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Complementary and Alternative Approaches to Therapeutic Dyslexia Intervention

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Abstract— **Although the prevalence of developmental dyslexia, according to DSM-V, varies from 10 to 15%, a major issue tormenting scientists to date is the lack of consensus on how dyslexia should be diagnosed or treated. Apart from the classical methods used in remedial teaching, popular methods for dyslexia treatment are the alternative and complementary approaches that include perceptual-motor training, visual interventions, auditory interventions, biofeedback and fatty acid interventions, many of which having already emerged in the 1980s. Each of the aforementioned forms of therapy has its supporters, in spite of the fact that there is still little evidence for their effectiveness.**

In the wider context of a multifactorial approach to the complex construction of dyslexia, this review aims to outline the main objectives, the implementation procedures and the extent to which alternative approaches contribute to dyslexia treatment. In brief, a review of the current literature leads to the conclusion that even though most of these methods have yet to be proven for their effectiveness, they should not be considered as having no therapeutic value. Nonetheless, until their efficacy has been proved, it is suggested that the most effective interventions in reading are those involving the combination of cognitive and behavioral intervention.

Index Terms—**Alternative approaches, audio-visual interventions, biofeedback, fatty acid interventions.**

I. INTRODUCTION

According to the American Psychiatric Association (APA) [1], the term *dyslexia* refers to a "special learning disorder" and in particular to a specific pattern of learning difficulties characterized by problems in accurate and fluent word recognition, in poor decoding and in poor spelling skills. The British Psychological Society [2] had already identified dyslexia as a special learning disability in the late 1990s. Dyslexia is evident when accurate and fluent word reading and/or spelling develops incompletely or with great difficulty, especially at word level, despite the appropriate learning opportunities. Regardless of the emphasis on learning difficulties, dyslexia appears to include a wide range of symptoms, such as poor short-term memory, dyscalculia, visual impairment, speech disorders [3], poor motor control [4], and emotional difficulties such as low self-esteem [5], chronic anxiety and conduct disorders [6]. Even though the prevalence of developmental dyslexia varies from 10 to 15% [1], the cause of dyslexia remains so far a field of controversy among researchers [7], along with the methods of its diagnosis and treatment [8].

The *phonological deficit* theory is the most well documented and confirmed cognitive explanation for the reading disorder in the last four decades [9], [10]. A recent study by Saksida et al. [11] confirmed that most children with dyslexia show deficient phonological awareness [12], [13]. This can provide an insight into later reading difficulties [12], [13], with phonological awareness being the most potent predictor [14], [15]. In studies for children with reading problems and normal readers the phonological processing, the short-term/working memory and the processing speed are considered basic cognitive processes [16], each of which has a phonological component that is important for reading. Children with dyslexia suffer from inadequate representation of linguistic sounds, resulting in problems in accurate word processing, which in turn lead to difficulties in conquering phonological awareness, alphabetic mapping, letter-sound decoding and, consequently, orthographic awareness [17], [18]. According to authors [17], [18], all the above can influence the rapid recognition of words and reading skills. Consistent with the findings of the double-deficit hypothesis study [19]-[21], both phonological and rapid naming difficulties are most prominent in dyslexic children.

Research on the aetiology of developmental dyslexia [22] suggests that acquisition of reading is based both on speech segmentation and the graphophonemic matching [23], as well as on the consecutive visual attention shift to series of letters that is meant by the magnocellular-dorsal pathway [24]-[27]. Letters should be identified rapidly, in the appropriate sequence [23], and selected accurately among other similar confounding graphs [28] in the rapid orientation of visual attention [29]. According to the *magnocellular deficit theory* [30], [31] visual processing dysfunction is an important feature in individuals with dyslexia [24], [26], [32]. The magnocellular neuronal impairment is evident at all levels of the visual system: in the retina, in the lateral geniculate nucleus, in the primary visual cortex and throughout the dorsal visuomotor pathway forward from the visual cortex to the posterior parietal and prefrontal cortices [23]. This anomaly destabilizes visual perception; hence its severity in individuals is associated with deficits in their reading skills.

Another factor often related with dyslexic symptoms is poor motor skills, which is explained by the *cerebellum dysfunction theory* [33]. In fact, motor learning studies have long been aware of the role of cerebellar vibration in

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acquiring skills such as the bimanual skill [34], [35]. The findings from these studies suggest that the role of the cerebellum is not limited to regulating the rate, force, rhythm and accuracy of the movements, but mainly to regulating the speed, capacity, consistency and suitability of cognitive and emotional processes [36]-[38]. Consequently, these indications support the functional interactions between motor control systems, language and reading [36], [39].

With regard to dyslexia treatment many different types of interventions have been proposed, based on the varied theories that stem from the diverse nature of developmental dyslexia. A classification of treatment methods is proposed by the Frith's model [40], proposing three categories based on the three levels of developmental disorders: biological, cognitive and behavioral. The *biological* approach, based on genetic and neuroimaging data, affects the nervous system by stimulating the brain (e.g. biofeedback) or strengthens the sensory organs. The *cognitive* approach entails cognitive training, in order to develop and improve functions such as memory, perception, attention, and especially phonological functions (e.g. phonological awareness and phonological memory), which play an important role during the reading process. The *behavioral* approach, taking into account the functionality of individuals with dyslexia and reading motivation [41], improves reading and/or writing skills through the practice and/or teaching of some strategies, e.g. combined reading [42] and reading in "phases" [43]. However, some methods should be categorized as mixed, considering that they refer to two levels of intervention at the same time, e.g. cognitive and behavioral approach [44].

Nowadays, the most promising interventions for dyslexia provide with intensive training in phonological awareness, systematic and explicit training in graphophonemic matching, training based on standards or strategies in order to overcome the letter-sound contradictions in words, text analysis, training in reading fluency, support in reading texts with increasingly difficult, training in written exercises and writing comprehension strategies [45]-[50]. In addition, other researchers [51] emphasize on the executive dysfunction in poor readers and argue that the development of metacognitive strategies and self-regulatory strategies can be considered extremely beneficial. Imaging intervention studies, which investigate how dyslexia remediation positively alters brain activity [52], [53], seem to promote the normalization of activity in the left hemisphere for reading and the language network, which exhibits reduced activity in dyslexia. Moreover, increased right hemisphere activation has been reported following dyslexia treatment, which is sometimes interpreted as a demonstration of compensatory procedures [49].

A solid base of evidence emphasizes on direct teaching in reading and phonological training. However, aiming to overcome the absence of satisfactory remediation through traditional educational models [56], many alternative therapies for dyslexia have been proposed [54], [55]. Such treatments are three times more likely to be used as a complement to conventional approaches for children with chronic conditions as compared to healthy children [57], the higher use of which is related to the severity of the disorder [58].

A variety of alternative methods offered to children with dyslexia include biofeedback [59], sensory integration therapy [60], music therapy [61], chiropractic technique [62], homeopathy [63], and Dyslexia–Dyspraxia–Attention-Deficit Therapy (DDAT) [64]. The most popular treatments selected by parents of children with dyslexia are dietary supplements followed by homeopathy and osteopathic / chiropractic treatment [8].

Each of these dyslexia treatment methods has its supporters, although there is little evidence for the effectiveness of each method [65]. It is a fact that these "magical therapies" cause concern to the academic community [66], as they provide parents with a false sense of security and unjustified expense, while drawing attention from traditional interventions for dyslexia [67]. There are relatively few published controlled studies that provide varying degrees of support for specific non-educational approaches [64], [68], [69]. Hence, it becomes apparent that there is a need for evidence-based, impartial information to the parents of dyslexic children as regards their treatment choices in order to avoid unnecessary costs in non-educational interventions that may prove to be ineffective, as suggested in related research studies [70].

In the context of exploring the role and necessity of multifactorial approaches to dyslexia, in the current review we are attempting a comparative study of alternative intervention methods (perceptual-motor training, visual interventions, auditory interventions, biofeedback, and fatty acid interventions) with reference to their objectives and characteristics in order to clarify their degree of contribution to the treatment of dyslexia.

With a view to presenting as much as possible from the current literature, we searched the electronic platforms of "PubMed" and "Scopus" using keywords such as "dyslexia" and "reading difficulties" in conjunction with the terms "developmental", "alternative forms of treatment", "treatment" and "brain imaging". Several review articles and books have been studied providing comprehensive and complete research into the subject of our study so far. The selection of the research articles has been largely based on publications made over the last 10 years, without excluding earlier publications that were relevant to the subject of this review and still endure over the years.

