THE
SECRET
EXECUTIVE
DIRECTOR
OF READING

EXECUTIVE FUNCTIONS

What are they, how are they related to reading, reading difficulties and reading remediation?

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Every proficient reader was once a beginning reader, learning the alphabetical system, step by step.

For proficient readers, the ability to translate automatically abstract shapes (letters) to sounds in the spoken language (an ability we call "reading") is automatic and effortless. Even the recognition of words, holistically, without reading each of the letters, is done automatically for most frequent words, even when flashed rapidly [1]. Most commercials rely exactly on this ability when flashing words on television, road signs and more. However, every proficient reader was once a beginning reader, learning the alphabetical system, step by step. In the reading acquisition stage, reading is not as easy and automatic and demands several critical components to achieve fluent and accurate reading: the first is phonological processing: the ability to identify the smallest parts in the spoken language (i.e. phonemes) [2] and executive functions (EF) [3].

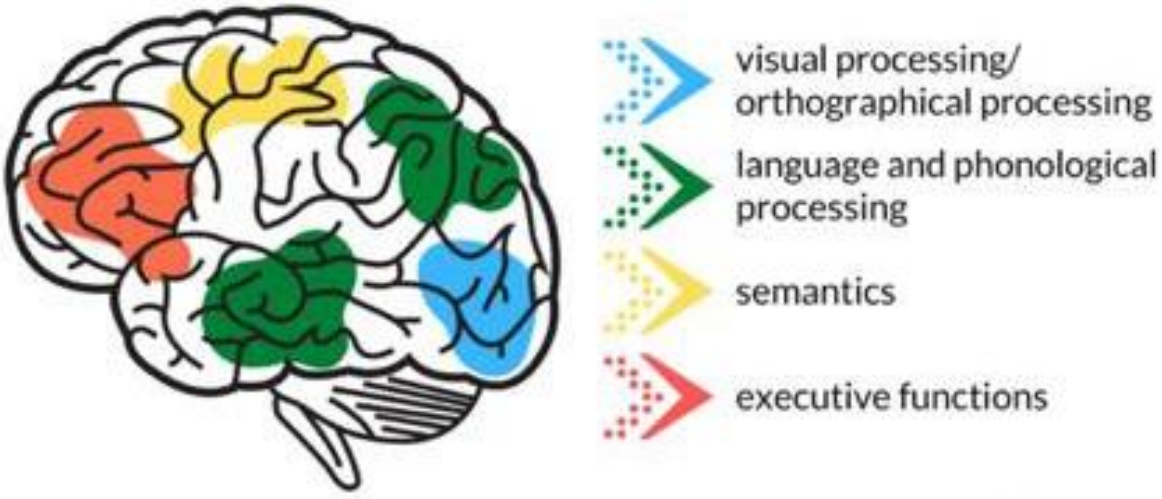
Executive functions are a set of cognitive abilities that support learning, not just related to academia but also in our everyday life [4]. Executive functions is the "title" for several sub-cognitive abilities, including the ability

- to track an object with our eyes (i.e., visual attention)
- to attend an auditory signal (i.e., auditory attention)
- to remember what we are currently doing and why and manipulate this information (working memory)
- to respond (or avoid doing so; inhibition) and move from one activity to the other (switching)
- to learn from our mistakes (error detection), and many more.

These abilities develop early in life (not all together, though); visual attention develops first [5, 6] and supports the child in exploring the environment. With age, when the child needs to allocate their attention for longer periods of time (e.g., in kindergarten, when the child learns the alphabet and corresponding sounds), the reliance on EF becomes more robust. As a matter of fact, EF plays a critical role in reading acquisition until reading becomes automatic (i.e., fast and accurate) [7]. Later in life, executive functions are used for reading comprehension and higher-order text inference [8]. Several scientific papers showed how typical reading at the age of 11 years is related to an intact activity of brain regions associated with EF at the age of 5 years [9].

SO, IS READING SO EASY AND INTUITIVE TO EVERYONE?

