qualified individual interviews the individual, who is thought to have a learning disability, over the whole field of mathematics and skills associated with mathematics. The interview usually involves a pencil and paper test; however, an evaluation for a learning disability goes beyond basic arithmetic. The evaluation is meant to reveal how a person understands and uses numbers along with math concepts to solve advanced-level problems as well as everyday situations. The evaluation compares a person's expected and actual levels of skills and understanding while taking into consideration the person's specific strengths and weaknesses. The following areas may be addressed in the evaluation:

- Ability with basic math skills like counting, adding, subtracting, multiplying and dividing
- Ability to predict appropriate procedures based on understanding patterns - knowing when to add, subtract, multiply, divide or do more advanced computations
- Ability to organize objects in a logical way
- Ability to measure-telling time, using money
- Ability to estimate number quantities
- Ability to self-check work and find alternate ways to solve problems.

While some types of dyscalculia are present from birth or at an early age, other types are acquired as a result of a brain injury. Furthermore, we have no clue where developmental dyscalculia comes from; however, research does suggest that developmental dyscalculia is a disability of genetic origin (Ashkenazi et al. 2013). At the moment, there is currently no way to diagnose dyscalculia since some types are present from birth accurately; however, an evaluation can be done to study the effects of dyscalculia. This sort of retracing is much more difficult because there are other factors involved in the difficulty of math. The following reasons are all valid for the difficulty of math:

- Inadequate instruction.
- Lack of motivation
- Attentional disorders
- Anxiety disorders
- Mental retardation

Currently Designed Methods

There is no current cure for dyscalculia; however, it is possible that children may outgrow of some types of dyscalculia that involve difficulty learning sequences and strategies (Geary, 1993). It is important, therefore, to seek help as the individual needs special assistance in order to catch up on mathematics. Most of the current methods designed to help the individual are quite effective as they provide concrete examples, based on prior knowledge, in lieu of them making sense of a new arithmetic with new numbers or a new problem with different ideas. Helping an individual identify his or her strengths and weaknesses is the first step to getting help. Following a diagnosis of dyscalculia, the individual can work with an educator or a learning disability professional to establish strategies that will help the student learn math more effectively. Daily tutoring lets the student and the professional focus on the difficulties that the individual is having and takes the pressure off moving to new topics too quickly. Repeated reinforcement and specific practice of straightforward ideas can make understanding easier. Other strategies for during and after tutoring can include:

- Using graph paper for the individual who has difficulty organizing ideas on paper.
- Work on finding different ways to approach math facts; i.e., instead of memorizing the multiplication tables, explain that eight times two is 16, so if 16 is doubled, eight times four must equal 32.
- Practice estimating as a way to begin solving math problems.
- Introduce new skills beginning with concrete examples and later moving to more abstract applications
- For language difficulties, explain ideas and problems clearly and encourage students to ask questions as they work.
- Provide a place to work with few distractions along with having pencils, erasers, and other tools on hand as needed.

The most incredible thing is that students with a learning disability are known to think outside the box. Thinking outside the box is essential for generating a group or class discussion on a topic, and it might lead to a more concrete understanding of the concept or topic being discussed. Students with learning disabilities are encouraged to become aware of their strengths and weaknesses. Students that become aware of their strengths and weaknesses that can translate into them understanding how they learn best. Knowing how they learn best is a big step in achieving academic success and confidence. As with every learning disability, there many alternate strategies a teacher or a student can employ to assist the student with their condition. An alternate strategy could be repeated reinforcement of a certain topic. Even though the student may find this strategy tedious, reinforcement is essential to get familiar with the essence of mathematics. Teachers could provide graph paper to students who have difficulty organizing their ideas on non-graph paper. Either the teacher or the student could work on finding different ways to approach math facts instead of memorization (NCLD 2013). Many other alternate learning strategies can help a student perform better in the classroom. Just because a student has a particular learning disability does not mean they cannot actively participate in the classroom; a way must always be found for the classroom to be an equitable learning environment for all students

Future Research Needs

As previously mentioned, dyscalculia is congenital present from birth, and it may be possible to determine the origins of dyscalculia with future research. Unfortunately, the evaluation might be inconclusive as the afflicted individual may have additional learning difficulties or additional disorders. Additional learning difficulties or additional disorders may include:

- Attentional disorders such as Attention Deficit Disorder (ADD) or Attention Deficit Hyperactive Disorder (ADHD)
- Anxiety Disorders
- Mental retardation

Apart from alternate learning strategies, another way to lessen the effect of dyscalculia is to conduct Trans-Cranial Direct Current Stimulation (TCDS) to part of the brain called the Parietal lobe, which can be found in **Figure 1** located below. The process sends a milliamp of electricity, through tiny electric impulses, to the Parietal lobe and stimulates the part of the brain damaged at birth. While this shock will not increase the ability to perform math procedures a significant amount, ability at math procedures will increase a good amount.

Sending an electric shock to the Parietal lobe is quite possibly the best research need that is worth looking into. The Parietal lobe plays important roles in integrating sensory information from various parts of the body, knowledge of numbers and their relations, and in the manipulation of objects. The Parietal lobe's function also includes processing information relating to the sense of touch. Damage to the right hemisphere of the Parietal lobe results in the loss of imagery and visualization of spatial relationships. Damage to the left hemisphere of the Parietal lobe will result in problems in mathematics, long reading, writing, and understanding symbols.