II. ALTERNATIVE AND COMPLEMENTARY TRAINING METHODS IN LITERATURE

A. *Perceptual-motor Training*

In the history of special education, a multitude of programs having accepted the occurrence of sensory integration deficits and motor functions in students with learning disabilities, argued that if these difficulties were resolved, students would be able to acquire academic skills more easily [71]. Evidence of the effectiveness of perceptual motor programs for the remediation of academic skills such as reading is generally absent despite their continued popularity [72], [73]. Smith [74] summed up the characteristics of this kind of interventions, which claim significant but unclear results, and argued that such practices stem from uncontrolled studies or subjective sources, such

as unpublished studies and testimonials, with the theoretical background being often inconsistent with accepted knowledge. Additionally, Kavale and Mattson [72] reported a meta-analysis, where motor awareness programs had little impact on reading. Similarly, Hammill's extensive review [75] revealed little correlation between perceptual motor skills and reading, noting that training in these skills is not helpful in remediating reading problems.

One of the most popular kinesthetic programs is perhaps the *Dore* program or otherwise the *Dyslexia Dyspraxia Attention Treatment* program - *DDAT* [76]. This program is based on the cerebellar theory as cause of dyslexia and it has been promoted as an intervention strategy that appears to benefit people with dyslexia, dyspraxia, attention deficit - hyperactivity disorder (ADHD) and Asperger's syndrome. It involves the physical exercise of the dyslexic child for 10 minutes, twice a day for about fourteen months [71].

Two comparative studies on the effectiveness of the Dore program, published in the Dyslexia Journal [64], [77], reported the success of the program. An unprecedented response from nine critics was published in response to the first study [64], highlighting the various shortcomings in the planning of the research and the over-estimated claims made by the authors of the study [70], [78]-[85].

More specifically, the unsuitable comparison of performance with the control group and the concerns about the real difficulties of the participants were pointed out. Because several students were already at regular reading levels prior to the program, the study by Reynolds et al. [64] did not target students who were experiencing serious reading difficulties, let alone dyslexia. In addition, it should be noted that out of the 35 children in total, only six were diagnosed with dyslexia, two with dyspraxia and one with ADHD, suggesting that most subjects did not cover the range of the difficulties that the Dore program seeks to remediate [71]. Furthermore, concerns were raised about Dore's funding for authors and the rightness of aspects of the editorial process [71]. Similarly, in the second study [77] which was a reassessment of the first, problems were observed in the methodology, such as the absence of a control group [71]. Consequently, it is argued that these two controversial studies are not convincing evidence for the effectiveness of the Dore program.

Another motor intervention aimed at enhancing academic skills relates to the treatment of primary reflexes, whose persistence has led to significant problems in the development of the motor function [86]. The mild persistence of primary reflexes has been associated with reading difficulties and motor impairments [87]. Asymmetrical tonic neck reflex (ATNR) is the most commonly observed primary cerebral reflex persistence in infants with neurological lesions [88], which should normally be suspended about 6 months after birth [86]. The findings of the McPhillips and Jordan-Black study [89] demonstrate that ATNR persistence in school-age children is associated with their poor performance in reading, spelling and pseudo-words reading. However, they stressed that not all children with difficulties in reading or spelling have persistent reflexes, and thus the persistence of reflexes should be considered as an early developmental risk factor and not as a direct causal factor of the reading difficulty, due to the fact that the subsequent consequences depend on the interaction of a range of cognitive, environmental and biological factors.

To address ATNR persistence, McPhillips invented the *Primary Movement Program*, a motor program including a series of movements similar to the early reflex movements that children are asked to perform in order to stimulate their main motor brain areas, including the cerebellum [10]. McPhillips et al. [87] demonstrated the effectiveness of the *Primary Movement Program* in reading, while Hyatt, Stephenson & Carter [90], after reviewing the research of the former, reported modest benefits in remediating reading difficulties. In contrast, Jordan-Black [91] confirmed the effect of McPhillips et al. [87] and expanded the impact of the program on improving mathematics. Specifically, Jordan-Black [91] concluded that the program has a significant impact on reducing ATNR persistence and improving the academic performance of primary school children, particularly in reading and mathematics, with a smaller impact on spelling. In addition, he noted that the impact of the program was evident in children with major learning difficulties. However, he pointed out that there are children with learning difficulties who do not experience ATNR persistence; consequently these children responded less to the intervention.

An additional alternative method combining nutritional supplements, herbs, homeopathy, acupuncture, osteopathy, applied kinesiology and neuro-lingual programming is known as the "*Sunflower*" therapy [92]. The conviction of "Sunflower" therapists is that children with learning disabilities suffer from a series of structural, biochemical and psychological imbalances that can be addressed by using complementary treatment to help the child perform and feel better. The therapy is based on applied kinesiology, a controversial muscular assessment diagnostic system for detecting physical and psychological imbalances, although there is a lack of high-quality research evidence to support its use [93].

Bull [68] concluded that Sunflower therapy does not lead to improvements in the cognitive function or literature for dyslexic children. However, dyslexic children who received this kind of treatment improved their academic and, to a lesser extent, their reading self-esteem. This is an interesting finding as self-esteem has been recognized as a major concern of the parents of dyslexic children [5]. Nonetheless, Bull [68] doubted whether the improvements came from the treatment they received or whether they were related to more general factors associated with participation in this research program.

At a similar level, the "*Brain Gym*", created by Paul and Gail Dennison (1987), proposes a form of learning through movement and includes the performance of 26 motor exercises [94]. According to the official "Brain Gym" website, the program can be used by persons of all ages, as well as by children with learning disabilities. The specific areas targeted by the program include concentration and memory, academic goals (reading, writing, and mathematics), physical co-ordination, self-responsibility, organizational skills, and mood. However, a recent review of the research on the "*Brain Gym*" program, has found no clear evidence of these claims due to lack of empirical

evidence [90]. Indeed, an article by Lilienfeld, Ammirati and David [95] who used Brain Gym, is particularly critical of the lack of related research. In addition, it claims that each of the 26 exercises improves some cognitive skills, but there is no evidence in exactly how these moves generate these improvements.

"Quadrato Motor Training" (QMT) is a whole-body sensory-motor training program, aimed at addressing learning difficulties through 12 possible movements [96]. In the study by Ben-Soussan et al. [96] the possible interactions between the sensory-motor and reading system and the role of cerebellum in reading skills in dyslexic individuals using the QMT program were investigated. Using magnetoencephalography (MEG), they measured the changes in alpha power and coherence after training. The results demonstrate improved reading speed after one month of 7-minute QMT daily training for both dyslexic and control subjects. Participants with dyslexia, however not the control group, experienced a significant increase in alpha cerebellum power after training. In addition, the intra-hemispheric alpha cohesion was higher in the dyslexic group compared to the control group. Nevertheless, some research constraints according to the authors themselves are the small sample of the study (12 adults with dyslexia and 10 normal readers), the use of a single training example, and the difficulty in distinguishing between the signals that occur in the cerebellum cortex and in the deep cerebellar nuclei.

B. Visual Interventions

It has already been reported that dyslexia may coexist with sensory difficulties or motor coordination difficulties. Nonetheless, many theories argue that a major cause of dyslexia is the visual processing disorder [97], such as the Meares-Irlen Syndrome (Scotopic Sensitivity Syndrome) [98] also known as "visual stress" [99]. The Meares-Irlen syndrome is a condition first characterized by Meares [100] and Irlen [101] and documented by Wilkins [99]. Symptoms may include light sensitivity, reading problems, discomfort (including page reflection and headaches in reading), attention and concentration problems, writing problems, depth perception problems, and alterations of letters and words in the page [102], [103]. Although the Meares-Irlen's syndrome etiology has not been adequately determined [104] the most widely accepted explanation is that of the visual cortex hyperstimulation proposed by Wilkins [105]. Kriss and Evans [106] found that the Scotopic Sensitivity Syndrome occurs in 20% of the general population and may be a little more common in dyslexia. Although visual stress is believed to be one of the main visual causes of reading difficulties [107] and is often associated with dyslexia [108] there is no evidence of the existence of a causal relationship between visual stress and dyslexia [102], [109]. Evans and Allen [102] concluded that visual stress may contribute to the general difficulties of a dyslexic child, but it is unlikely to be a cause of dyslexia, as many adults without reading disorders experience visual alterations and visual stress [108].