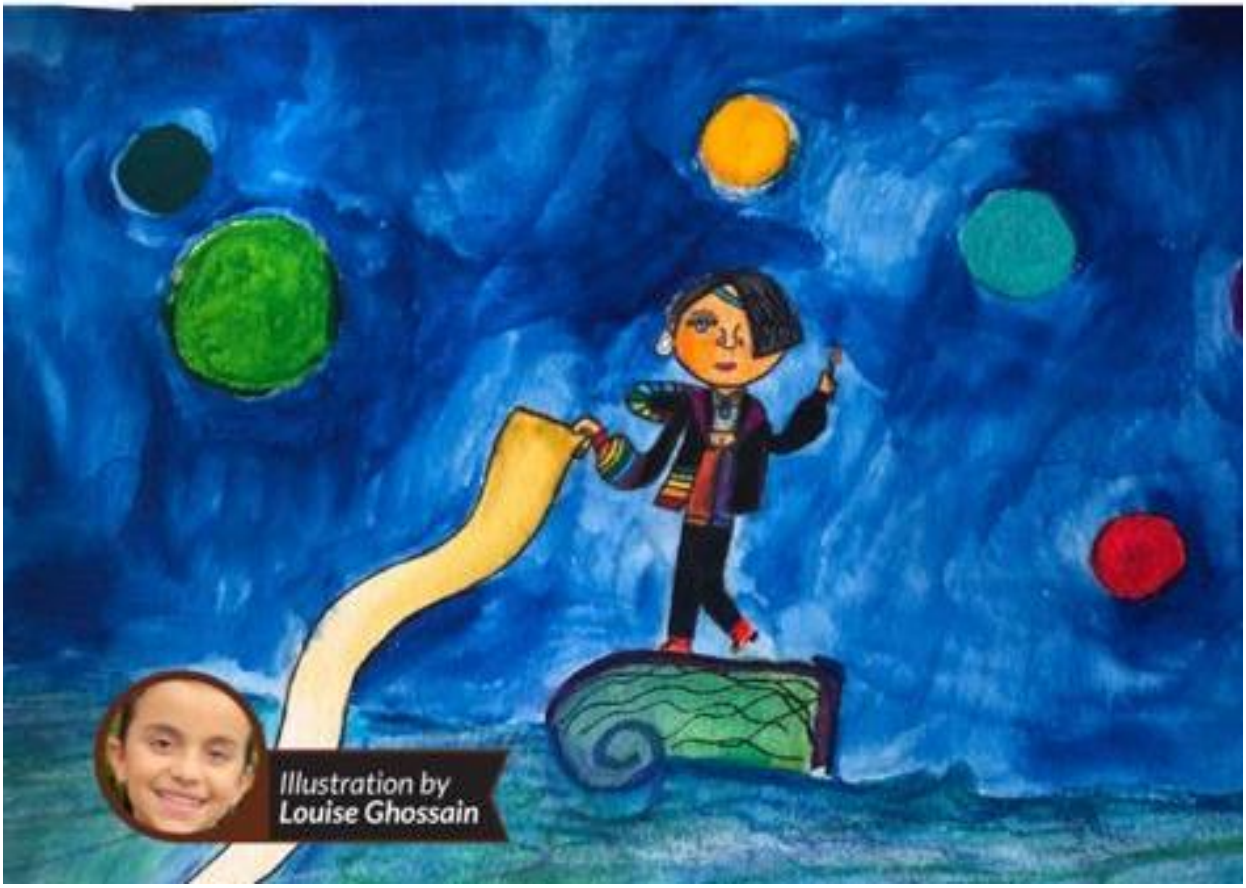
Unfortunately, not. About 10-15% of the population suffer from reading difficulties that is not attributed to lower intelligence or lower exposure to literacy [10]. This disorder is called dyslexia, and it primarily stems from a phonological deficit [2]. However, there are accumulated studies in the past years suggesting that individuals with dyslexia, both children and adults, also suffer from difficulties in executive functions [3]. These lower executive functions abilities are not specific to when these individuals read but were also found in non-reading tasks, such as in a cards game where the rules are changing, and an adaptation to the new rule is required (also called Wisconsin card sorting game; [11]). Challenges were also found for the Stroop task, a game where the participants are supposed to ignore the written word and only name the color of the print of the word (called 'Stroop') where children with dyslexia showed lower performance and utilized different brain regions than typical readers [12]. These studies provoked several discussions of the need to include EF as part of the reading network, in addition to the classical phonological processing, orthographical, language and semantics [13] and even as part of reading remediation for individuals with dyslexia (as shown below).



The Reading Brain: Brain regions involved in reading process

Tzipi and her son Yair

Several studies have suggested that training executive functions [14] or having an executive functions component to training [15, 16], may improve reading ability in adults and children with dyslexia. One of the assumptions is, that when we train reading together with EF (or with executive function components), we may "synch" the visual and phonological modalities (or brain regions). This often seems not to be working in synch in those with dyslexia, and by that, we may increase the ability to gain from reading training [16]. In a recent study, utilizing a computerized reading training which relies on replacing the letters on the screens with other characters in a faster manner (which triggers visual attention, working memory and speed of processing), we showed how 8-12 years old children with and without reading difficulties improved reading as well as better executive functions.