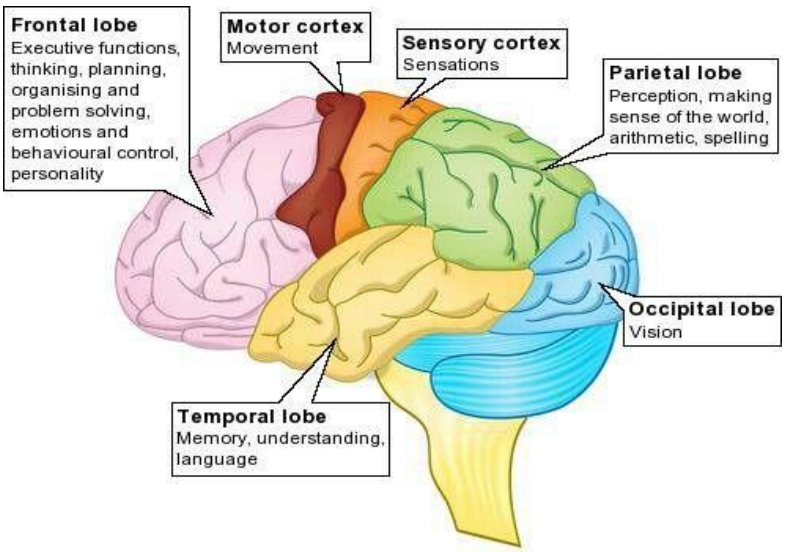

Figure 1 Lobes of the brain and their function. Reprinted from The Lobes, of the Brain on Pinterest. Retrieved March 22, 2014

TCDS can easily be implemented in a few years and is the most effective as the effects of TCDS are immediate and long lasting. TCDS should not be confused with Electroconvulsive Therapy (ECT) as ECT uses pulses of 800 milliamps of electricity to induce convulsions whereas TCDS uses one milliamp of electricity and is far less invasive. TCDS is used for stimulating connectivity between two brain regions, in this case, the left and right Parietal lobes. Connecting these two sides of the parietal lobe would be efficient as the Parietal lobe is used for understanding mathematics, mathematical symbols, and imagery of procedures. Other brain functions will not be affected by such a small electrical shock; however, the patient will feel the shock for about 10-15 seconds. The effects of the Parietal lobe being stimulated is predicted to be worthwhile in curing dyscalculia. The effects of TCDS are long lasting, and while the overall effect may wear off eventually, the mathematical ability will not be significantly lower than immediately after the shock. The shock certainly will not make the individual the next Albert Einstein; however, it will allow the individual to boost their mathematical ability to compensate with what ability they do not possess. Moreover, different parts of the brain, when stimulated, can perform better than before. For example, the area that is associated with mathematical ability, if stimulated, the functions could be heightened. Currently, scientists do not understand how electrical stimulation enhances mental abilities, but one possibility is that the current influences brain chemicals called neurotransmitters. The structure of a neurotransmitter can be found below in **Figure 2**.

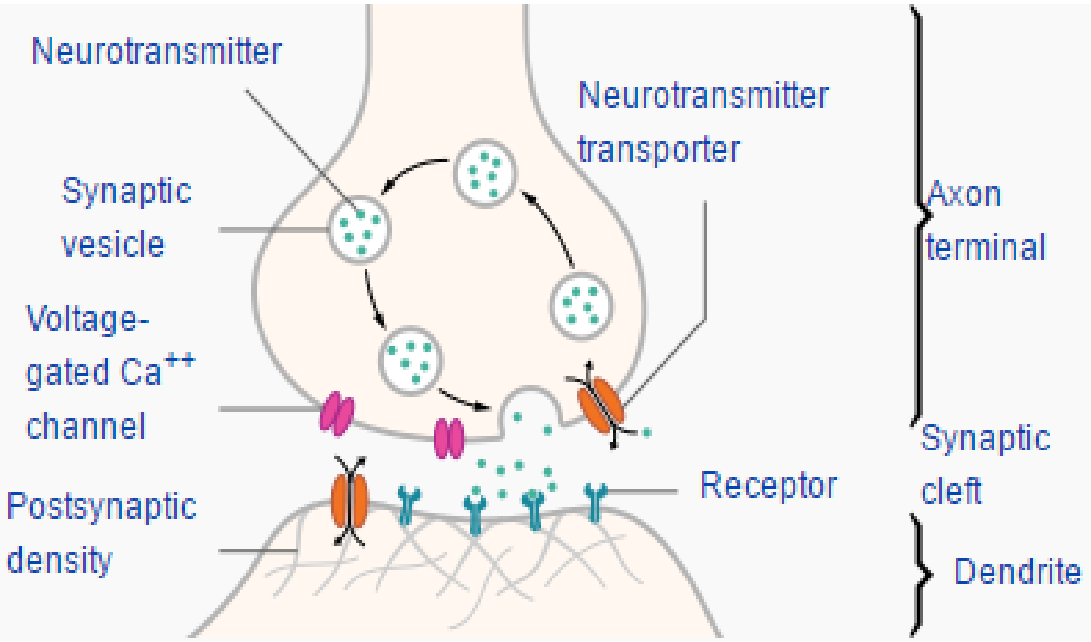

Figure 2 Chemical Synapse Reprinted from Structure of a typical chemical synapse on Wikipedia. Retrieved March 22, 2014

Neurotransmitters are chemicals that transmit signals across a synapse from one brain cell to another brain cell. A synapse is a structure that permits a nerve cell to pass an electrical or chemical signal to another cell. As a result, when a person has dyscalculia, these neurotransmitters may slow down or do not pass the synapse, i.e., not performing their neurological function correctly. With electrical stimulation, the electrical current will stimulate the neurotransmitter causing the neurotransmitter to do its job correctly. TCDS could lead to new, long-lasting treatments for people with moderate to severe math impairments such as dyscalculia.

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