For the treatment of visual stress in reading, the hypothesis has been formulated [108], [110]-[116] that by changing the spectral synthesis of the image on the retina with colored filters, cortical activity can be rearranged so as to avoid strong local stimulation in the hypersensitive areas of the visual cortex [105]. Readers with dyslexia, when reading a text with a colored overlay, exhibit decreases in the symptoms of visual stress including eye strain and headache [105] and improvements in reading speed [113], [117]-[119], whereas it has also proved beneficial to text comprehension and reading accuracy [120], [121]. Additionally, the prolonged voluntary use of colored lenses by research participants demonstrates that individuals experience contiguous benefits [117], [122]. The two most popular and effective filter colors for children with visual reading problems have been proved to be yellow and blue [23]. Yellow filters reduce the total amount of light entering the eye, causing pupillary dilation by increasing the amount of yellow light that falls on the retina, stimulating more the magnocellular neurons [123]. In a double-blind, randomized, controlled study by Ray et al. [123] was attested that those who received the yellow filters improved the responses of their magnocellular neurons and this improvement was accompanied by improved word reading. In regard to blue filters, there are many unpublished reports suggesting that successful addressing of reading difficulties with the use of this color is accompanied by fewer headaches. Moreover, blue filters are reported to improve the sleep of children who have sleep disorders and visual reading problems [124].

However, today many commercial companies sell a wide range of color filters to improve reading problems by claiming that using only the yellow and blue filters will not meet the personalized needs, which is why every person needs an individual color for better results [23]. Wilkins et al. [115] concluded that few over the average of the sample receiving different color filters, reported a decrease in symptoms for visual fatigue and headache. Nonetheless, it is interesting that the colors of the effective filters mainly concentrated around the yellow or blue, and there was no evidence that plain yellow and blue would not be just as effective or more effective. In addition, Hall et al. [125] comparing their own filters, blue and yellow, with a wider range of colors of a company concluded these filters actually achieved better results. Consequently, there is little evidence of the need for a wide range of colors on the filters, as the individual colors chosen are usually concentrated around yellow and blue, rendering only these two colors sufficient [23].

Robinson and Foreman [126], wishing to maintain a balance in the evidence for color filters, argued that reducing letter alterations may not be enough to create improved word recognition skills without additional remedial teaching in reading, and this can be indicated by the non-significant increase in the reading rate. Similarly, Optometry College in the United Kingdom supports the use of individual colored lenses to improve the symptoms of visual stress [127], which may be part of the dyslexic profile or autonomous [106]. In contrast, the American Pediatric Society [128] does not support the use of color filters for dyslexics, stating that reading difficulties do not stem from visual perceptual deficits and that color filters do not work in practice. The latter view seems to be consistent with Menacker et al. [129], who studied dyslexics and concluded

that colored glasses had no impact on reading. This conclusion seems reasonable if one considers that not all dyslexics have a significant degree of visual stress [106] and it is likely that only some of the participants had visual stress. Evans and Allen [102] seem to be on a similar wavelength, concluding that color filters improve reading performance in individuals with visual stress but are unlikely to affect phonological and memory deficits associated with dyslexia, and thus these are not a cure for dyslexia.

C. *Auditory interventions*

The development of basic auditory interventions has been influenced in theory by the work of Tallal [130], in which it is argued that the difficulties associated with dyslexia can be attributed to shortcomings in rapid temporal auditory processing [130]-[134]. This weakness prevents dyslexics from perceiving and discerning the sounds of the language in a fast and effective way, thereby influencing the development of appropriate phonological skills, resulting in reading difficulties [135]. Due to the plasticity of the brain, this theory supports that proper training can lead to permanent improvement of the underlying neural systems and the simultaneous improvement of language and reading skills in children [136]. Similarly, Alexander and Slinger-Constant [137] developed two basic electronic programs to address the difficulties in auditory processing, the “Fast ForWord” program [138] and the “Earobics” program [139].

"Earobics" [140], [141] is a computer-aided training program designed to improve comprehension and literature skills [142] by improving the auditory processing of language, memory and phonological awareness, with tests such as the recognition and distinction of phonemes. Three studies, conducted by the same team of researchers who are independent of Earobics developers, have evaluated the use of Earobics as a training program.

Hayes et al. [143] studied 27 children with learning disabilities who received auditory perception training with the "Earobics" program for 8 weeks. The children, compared with the control group and a group of children with learning difficulties without treating, exhibited improvements in their auditory processing skills, whereas their cortical activity was altered with the use of speech syllables. In a typically more mature pattern in quiet conditions they showed increased resistance to degradation in background noise. The potential impact of these results on children with dyslexia is unclear due to the fact that only children with attention deficit were included in the study [137]. Similarly, Warrier et al. [144] demonstrated that children with learning disabilities showed improvement within the standard limits after training, while there were no changes in the corresponding measurements for the untrained group. The neurophysiological improvement observed in the group of trained children was also associated with better performance in speech perception tests. The last study was repeated by Russo et al. [145], who added the speech-induced auditory potentials of the brain stem and speech perception in noise. They showed that the morphology of the waveform of the auditory responses of the brainstem recorded in noise even poor in quiet, after training was improved and resembled to the response in quiet. This improvement in the subcortical level (auditory changes in the brainstem in noise) was associated with improvements in cortical activity in noise. However, none of these three studies referred to improved performance in literature skills after training [146].

Additional computer-based auditory training program was developed by Merzenich et al. [147] and Tallal et al. [134], known as "Fast ForWord" (FFW). This training program intervention is recommended for a period of over 6 to 8 weeks (100 minutes per day, 5 days a week) [148] and results in the improvement of language and reading skills [149]. The program encompasses audiovisual games for children with language difficulties aged between 4 and 14, which consist of phonological skills exercises, as well as syntactic and semantic comprehension once and use acoustically modified speech adapted to the child’s progress, target to a gradually decreasing modification [150].

There is much debate about the effectiveness of FFW [151]. Many of the claims made by the Scientific Learning Corporation appear to be based on findings from privately guided [152], [153] rather than independent studies and reviews published in reputable scientific journals. For example, studies by Tallal et al. [134] and Merzenich et al. [147] showed improvements in language skills after using the FFW program. However, there are several limitations in both studies challenging the efficacy of the program, as following: i) both of them are small scale studies, while there is no control group in the first study [149]; ii) the children in both studies were trained in additional tests beyond computer exercises, which make it impossible to attribute the effects of treatment exclusively to FFW exercises [154]. Furthermore, only a few of the FFW exercises were included in these studies, thus, the FFW program per se is not evaluated; iii), as the intervention was multifaceted, it is difficult to isolate the components of the therapeutic program related to improvements in auditory perceptual skills and language performance [154]-[156]; iv) some of the outcome measures were similar to the FFW exercises, possibly biasing the results in favor of positive treatment effects [156]. Therefore, design constraints exclude any claim about the effectiveness of FFW from these studies [149].

Similar methodological weakness is evident in the report by Institute of Education Sciences [157] about the effects of FFW on beginner readers, which concludes that stress positive effects of FFW on phonic reading skills but mixed effects on comprehension outcomes. Nonetheless, the procedures used in that review have been criticized by McArthur [158], who argued that it was largely based on unpublished studies conducted by the Scientific Learning Corporation, and did not include a key study that was published in a peer-reviewed journal.

The exact role of the auditory training theory based on the FFW program is further questioned by large-scale randomized control studies [159], [160], who did not demonstrate a significant advantage of FFW in comparison to other language remedial programs in which the rapid auditory processing component was omitted. This concern raises considerable doubts about the clinical efficacy of this program in problems of rapid auditory processing, and about whether these improvements in the language skills of

children with language disorders can be transferred [134]. This view is shared by Hook, Macaruso & Jones [161], who conducted an independent evaluation of FFW. Children who participated in the evaluation showed immediate benefits in producing speech, but not in language comprehension and the rate of serial naming, or the working memory, while gains on oral speech were not maintained two years later. Nevertheless, these findings should be interpreted with caution due to the limited sample of the study [162]. In addition, McArthur et al. [163] studied children with Specific Language Impairment (SLI) and reading disorders, who had auditory processing deficits and were trained to address the weaknesses of their auditory processing. In that study, training was effective in restoring auditory processing skills, but there were no effects on literature and language. Furthermore, the systematic reviews of Sisson [164] and Cirrin and Gillam [151] demonstrate that there is no significant impact of the FFW program on the academic performance and therefore its use is not necessary. Moreover, according to a more recent review [149] there is no evidence that FFW is effective as a treatment for children's weaknesses in reading or lexical expression or comprehension. Conversely, conventional forms of treatment may result in modest but reliable improvements in these skills [165], [166].