Interestingly, this training also triggered brain regions related to executive functions, mainly to the ability to monitor errors and those associated with visual attention [17-20]. These studies may suggest that other types of EF-based trainings conducted in preschool or kindergarten (such as Dialogic reading;[21] and Mindfulness [22]) may have long-lasting effects also on reading in schools.

To conclude, executive functions are a set of critical components for learning and intact reading acquisition with evidence of decreased EF abilities in those with reading difficulties. These points need to be considered during the assessment/diagnosis of reading abilities and when determining the appropriate reading intervention to improve reading skills. Extra consideration needs to be taken when discussing reading difficulties in the broad sense, as although dyslexia is a specific difficulty in the reading domain, there are many other clinical populations suffering from reading difficulties (such as those with epilepsy, emotional and behavioral disorders, attention difficulties hyperactive disorder and more, see [23]).

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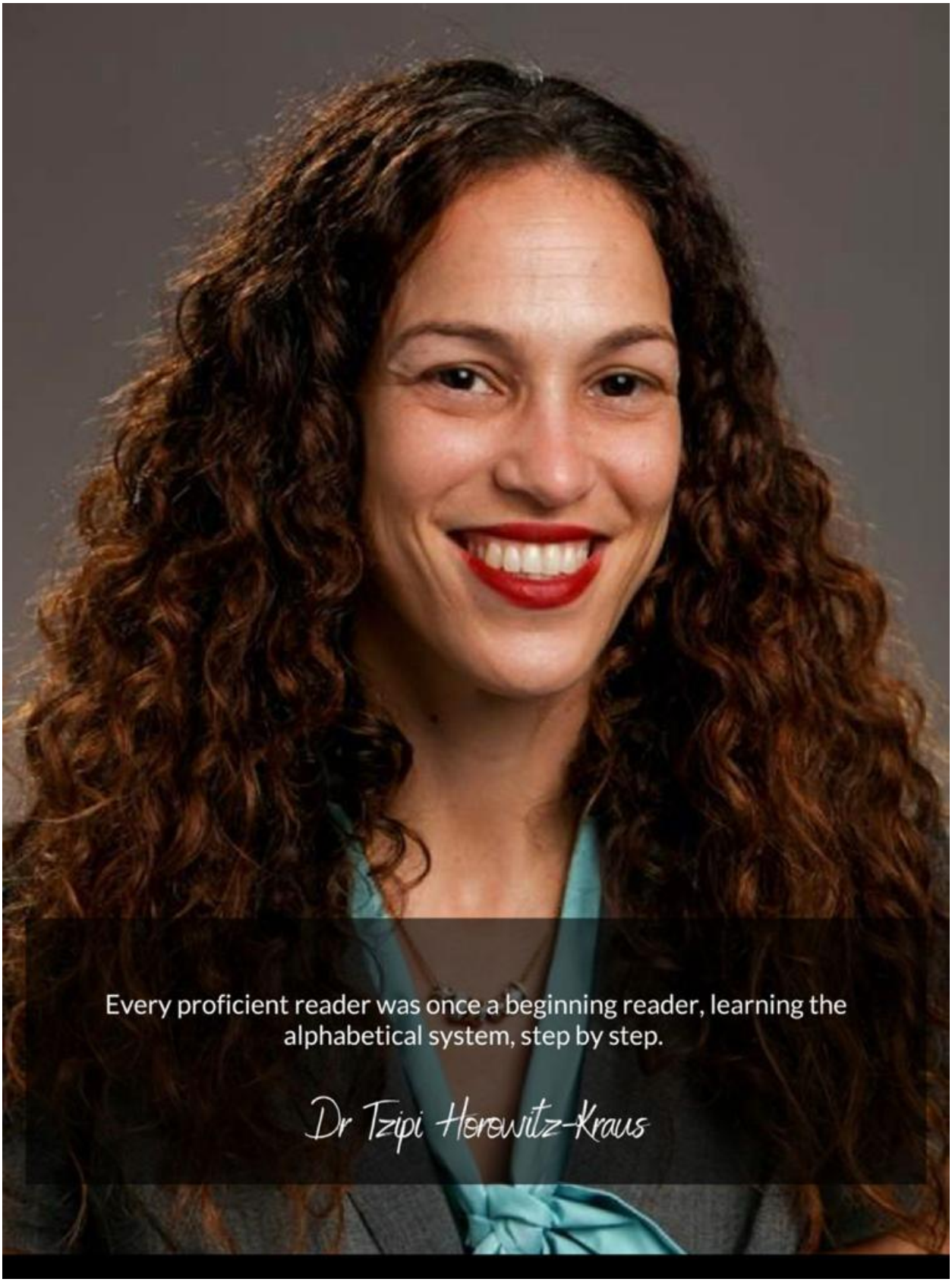
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