Developmental Dyscalculia

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What is dyscalculia?

First, a brief history of the term: while *dyscalculia* has been used since the 1980s, *developmental dyscalculia (DD)* or *math learning disabilities* is typically how the disability is referred to in the more recent literature (e.g. De Smedt, Peters, & Ghesquière, 2019; Rubinsten & Tannock, 2010), and the DSM-5 calls it a *specific learning disability with impairment in mathematics* ("Neurodevelopmental Disorders", n.d.). For the rest of this paper, I will use the term *DD*.

DD is a learning disability (LD) that severely impacts a student's ability to learn and do math. The DSM-5 criteria for a referral or diagnosis for DD requires that a student have problems with number sense, memorizing math facts, performing calculations, and/or mathematical reasoning (e.g. being able to do ballpark estimates). These problems cannot be "better accounted for by . . . other mental or neurological disorders . . . or inadequate educational instruction" ("Neurodevelopmental Disorders", n.d.)—so, for example, a problem with memorizing math facts that can be better explained by general memory problems would preclude a diagnosis.

DD occurs at a rate of about 4–6% (Von Aster & Shalev, 2007) and appears to be equally prevalent among boys and girls (Devine, Soltész, Nobes, Goswami, & Szűcs, 2013; Pandey & Agarwal, 2016). It is also an inherited trait (Alarcón, DeFries, Light, & Pennington, 1997).

The causes of DD are not well understood; however, because it is inherited, it is likely that there is some genetic component. Imaging studies (De Smedt et al., 2019) show differences in the frontoparietal lobes of subjects with DD compared with neurotypical subjects, but whether these differences are innate and cause DD, or are acquired and are symptomatic of DD, is unclear.

Websites

For parents navigating the world of DD (or any LD) with their child, I recommend *Understood: For Learning and Attention Issues* (n.d.). *Understood* is a nonprofit whose mission is to help parents of children with LD and ADHD diagnoses understand their children and their needs. They have a wealth of research, regular online chats with experts, and even simulations to approximate the experience of having an LD.

Their information is extremely well-researched, clearly and succinctly presented, and well organized. The website itself is very easy to navigate and search. And it is useful not only to parents, but to teachers; while their primary target is parents, they also have many resources for working with students in the classroom in their *Understood for Educators* (n.d.) section.

This website is very special because it focuses on the whole child—both their unique academic needs, and their unique emotional and social needs. And because *Understood* is not DD-specific, it has a wealth of valuable information about ADHD, emotional disorders, and other LD. DD is frequently comorbid with other conditions, including dyslexia and ADHD (Butterworth, Varma, & Laurillard, 2011), and *Understood* has information on both those and much more, making it a kind of one-stop shop for parents seeking information on how best to parent and advocate for their child.

The advocacy-specific resources on *Understood* are just as thorough as their education-specific ones. They have pages on special education laws, on what FAPE entails, and even on negotiation tactics. I wish that a page on negotiation tactics were not necessary, but I also know that it can be *invaluable* to parents, especially parents in private schools[1].

Unfortunately, some websites appear to be less useful for a parent or teacher seeking introductory information. *Dyscalculia.org* (Hamilton-Newman, n.d.) shows up early in a

[1] No formal citation on this, but feel free to ask my mom about when we sent my sister to Catholic school. She's a very evidence-driven instructional design person; you two would probably get on like a house on fire.

Google search, but I would not recommend it as a starting point. The site is extremely busy and difficult to navigate, and the resources it provides are poorly organized, only occasionally helpful, and for no specific target audience (for instance, when looking for resources on remediation, your first reference is to a school in Berkshire, UK, while the website appears to be based in Michigan).

The most troubling aspect of the website, however, is that it frequently asks for money. The "Diagnosis" section of the website does not explain the general process of obtaining a diagnosis, but a specific process of obtaining a diagnosis from the site creator. Similarly, when looking for "Best Tools," the solutions from the site creator are (1) prominently displayed and (2) cost money. While the website does appear to contain *some* useful information, and while many important services for kids with LD cost money, I worry that a concerned parent could be taken advantage of. *Dyscalculia.org* seems to be more of a for-profit operation than I would ever suggest to a parent, especially a parent making sense of a recent diagnosis.

Intervention Strategies

One of the traditional intervention strategies for students with low mathematical ability (not necessarily DD) is essentially targeted tutoring. Multiple studies (e.g. Re, Pedron, Tressoldi, and Lucangeli (2014)) have demonstrated that this can be very effective, both for students with DD and students without DD who still need extra help. These interventions may be one-on-one or in small groups (Monei & Pedro, 2017), and involve a variety of tactics and technologies, depending on the needs of the student.