Rhythmic stimulation is a different auditory training program proposed by many researchers for children with developmental dyslexia [22], [167]-[172], who appear to perform poorly in rhythmic and musical perception tasks [173]. Many study results in the respective literature indicate strong links between rhythmic and linguistic abilities [174]-[179]. In a recent study, the effectiveness of a Cognitivo-Musical Training (CMT) based on the music - language analogies and the temporal and rhythmic features of music was tested [180]. Habib et al. [180] assumed that the music training of dyslexic children could contribute to the improvement of brain circuits that are common to music and language processes, whereas the temporal and rhythmic features of music could have a positive effect on temporal processing deficits, which are characteristic of some dyslexia types. Thus, , in addition to the intensive training of various characteristics of the musical auditory signal, they used a series of musical exercises involving sensory (visual, auditory, somatosensory) and motor systems, with particular emphasis on rhythmic perception and production. The researchers [180] conducted two separate studies; in the first study children with dyslexia received intensive musical exercises concentrated over 18 hours during three consecutive days, while in the second one the musical training was spread over 6 weeks. The first study yielded significant improvement in the categorical perception and auditory perception of temporal components of speech, while the second study revealed additional improvements in auditory attention, phonological awareness (syllable fusion), reading abilities and repetition of pseudo-words.

However, according to Habib et al. [180], there are a number of caveats concerning the mentioned results, mainly due to the absence of an already trained control group, thus, the small number of the sample for this procedure probably resulted in more extraneous effects due to τηε individual differences. Lastly, they commented on the inability to exclude the impact of attention on the improvement of specific cognitive mechanisms.

A related research based on rhythmic procession deficits in dyslexia was that of Thomson, Leong & Goswami [135], who remediated these deficits and compared the results with that of the phonological training received at the same time by another group of children with dyslexia. Comparisons between the two groups indicated that both rhythmic and phonological intervention have led to significant gains in phonological awareness (both in prosody and at a phonemic level). On the contrary, interventions did not have a specific impact on the development of basic auditory processing, such as duration and intensity (see also [181]). In addition, both programs did not have a significant impact on reading and writing compared to the control group.

In conclusion, while there were benefits in the basic auditory processing and phonological awareness as a result of the various auditory interventions, data were often inconsistent, while findings in literature skills were inadequate. Consequently, it is of importance for future studies in this field of expertise to demonstrate i) whether appropriate training programs can be developed to improve children's rapid auditory temporal processing and, ii) if feasible, whether these improvements are related to the corresponding improvements in the skills of language processing and, consequently, in literature.

D. Biofeedback

The biofeedback method becomes gradually more popular in comparison with the theoretical approaches to dyslexia, with its most significant application being in the framework of the phonological and the magnocellular theory. Recent study by Heth and Lavidor [182] examined the impact of transcranial Direct Current Stimulation (tDCS) on text reading accuracy and fluency in adults with developmental dyslexia. The current study was designed in the context of magnocellular deficit theory [183], which has been criticized in the past for the causal relationships of dyslexia [184]. The left visual area V5, which facilitates the magnocellular pathway of dorsal activity, was chosen for anodal stimulation, so as to achieve word recognition [185] and thus to improve oral text reading accuracy and speed [31], [186]-[188]. The results showed improvement in oral text reading, as well as in the letter-naming and number-naming speed, which is considered a predictive factor of reading fluency [189], [190]. The increased reading speed did not decrease the accuracy, which was maintained and even increased after one week of stimulation. In essence, the study expands the previous findings by showing the improvement these can bring to comprehension, as suggested by Fuchs et al. [191], who argue that oral text reading is an indication of comprehension. However, while there was improvement in text reading and in the letter-naming and number-naming speed, the degree of visual reading of nonverbal material was not affected by the anodal stimulation of the left visual area V5, highlighting a more specific effect of V5 in the spelling processing speed [192]. Consequently, Heth and Lavidor [182] concluded that the V5 visual area is involved in reading and suggest the use of tDCS as a possible treatment, taking on consideration that

improvements were maintained even when tested one week after the end of the stimulation sessions.

In any case, we should interpret these findings with caution due to the small sample of the study but also due to its uniqueness, as according to the authors themselves [182] it was the first study using the tDCS method in individuals with developmental dyslexia, thus further investigation of these findings is required. The results of tDCS have also been confirmed by Turkeltaub et al. [193], who concluded that a single tDCS session over the posterior temporal cortex improved the reading of real and non-words of no readers with dyslexia but slow readers.

The only study in adults with developmental dyslexia performed before the study of Heth and Lavidor [182] is the one by Costanzo et al. [194], who applied trans-magnetic stimulation (TMS) instead of tDCS to 10 adults, in order to stimulate language areas that underperform in dyslexia. The study reported improved text reading accuracy and faster reading of pseudowords. Nonetheless, the small sample of the study is a clear limitation on the reliability of the results, while many individuals reported distress and pain using similar protocols [195] in contrast to the non-invasive tDCS method [182].

The controlled study by Breteler et al. [196] for neurofeedback treatment in dyslexia is based on the phonological deficit theory, which reports a particular deficit in representation, storage and recall of phonemes. Based on the phonological theory (e.g. [197]) one would expect greater activity of the quantitative electroencephalography (qEEG) in frontal-temporal areas, indicating the absence of improvements in reading.

This contrasts with two non-controlled studies on neurofeedback and dyslexia that reported increases in the quality of reading [198], [199] despite the small sample and the lack of a control group in both studies. Additionally, a significant improvement in spelling was reported, which, however, according to Breteler et al. [196] may be due either to the remedial teaching received by children with dyslexia or to the attentional processes involved in improving spelling. The results of Breteler et al.'s [196] should be treated with caution due to the small number of participants (n=19). Additionally, no selection was made with regard to any dyslexia subtype, as deficits in different kinds of reading skills may require different neuro-feedback protocols, according to Wilmer et al. [200].

Bakker, Moerland & Goekoop-Hoetkens [201] instead used Hemisphere-Specific Stimulation (HSS) to treat dyslexia subtypes, such as the P-type dyslexic (slow e.g. word repetition, hesitations, but accurate, processing is based on the right hemisphere) and the L-type dyslexic (fast, but makes a lot of substantive errors such as omissions, additions, processing is based on the left hemisphere). Bakker et al. [201] concluded that HSS had a beneficial impact on a sample of 174 individuals. L-type dyslexics achieved improved accuracy in word reading and improved comprehension, and P-type dyslexics showed a faster reading rate.

Similarly, Kappers [202] reported significant benefits after HSS intervention in reading, but the number of intervention sessions was not the same for all children, some children receiving intervention for up to two years. Similar benefits after the use HSS were also reported by Lorusso et al. [203] in dyslexic readers with improvements in reading speed and accuracy, phonemic awareness and memory after four months of intervention, twice a week. However, the latter suggested that in addition to the enhancement of the inferior hemisphere, a more automated processing, due to time pressure for information processing during the stimulation, may be the main mechanism for observed benefits.

A recent pilot study was conducted by Au et al. [204] on the feasibility and clinical implication of neurofeedback training as an intervention to improve attention and inhibitory control in four dyslexic children from China. The training consisted of ten neurofeedback sessions for each participant, using power protocols (C3/β) and bipolar protocols (C3-C4/β), targeted to increase β amplitude and decrease θ and hi-β amplitudes at the primary sensorimotor cortex (i.e. C3 and C4). The θ/β ratios were analyzed as dependent effects of neurofeedback training. Within-subject comparisons were conducted. The results yielded a reduction in θ waves and an increase in β waves in all participants, as reflected by a reduction in the θ/β ratios. Enhancement of β activation resulted in remarkable improvement of participants in reaction time and in errors, proving an intensity of vigilance. In addition, suppression of θ frequencies resulted in improved attention to all participants, demonstrating better performance in areas such as sustained attention, selective attention and attentional shifting. Training with θ-suppression and β-stimulation in the sensorimotor cortex (C3, C4) also caused some improvement in the inhibitory control of the participants, although the underlying mechanism is currently not known.

