Dyscalculia: A brief literature review

Children all over the world can count objects, understand the idea of greater than or less than, and recognize patterns. This happens naturally, as part of cognitive development-- except when it does not. For some children, the parietal lobe in the prefrontal cortex of the brain has weakened neurological connections; mathematical thinking develops slowly and with great difficulty (Butterworth, Varma & Laurillard, 2011; Geary, 2011; Price & Ansari, 2013). This Specific Learning Disorder is called dyscalculia. People can be born with dyscalculia (developmental dyscalculia, or DD) or they may develop it after a brain injury (called acquired dyscalculia, or AD); in both cases, this is a condition that can be accommodated, but not treated (Butterworth, Varma & Laurillard, 2011; Geary, 2011). Children with dyscalculia persistently perform in the lowest-achieving groups in math class, reporting difficulties learning how to tell time, estimate, or remember basic math facts (Butterworth, 2005; Kaufmann, et al., 2013; Shalev & Gross-Tsur, 2001). There are few well-researched interventions or accommodations that are known to help these students, making dyscalculia frustrating for educators and students alike.

In 2013, researchers Price and Ansari compiled studies of dyscalculic students at various grade levels. They found that the earliest recognizable feature of a potential developmental dyscalculia (DD) diagnosis is a lack of known math facts by the end of grade 2 (Price & Ansari, 2013). Typically developing children can recall up to three times as many facts as those with DD; atypical children may not develop sophisticated counting methods at the same rate as their peers; atypically developing students also have more trouble linking number of objects to word form of those numbers (Price & Ansari, 2013). Currently little research exists to show potential relationships between early screening, targeted interventions, and future math achievement.

Dyscalculic students show math deficits in many areas. The nature of the disorder involves the degeneration of learned information over time (Butterworth, Varma & Laurillard, 2011; Price & Ansari, 2013; Shalev & Gross-Tsur, 2001). Dyscalculics have low numeracy skills and lack Subitization: the ability to estimate quantities when looking at a group of dots (Price & Ansari, 2013). People with dyscalculia will count each of the dots, every time, due to delayed development of automatic counting methods (Butterworth, 2005; Bélanger, 2011). Sophisticated algorithms for performing mathematical operations develop slowly or not at all.

Additionally, the Approximate Number System (ANS), an important foundation of all math skills, is weak or underdeveloped in people with dyscalculia (Butterworth, Varma & Laurillard, 2011; Shalev & Gross-Tsur, 2001). In a 2004 study conducted by Landerl, Bevan, and Butterworth, dyscalculic students (n=10) were compared to non-dyscalculic students (n=18) in a battery of math-related tasks. They found a statistically significant difference between the two groups in three areas: in solving addition, subtraction, and multiplication questions; in median response times; and in two-digit number naming (Landerl, Bevan, & Butterworth, 2004). Dyscalculics tend to have multiple deficit areas that need to be addressed, making treatment of dyscalculia difficult.

While researchers debate a core deficit model (Butterworth, 2005) versus a mixed bag of deficits (Geary, 2011), at the heart of dyscalculia lies persistently low number acuity—the ability to mentally estimate amounts correctly. The Approximate Number System handles this task; for people with dyscalculia, it is difficult to know which set of dots contains more objects due to deficiencies in the ANS (Figure 2) (Butterworth, Varma & Laurillard, 2011). Shalev & Gross-Tsur (2001) conducted an experiment to test number acuity in children in kindergarten (n = 44), at 10 years old (n = 54), and adults (n = 20) with and without dyscalculia. Participants were shown a series of images (Figure 2) and had to choose which circle contained more objects (Shalev & Gross-Tsur, 2001). The number of dots pairings remained consistent throughout the experiment; for example, the first circle always contained 16 dots and was paired with a circle containing either 12, 13, 14, 15, 17, 18, 19, or 20 dots (Shalev & Gross-Tsur, 2001). While the pairings were consistent, the physical presentation of the dots varied: they could have been clumped together, spaced far apart, or drawn using small or large dots (Shalev & Gross-Tsur, 2001). Responses were tallied for accuracy as well as for speed. Participants with dyscalculia scored significantly worse on number acuity tests, in all age groups; in fact, 10-year-old dyscalculics had number acuity scores at the same level as kindergartners without dyscalculia (Shalev & Gross-Tsur, 2001). However, in each age group, dyscalculics matched mean response times with non-dyscalculics (Shalev & Gross-Tsur, 2001). These findings show that students with dyscalculia might answer a math question in the same amount of time as typically developing children, but they more than likely have the wrong answer and do not understand why.

- Honora Wall, 2021. *Parts of this position paper were rephrased from the author's dissertation for an Ed.D. program.*

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