Manipulatives are a very popular technology in math-related interventions. These are simply objects used to represent quantities. They may be simple objects, like beans or buttons, or specially-designed objects, like stackable blocks and fraction pies. Manipulatives have been shown to provide long-term gains in mathematical ability (Cass, Cates, Smith, & Jackson, 2003); however, using them effectively requires extra effort from

teachers, and may even require special training or meeting with a specialist (Butterworth et al., 2011).

For instance, students with DD tend to have difficulty subitizing, or breaking quantities down into groups (Butterworth, 2008). So, if a student presented with two groups of five beans, they would need to count each individual bean to say that there are ten there. It is not enough to present them with two groups of five beans, to give them manipulatives; *how* that lesson is run, and how the knowledge is assessed and reinforced, is the most important factor.

Fortunately, teachers wanting to use manipulatives don't have to go in blind. The companies that make the manipulatives have lesson plans to accompany them, and websites like *Math for Love* (n.d.) and *National Council of Teachers of Mathematics* (n.d.) have further resources on theory and implementation. There are manipulatives that look like money; there are manipulatives designed specifically to teach place value, fractions, addition, and subtraction; there are virtual manipulatives, such as NumberBeads (Laurillard, 2016), in which students can drag, drop, slice, and meld strings of beads to develop their ability to subitize. Because of the wide variety of manipulatives, there is no one way to implement them, so it is important that teachers familiarize themselves with the specific manipulatives they plan to use and are conscientious as they plan their lessons with them.

Students with DD can struggle not just academically, but also emotionally. They can develop math anxiety (Rubinsten & Tannock, 2010; Passolunghi, 2011) because general education math classes do not meet their needs, and so they consistently underperform. Butterworth (2008) included interviews with 9-year-olds with DD about their experiences in math class:

> Child 5: It makes me feel left out, sometimes.
>
> Child 2: Yeah.
>
> Child 5: When I like—when I don't know something, I wish that I was like a

clever person and I blame it on myself—

Child 4: I could cry and wish I was at home with my mum and it would be—I won't have to do any maths.

It is clear that, from purely a mental health standpoint, interventions to alleviate these students' anxiety are absolutely necessary. But there is a further, more pedagogical motivation here, too: anxiety strongly affects academic performance and working memory (Mammarella, Hill, Devine, Caviola, & Szűcs, 2015), so addressing it will both help student take care of themselves and learn more effectively.

Fortunately, many interventions for other anxiety are shown to work well for students with math anxiety. Practices rooted in mindfulness, like focused breathing exercises Brunyé et al. (2013), and other therapeutic practices, like expressive journaling (Park, Ramirez, & Beilock, 2014), have been shown to both allay students' fears about math and improve their performance on math assignments.

The focused breathing exercise that Brunyé et al. (2013) used in their study was a simple mindfulness routine, in which, as a person breathes, they focus on the sensation of breathing: the feeling of the breath in their nostrils and lungs, the movements of their chest and belly.

There are many other structured breathing exercises that have been shown to alleviate anxiety, such as guided visualizations (like keeping an imaginary feather aloft with your breath) and four-corner or tactical breathing: breathe in for four seconds, hold for four seconds, breathe out for four seconds, hold for four seconds. Teachers looking for resources on breathing exercises can look to apps like *Stop, Breathe & Think*, which has kid-friendly meditations and many resources for educators (*Stop, Breathe & Think*, n.d.), or websites like *Coping Skills for Kids* (Halloran, n.d.).

To implement expressive journaling with their students, Park et al. (2014) asked students to "write as openly as possible about your thoughts and feelings regarding the math problems you are about to perform.. . . really let yourself go and explore your

emotions and thoughts.... Please try to be as open as possible as you write." They then allowed students to freewrite for seven minutes before they completed a math assignment.

Of the students with math anxiety, those who were highly expressive about their anxiety had higher performance gains than those who used less specific language, and all of those who journaled did better than those who did not. This suggests that emotional honesty is key to this process; therefore, teachers who want to implement this intervention should emphasize to students that no one else will read their journals, or that they will be anonymized. This way, students may feel safe enough to express themselves.

Any teacher wishing to introduce a strategy to help students' anxiety should do so carefully; well-meaning but poorly-executed exercises don't help anyone. Teachers should both educate themselves on anxiety conditions (*Understood* and *Coping Skills for Kids* are both good resources) and consult with their school's counselor or another specialist on how to most effectively implement any therapeutic strategies.

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