An additional finding of that study was the enhancement of phonological awareness among all participants, which is probably associated with neurofeedback in the left motor region (C3). According to Au et al. [204] this correlation can be explained on the basis of the cerebellar theory. However, this neurofeedback training method does not show the same degree of effectiveness for all individuals with dyslexia, but is subject to separate profiles, such as the extent of the attention deficit and IQ. Additional constraints are the small number of participants, the small frequency of sessions (this study had only ten sessions, which is about one-third of a standard neurofeedback training protocol), and the lack of control group. Besides, the underlying mechanisms of the observed changes remain unknown, leading researchers to making various speculations, which are yet to be proved by future well-controlled studies.

E. Fatty Acids Interventions

Omega-6 and omega-3 polyunsaturated fatty acids (PUFAs) play a central role in the normal development and functioning of the brain and central nervous system [205]. In particular, long-chain PUFAs (LC-PUFAs) such as eicosapentaenoic acid (EPA, C20:5ω-3), docosahexaenoic acid (DHA, C22:6ω-3) and arachidonic acid (AA, C20:4ω-6), are involved in membrane fluidity, gene expression, and neuronal membrane structure and function, all critical for cell transduction and the process of learning [205]-[207]. Recent data suggest that there is a link between defects in the metabolism of polyunsaturated fatty acids (PUFAs) and

neurodevelopmental disorders such as dyslexia [208]-[211]. This finding is based on the assumption that the function of the highly sensitive visual magnocellular system is dependent on high unsaturated fatty acids content [212]. Thus, if the neurological development of the visual system is reduced, reading difficulties may arise [31], [212]. Dyslexia is often associated with a relative lack of omega-3 fatty acids [205] and therefore dietary supplements could help children with dyslexia [68], [210], [213]-[217]. However, even though the clinical benefits of supplements with polyunsaturated fatty acids in children and adolescents with dyslexia have been studied, evidence remains limited [211].

One of the studies dealing with the effects of dietary supplements on the learning ability of children with dyslexia is the study by Lindmark and Clough [218]. They conducted an open-label pilot study to investigate the effects of a docosahexanoic-acid-rich supplement on a group of 17 children in Sweden who had a formal diagnosis of dyslexia. Children received eight capsules per day containing high-DHA fish oil and primrose oil. The evaluation was completed before and after the 4 months of supplement intake to measure word decoding (reading speed) and letter decoding (motor-perceptual speed). Significant improvements were observed after the supplement intake in the reading speed, which improved by 60%, and the motor-perceptual speed, which improved by 23%. However, this study consisted of a small sample of dyslexic children, it was not randomized, or controlled or blind (it was an open-label study) and did not include any comparison group [219].

Richardson and Puri [69] in a randomized, double-blind study, investigated the effect of supplementation with polyunsaturated fatty acids (EPA, DHA, AA, γ-linolenic acid, vitamin E, conjugated linoleic acid, and thyme oil) in various areas, among which learning abilities. Supplements were administered for three months to 41 children aged 10-18 years with symptoms of attention deficit - hyperactivity disorder and developmental dyslexia, which was diagnosed with criteria - although not named - whose description matched those of DSM-IV [220]. However, that study did not report the results of the weighted tests for reading, writing, spelling and mathematics.

Similarly, the study by Kairaluoma et al. [221] evaluated in a double-blind, controlled study whether dietary supplements with a combination of eicosapentaenoic acid (EPA) and carnosine would have positive effects on reading and spelling skills in 61 children with reading disorder. The results in this study showed no differences between the control group and the intervention group, although children in both groups improved in most measurements during treatment. This improvement can be explained, according to Kairaluoma et al. [221], by the children's normal development, the placebo effect, and the effect of repeating the tasks. Therefore, in this study, fatty acid supplements did not have specific therapeutic effects on the literature skills of dyslexic children. However, there is no available data on which to base estimation of the doses required or the duration of administration in order to achieve a result, while the relatively small sample size can also be considered as a limitation of this study.

A separate study that did not involve children with dyslexia but children with coordination disorders is the Oxford and Durham study [216]. This study evaluated the effect of dietary supplements with omega-3 and omega-6 fatty acids (EPA, DHA, γ-linoleic acid, vitamin E) on 117 children with coordination disorders. Despite the fact that the results demonstrated improvement in reading and spelling in children with developmental coordination disorders, the study was conducted without clearly defined groups and without taking into account pre-treatment literature skills, thus making the findings from the present research questionable.

III. DISCUSSION

Currently, the main part of the scientific and research community in regard to diagnostic and concomitant therapeutic approaches in the field of specific learning difficulties, as well in particular dyslexia, is determined by theoretical and clinical approaches that are widely accepted as conventional [23], [49], [222]-[225]. However, in the context of a broader approach and with the aim of contributing to a fuller and deeper presentation of all approaches, and of a representative presentation of the current literature, we conducted a review of alternative and complementary methods for dyslexia treatment. A variety of alternative methods designed and proposed for dyslexic children include perceptual-motor training, visual interventions, auditory interventions, biofeedback, and fatty acid interventions. Each of these methods of dyslexia treatment has its supporters, although there is little evidence for their effectiveness [65].

Taking into account the research findings on perceptual-motor training, it is quite rational to inquire what specific types of exercises could be responsible for each result. If there is a clear result, one would expect a relationship between the types of exercises and the effects that have occurred. Even the theorists who support the cerebellar deficit hypothesis have agreed that difficulties in balance and motion are not necessarily associated with reading difficulties, as well as that the cerebellar deficit that causes reading difficulties is only present in language-related areas [226]. This finding is supported by Rochelle and Talcott [227], who compared studies with dyslexic and non-dyslexic participants in their meta-analysis examining the emergence of balance difficulties. They also concluded that the lack of connection between the difficulties of balance and reading raises doubts about the effectiveness of interventions using both balance exercises and motor exercises in general with the goal of immediate reading improvement.

More specifically, the effectiveness of the most popular kinesthetic program, "Dore" remains controversial, with research in favor of this program being hampered by a variety of methodological weaknesses (e.g., [70], [81]). Similar claims have been made for the programs “Brain Gym” and “Sunflower”, concluding that perceptual-motor training has no impact on learning [228], [229], namely on literature [70]. In comparison, it appears that the only potentially proven reading results are emerging from exercises that are different from those used in the “Dore”

program, such as the “Primary Movement Program” [87], [91]. However, the “Primary Movement Program” is not a panacea for the remediation of learning difficulties at school, and it could complement but not replace other strategies that have been shown to have a positive impact on the learning abilities of children [91]. Moreover, due to the stability of the results for the “Primary Movement Program” up-to-date, these findings should be treated with caution. Similarly, the effectiveness of "Quadrato Motor Training" should be interpreted with caution, taking into account that the research by Ben-Soussan et al. [96] was the first attempt to use this program in individuals with dyslexia; moreover, there are no relevant studies to compare these results.

Visual interventions are frequently preferred as well for coping with reading difficulties in children with dyslexia. Despite the promising data reported for the use of color filters/lenses in reading [105], [113], [120], allegations that colored filters help with reading remain controversial [107], [230], [231]. Several studies have found no significant differences between reading with or without the overlay or lenses [129], [232]-[237], while in the review by Albon, Adi and Hyde [238] methodological weaknesses in over half the studies supporting the use of color overlay were identified, concluding that there was no clear evidence that color filters improve reading skills in dyslexia. From the above, it becomes evident that the provision of colored filters/lenses to reduce the symptoms of visual stress remains clearly a controversial issue; thus the need for more extensive, stricter, randomized, and controlled testing of visual stress interventions seems imperative [102].

In the field of auditory training, although benefits have been demonstrated in basic auditory processing and phonological awareness, data is often inconsistent, while the findings in literature skills are considered insufficient. The “Earobics” program training appears to have a positive impact on children's phonological awareness skills but with limited evidence (no proved effect) on the efficacy of the program in improving literature skills. However, this conclusion is based only on three studies conducted by the same group of researchers, thus additional independent studies from other researchers are necessary [146].

The "FFW" program is also one of the auditory training programs for which there is much debate about its efficacy [151], as many of the claims of the program appear to be based on findings from privately guided [152], [153] rather than independent studies and reviews published in reputable scientific journals [158]. Moreover, there are several methodological weaknesses in the studies in favor of the “FFW” program (e.g. [134], [147]); as a result Strong et al. [149] in a recent review concluded the lack of evidence for the efficacy of this program as a therapy for children's weaknesses in reading or lexical expression or comprehension.

Nevertheless, data on the efficacy of rhythmic training, a different auditory training program, demonstrate that it can play an important role in the development of phonological skills that are vital to effective reading and writing acquisition [239]. This view is supported by conventional theoretical approaches to phonological development in childhood, which also emphasize the interdependence of phonological and prosodic information [240], [241]. Such interdependence could suggest that a combination of rhythmic and phonological intervention would be more effective for children with dyslexia than the provision of other types of training individually. This may apply particularly to children with dyslexia who are resistant to conventional phonological training methods.

An additional alternative training method in dyslexia is biofeedback, which has become more popular in the last decade. Most of the studies reveal support for the efficacy of the biofeedback method in reading performance [182]. However, due to the various failures in the methods used by several of the reported studies (e.g. [196], [204]), and to the relatively recent research interest in this alternative intervention method in dyslexia, it is imperative to carry out more research in this field so as to confirm the limited findings.

Finally, we have seen that recent research suggests a link between defects in the metabolism of polyunsaturated fatty acids (PUFAs) and neurodevelopmental disorders, such as dyslexia [208], [209], [211]. However, despite the fact that fatty acids have been suggested as a possible therapy for reading problems, only a few studies focusing on dyslexia interventions have been published to date (e.g. [69], [218], [221]), the results of which in reading are controversial. Consequently, there is insufficient evidence to determine the efficacy of fatty acids treatment in dyslexia, reading problems and other learning difficulties [242].

Again, due to the small number of studies on the effect of fatty acids on dyslexia, there is need for more well-designed, randomized, controlled studies with explicitly defined populations of children with special learning disabilities diagnosed with weighted diagnostic criteria [219]. Thus, uniform diagnostic criteria for dyslexia, objective measurements of fatty acid deficiency and close monitoring of dietary intake are some of the proposed factors [211] that could improve the quality of research in this field.

IV. CONCLUSION

Although the majority of methods mentioned in the current review have not proven to be effective in their entirety, they should not be considered as having no therapeutic value, as science should move forward collectively. However, clear evidence is required before a specific program or intervention is accepted by experts and this information is provided to parents of dyslexic children with a view to finding appropriate therapy options [65]. This is especially important for parents who have experienced dyslexia as a disease and decided to use such methods more often in the training and development of their children, with the most popular methods being dietary supplements/special diets, homeopathy and osteopathy/chiropractic, thus investing time and money in unproven therapies or therapies that have been recognized as ineffective through research studies [8].

In the light of modern research approaches to dyslexia, the necessity for several rather comprehensive and extensive researches towards discovering a universal program to address literature difficulties becomes a certainty, given that complex cognitive processes require simultaneous action of

many neurological systems. Hence, an effective therapeutic intervention for students with dyslexia should not be limited to reading training alone but mainly to developing the cognitive abilities that are subject to this ability [65]. This explains the variety of phenotypes of reading difficulties in one person. Thus, many dyslexia theories do not necessarily conflict with one another, but may explain different aspects of the reading disorder [182].

Today, one of the most effective therapeutic approaches to reading disorders is the acquisition of phonological awareness and recognition of letters, the clear and systematic teaching of phonology and the use of these skills in actual reading and writing [243]-[246]. Concluding this review of literature on alternative intervention forms in dyslexia, it is worth to highlight the positive fact of continuous research for effective interventions in dyslexia, to design and develop as much as possible integrated, multifactorial both diagnostic and therapeutic approaches to dyslexia.

CONFLICT OF INTEREST

Neither of the authors had no conflicts of interest during the development and publication of this paper.

REFERENCES

[1] American Psychiatric Association. *Diagnostic and statistical manual of mental disorders (DSM-V)*. Washington: American Psychiatric Pub, 2013.

[2] British Psychological Society. Division of Educational and Child Psychology. *Dyslexia, literacy and psychological assessment*. London: British Psychological Society, 1999.

[3] L. Peer, What is dyslexia? In *British Dyslexia Association Handbook*. Bracknell: British Dyslexia Association, 1999, pp. 61.

[4] A. J. Fawcett, & R. I. Nicolson. (1995). Persistent deficits in motor skill of children with dyslexia. *Journal of Motor Behavior*, *27*(3), pp. 235-240.

[5] B. Riddick, *Living with Dyslexia*. London: Routledge, 1996.

[6] N. Nieves. (1991). Childhood psychopathology and learning disabilities: neuropsychological relationships. *Neuropsychological foundations of learning disabilities*, pp. 113-146.

[7] J. Tijms. (2011). Effectiveness of computer-based treatment for dyslexia in a clinical care setting: outcomes and moderators. *Educational Psychology*, *31*(7), pp. 873-896.

[8] L. Bull. (2009). Survey of complementary and alternative therapies used by children with specific learning difficulties (dyslexia). *International Journal of Language & Communication Disorders*, *44*(2), pp. 224-235.

[9] F. R. Vellutino, J. M. Fletcher, M. J. Snowling, & D. M. Scanlon. (2004). Specific reading disability (dyslexia): what have we learned in the past four decades?. *Journal of child psychology and psychiatry*, *45*(1), pp. 2-40.

[10] J. G. Elliott, & E. L. Grigorenko. The Dyslexia Debate. Cambridge: University Press, 2014.

[11] A. Saksida, S. Iannuzzi, C. Bogliotti, Y. Chaix, J. F. Démonet, L. Bricout, ... & F. George. (2016). Phonological Skills, Visual Attention Span, and Visual Stress in Developmental Dyslexia. *Developmental Psychology*, *52*(10), pp. 1503-1516.

[12] J. P. Rack, M. J. Snowling, & R. K. Olson. (1992). The nonword reading deficit in developmental dyslexia: A review. *Reading Research Quarterly*, pp. 29-53.

[13] M. J. Snel, C. A. J. Aarnoutse, J. Terwel, J. F. J. Van Leeuwe, & W. M. Van der Veld. (2016). Prediction of word recognition in the first half of grade 1. *European Early Childhood Education Research Journal*, *24*(2), pp. 229-238.

[14] T. Papadopoulos, P. Kendeou, & G. Spanoudis. (2012). Investigating the Factor Structure and Measurement Invariance of Phonological Abilities in a Sufficiently Transparent Language. *Journal of Educational Psychology*, *104*(2), pp. 321-336.

[15] E. G. Willcutt, S. A. Petrill, S. Wu, R. Boada, J. C. DeFries, R. K. Olson, & B. F. Pennington. (2013). Comorbidity between reading disability and math disability: Concurrent psychopathology, functional impairment, and neuropsychological functioning. *Journal of learning disabilities*, *46*(6), pp. 500-516.

[16] E. S. Johnson, M. Humphrey, D. F. Mellard, K. Woods, & H. L. Swanson. (2010). Cognitive processing deficits and students with specific learning disabilities: A selective meta-analysis of the literature. *Learning Disability Quarterly*, *33*(1), pp. 3-18.

[17] F. R. Vellutino, D. M. Scanlon, & D. Spearing. (1995). Semantic and phonological coding in poor and normal readers. *Journal of experimental child psychology*, *59*(1), pp. 76-123.

[18] F. R. Vellutino, D. M. Scanlon, E. R. Sipay, S. G. Small, A. Pratt, R. Chen, & M. B. Denckla. (1996). Cognitive profiles of difficult-to-remediate and readily remediated poor readers: Early intervention as a vehicle for distinguishing between cognitive and experiential deficits as basic causes of specific reading disability. *Journal of Educational Psychology*, *88*(4), pp. 601.

[19] T. Katzir, Y. S. Kim, M. Wolf, R. Morris, & M. W. Lovett. (2008). The varieties of pathways to dysfluent reading: Comparing subtypes of children with dyslexia at letter, word, and connected text levels of reading. *Journal of Learning Disabilities*, *41*(1), pp. 47-66.

[20] M. W. Lovett, K. A. Steinbach, & J. C. Frijters. (2000). Remediating the core deficits of developmental reading disability. A double-deficit perspective. *Journal of Learning Disabilities*, *33*(4), pp. 334-58.

[21] T. Papadopoulos, G. Georgiou, & P. Kendeou. (2009). Investigating the Double Deficit Hypothesis in Greek. Findings from a longitudinal study. *Journal of Learning Disabilities, 42*(6), pp. 528-47.

[22] U. Goswami, T. Fosker, M. Huss, N. Mead, & D. Szucs. (2011). Rise time and formant transition duration in the discrimination of speech sounds: The BA-WA distinction in developmental dyslexia. *Developmental Science, 14*, pp. 34-43.

[23] J. Stein. (2014). Dyslexia: the role of vision and visual attention. *Current developmental disorders reports*, *1*(4), pp. 267-280.

[24] A. Facoetti, A. N. Trussardi, M. Ruffino, M. L. Lorusso, C. Cattaneo, R. Galli, ... & M. Zorzi. (2010). Multisensory spatial attention deficits are predictive of phonological decoding skills in developmental dyslexia. *Journal of cognitive neuroscience*, *22*(5), pp. 1011-1025.

[25] G. Ferretti, S. Mazzotti, & D. Brizzolara. (2008). Visual scanning and reading ability in normal and dyslexic children. *Behavioural Neurology*, *19*(1-2), pp. 87-92.

[26] S. Franceschini, S. Gori, M. Ruffino, K. Pedrolli, & A. Facoetti. (2012). A causal link between visual spatial attention and reading acquisition. *Current Biology*, *22*(9), pp. 814-819.

[27] A. Kevan, & K. Pammer. (2009). Predicting early reading skills from pre-reading measures of dorsal stream functioning. *Neuropsychologia*, *47*(14), pp. 3174-3181.

[28] H. Bouma. (1970). Interaction effects in parafoveal letter recognition. *Nature*, *226*, pp. 177-178.

[29] Y. Yeshurun, & E. Rashal. (2010). Precueing attention to the target location diminishes crowding and reduces the critical distance. *Journal of Vision*, *10*(10), pp. 16-16.

[30] M. S. Livingstone, G. D. Rosen, F. W. Drislane, & A. M. Galaburda. (1991). Physiological and anatomical evidence for a magnocellular defect in developmental dyslexia. *Proceedings of the National Academy of Sciences*, *88*(18), pp. 7943-7947.

[31] J. Stein, & V. Walsh. (1997). To see but not to read; the magnocellular theory of dyslexia. *Trends in neurosciences*, *20*(4), pp. 147-152.

[32] M. Zorzi, C. Barbiero, A. Facoetti, I. Lonciari, M. Carrozzi, M. Montico, ... & J. C. Ziegler. (2012). Extra-large letter spacing improves reading in dyslexia. *Proceedings of the National Academy of Sciences*, *109*(28), pp. 11455-11459.

[33] C. J. Stoodley, & J. F. Stein. (2011). The cerebellum and dyslexia. *Cortex*, *47*(1), pp. 101-116.

[34] C. I. De Zeeuw, F. E. Hoebeek, L. W. Bosman, M. Schonewille, L. Witter, & S. K. Koekkoek. (2011). Spatiotemporal firing patterns in the cerebellum. *Nature Reviews Neuroscience*, *12*(6), pp. 327-344.

[35] S. P. Swinnen. (2002). Intermanual coordination: from behavioural principles to neural-network interactions. *Nature Reviews Neuroscience*, *3*(5), pp. 348-359.

[36] R. L. Buckner. (2013). The cerebellum and cognitive function: 25 years of insight from anatomy and neuroimaging. *Neuron*, *80*(3), pp. 807-815.

[37] B. K. Hölzel, J. Carmody, M. Vangel, C. Congleton, S. M. Yerramsetti, T. Gard, & S. W. Lazar. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry Research: Neuroimaging*, *191*(1), pp. 36-43.

[38] J. D. Schmahmann. (2004). Disorders of the cerebellum: ataxia, dysmetria of thought, and the cerebellar cognitive affective syndrome. *The Journal of neuropsychiatry and clinical neurosciences*, *16*(3), pp. 367-378.

[39] G. Hickok, J. Houde, & F. Rong. (2011). Sensorimotor integration in speech processing: computational basis and neural organization. *Neuron*, *69*(3), pp. 407-422.
[40] U. Frith, Rozwiązywanie paradoksów dysleksji. (Resolving the paradoxes of dyslexia), In G. Reid, J. Wearmouth (Eds.), Dysleksja. Teoria i praktyka (Dyslexia and Literacy: Theory and Practice). Gdańsk: Gdańskie Wydawnictwo Psychologiczne, 2008, pp. 71–101.
[41] L. S. Fuchs, D. Fuchs, & D. L. Compton. (2010). Rethinking response to intervention at middle and high school. *School Psychology Review*, *39*(1), pp. 22-28.
[42] J. Pollock, & E. Waller, *Day-to-Day Dyslexia in the Classroom*. London: Routledge, 2001.
[43] M. Bogdanowicz, & A. Adryjanek, *Uczeń z dysleksją w szkole. Poradnik nie tylko dla po lonistów* (A student with dyslexia in school. Guide not only for Polish language teachers). Gdynia: Operon, 2004.
[44] S.P.K. Jena, *Learning Disability. Theory to Practice.* SAGE Publications India Pvt Ltd. India, 2013.
[45] L. A. Ellis, K. Wheldall, & R. Beaman. (2007). The research locus and conceptual basis for MULTILIT: Why we do what we do. *Australian Journal of Learning Disabilities, 12*, pp. 61–65.
[46] M. W. Lovett, R. W. Barron, & N. J. Benson. (2003). Effective remediation of word identification and decoding difficulties in school-age children with reading disabilities. *Handbook of learning disabilities*, *11*, pp. 273-292.
[47] National research Council, *Preventing reading difficulties in young children*. Washington DC: National Academies Press, 1998.
[48] R. K. Olson, & B. Wise, "Computer-based remediation for reading and related phonological disabilities", in *International handbook of literacy and technology*, vol. 2, M. C. McKenna, L. D. Labbo, R. D. Kieffer, & D. Reinkin, Ed. Mahwah, NJ: Lawrence Erlbaum, 2006, pp. 57–74.
[49] R. L. Peterson, & B. F. Pennington. (2012). Developmental dyslexia. *The Lancet*, *379*(9830), pp. 1997-2007.
[50] K. Rayner, B. R. Foorman, C. A. Perfetti, D. Pesetsky, & M. S. Seidenberg. (2001). How psychological science informs the teaching of reading. *Psychological science in the public interest*, *2*(2), pp. 31-74.
[51] V. W. Berninger, W. Raskind, T. Richards, R. Abbott, & P. Stock. (2008). A multidisciplinary approach to understanding developmental dyslexia within working-memory architecture: Genotypes, phenotypes, brain, and instruction. *Developmental neuropsychology*, *33*(6), pp. 707-744.
[52] J. F. Démonet, M. J. Taylor, & Y. Chaix. (2004). Developmental dyslexia. *The Lancet*, *363*(9419), pp. 1451-1460.
[53] J. D. Gabrieli. (2009). Dyslexia: a new synergy between education and cognitive neuroscience. *science*, *325*(5938), pp. 280-283.
[54] A. Fawcett, *Evaluating Therapies Excluding Traditional Reading and Phonological Based Therapies: A Review for the Department of Education and Skills, the British Dyslexia Association and the Dyslexia Institute*. London: Department of Education and Skills, 2002.
[55] B. F. Pennington. (2011). Controversial therapies for dyslexia. *Perspectives on language and literacy: a quarterly publication of the International Dyslexia Association*, *37*.
[56] H. Swanson, *Interventions for Students with Learning Disabilities: A Meta-Analysis of Treatment Outcomes*. New York: Guilford, 1999.
[57] L. J. McCann, & S. J. Newell. (2006). Survey of paediatric complementary and alternative medicine use in health and chronic illness. *Archives of disease in childhood*, *91*(2), pp. 173-174.
[58] D. Z. Samdup, R. G. Smith, & S. I. Song. (2006). The use of complementary and alternative medicine in children with chronic medical conditions. *American journal of physical medicine & rehabilitation*, *85*(10), pp. 842-846.
[59] M. A. Tansey. (1991). Wechsler (wisc-r) changes following treatment of learning disabilities via eeg biofeedback raining in a private practice setting. *Australian Journal of Psychology*, *43*(3), pp. 147-153.
[60] A. Davis, *Sound Therapy Through the Listening Program*. MT Arlington, NJ: Advanced Brain Technologies, 2002.
[61] D. Aldridge, D. Gustorff, & L. Neugebauer. (2002). A pilot study of music therapy in the treatment of developmental delay. *Complementary Therapies in Medicine*, *3*, pp. 197–205.
[62] C. Ferrari, & R. Wainright, *Breakthrough for Dyslexia and Learning Disabilities*. Fort Lauderdale, Florida: Exposition, 1984.
[63] J. Hinds. (1985). Observations on the use of Baryta Carbonica in adult dyslexics. *Communications*, *1*, pp. 55–59.
[64] D. Reynolds, R. I. Nicolson, & H. Hambly. (2003). Evaluation of an exercise-based treatment for children with reading difficulties. *Dyslexia*, *9*(1), pp. 48-71.
[65] K. M. Bogdanowicz, G. Krasowicz-Kupis, & K. Wiejak. (2016). In search of effective remediation for students with developmental dyslexia–a review of contemporary English literature. *Polish Psychological Bulletin*, *47*(3), pp. 270-280.
[66] P. D. Pumfrey, & R. Reason, *Specific Learning Difficulties, Challenges and Responses*. London: NFER-Nelson, 1991.
[67] P. R. Ziring, D. Brazdziunas, W. C. Cooley, T. A. Kastner, M. E. Kummer, D. Pijem, ... & W. Anderson. (1998). Learning disabilities, dyslexia, and vision. *Pediatrics*, *102*(5), pp. 1217-1219.
[68] L. Bull. (2007). Sunflower therapy for children with specific learning difficulties (dyslexia): a randomised, controlled trial. *Complementary therapies in clinical practice*, *13*(1), pp. 15-24.
[69] A. J. Richardson, & B. K. Puri. (2002). A randomized double-blind, placebo-controlled study of the effects of supplementation with highly unsaturated fatty acids on ADHD-related symptoms in children with specific learning difficulties. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *26*(2), pp. 233-239.
[70] D. V. Bishop. (2007). Curing dyslexia and attention-deficit hyperactivity disorder by training motor co-ordination: Miracle or myth?. *Journal of paediatrics and child health*, *43*(10), pp. 653-655.
[71] J. Stephenson, & K. Wheldall. (2008). Miracles take a little longer: Science, commercialisation, cures and the Dore program. *Australasian Journal of Special Education*, *32*(1), pp. 67-82.
[72] K. A. Kavale, & P. D. Mattson. (1983). 'One jumped off the balance beam': Meta-analysis of perceptual-motor training. *Journal of Learning Disabilities, 16*, pp. 165–173.
[73] J. Stephenson, M. Carter, & K. Wheldall. (2007). Still jumping on the balance beam: Continueduse of perceptual motor programs in Australian schools. *Australian Journal of Education, 51*, pp. 6–18.
[74] T. Smith, "The appeal of unvalidated treatments", in *Controversial therapies for developmental disabilities: Fad, fashion, and science in professional practice*, J. W. Jacobson, R. M. Foxx, & J. A. Mulick, Ed. Mahwah, NJ: Lawrence Erlbaum, 2005, pp. 45–57.
[75] D. D. Hammill. (2004). What we know about correlates of reading. *Exceptional Children, 70*, pp. 453–468.
[76] W. Dore, & D. Brookes, *Dyslexia: The miracle cure*. London: John Blake, 2006.
[77] D. Reynolds, & R. I. Nicolson. (2007). Follow-up of an exercise-based treatment for children with reading difficulties. *Dyslexia, 13*, pp. 78–96.
[78] P. J. Hatcher. (2003). Reading intervention: A 'conventional' and successful approach to helping dyslexic children acquire literacy. *Dyslexia, 9*, pp. 140–145.
[79] M. McPhillips. (2003). A commentary on an article published in the February 2003 edition of Dyslexia, 'Evaluation of an exercise-based treatment for children with reading difficulties' (Reynolds, Nicolson, & Hambly). *Dyslexia, 9*, pp. 161–163.
[80] J. Rack. (2003). The who, what, why and how of intervention programmes: Comments on the DDAT evaluation. *Dyslexia, 9,* pp. 137–139.
[81] J. P. Rack, M. Snowling, C. Hulme, & S. Gibbs. (2007). No evidence that an exercise-based treatment program (DDAT) has specific benefits for children with reading difficulties. *Dyslexia, 13*, pp. 97–104.
[82] I. L. Richards, E. Moores, C. Witton, P. A. Reddy, G. Rippon, & K. S. H. Rochelle, et al. (2003). Science, sophistry and 'commercial sensitivity': Comments on 'Evaluation of an exercise-based treatment for children with reading difficulties' by Reynolds, Nicolson and Hambly. *Dyslexia, 9*, pp. 146–150.
[83] C. Singleton, & M. Stuart. (2003). Measurement mischief: A critique of Reynolds, Nicolson, and Hambly (2003). *Dyslexia, 9,* pp. 151–160.
[84] M. J. Snowling, & C. Hulme. (2003). A critique of claims from Nicolson & Hambly (2003) that DDAT is an effective treatment for children with reading difficulties—'lies, damned lies and (inappropriate) statistics?' *Dyslexia, 9*, pp. 127–133.
[85] H. Whiteley, & D. Pope. (2003). Reynolds, D., Nicolson, R. I. and Hambly, H. (2003), Evaluation of an exercise-based treatment for children with reading difficulties. *Dyslexia, 9*, pp. 164–166.
[86] K. S. Holt, *Child development: Diagnosis and assessment*. London: Butterworth–Heinemann, 1991.
[87] M. McPhillips, P. G. Hepper, & G. Mulhern. (2000). Effects of replicating primary-reflexmovements on specific reading difficulties in children: A randomised, double-blind, controlled trial. *The Lancet*, *355*(9203), pp. 537–541.
[88] R. S. Paine. (1964). The evolution of infantile postural reflexes in the presence of chronic brain syndromes. *Developmental Medicine and Child Neurology*, *6*, pp. 345–361.
[89] M. McPhillips, & J. A. Jordan-Black. (2007). Primary reflex persistence in children with reading difficulties (dyslexia): A cross-sectional study. *Neuropsychologia*, *45*(4), pp. 748-754.

[90] K. J. Hyatt, J. Stephenson, & M. Carter. (2009). A review of three controversial educational practices: Perceptual motor programs, sensory integration, and tinted lenses. *Education and Treatment of Children*, *32*(2), pp. 313-342.
[91] J. A. Jordan-Black. (2005). The effects of the Primary Movement programme on the academic performance of children attending ordinary primary school. *Journal of Research in Special Educational Needs*, *5*(3), pp. 101-111.
[92] M. Mathews, R. Mathews, & E. Thomas, *The sunflower method: a new approach to helping children with learning difficulties*. Guildford: Sunflower Trust, 1998.
[93] B. Klinkoski, & C. Leboeuf. (1990). A review of the research papers published by the international college of applied kinesiology from 1981 to 1987. *Journal of Manipulative Physiological Therapy, 13*(4), pp. 190–4.
[94] Brain Gym International. (2016, 27 November). Available http://www.braingym.org/about
[95] S. O. Lilienfeld, R. Ammirati, & M. David. (2012). Distinguishing science from pseudoscience in school psychology: Science and scientific thinking as safeguards against human error. *Journal of School Psychology, 50*(1), pp. 7–36.
[96] T. D. Ben-Soussan, K. Avirame, J. Glicksohn, A. Goldstein, Y. Harpaz, & M. Ben-Shachar. (2014). Changes in cerebellar activity and inter-hemispheric coherence accompany improved reading performance following Quadrato Motor Training. *Frontiers in systems neuroscience*, *8*, pp. 81.
[97] J. Stein, & Z. Kapoula, *Visual aspects of dyslexia*. Oxford: Oxford University Press, 2012.
[98] H. Irlen, *Reading by the colours: Overcoming dyslexia and other reading disabilities through the Irlen method*. New York: Avery, 1991.
[99] A. J. Wilkins, *Visual Stress*. Oxford: Oxford University Press, 1995.
[100] O. Meares. (1980). Figure/ground, brightness contrast, and reading disabilities. *Visible language*, *14*(1), pp. 13-29.
[101] H. Irlen, *Successful treatment of learning difficulties*. The Annual Convention of the American Psychological Association, Anaheim, USA, 1983.
[102] B. J. Evans, & P. M. Allen. (2016). A systematic review of controlled trials on visual stress using Intuitive Overlays or the Intuitive Colorimeter. *Journal of Optometry*, *9*(4), pp. 205-218.
[103] J. Stein, & S. Fowler. (1985). Effect of monocular occlusion on visuomotor perception and reading in dyslexic children. *The Lancet*, *326*(8446), pp. 69-73.
[104] R. Kruk, K. Sumbler, & D. Willows. (2008). Visual processing characteristics of children with Meares–Irlen syndrome. *Ophthalmic and Physiological Optics*, *28*(1), pp. 35-46.
[105] A. J. Wilkins, *Reading through colour: how coloured filters can reduce reading difficulty, eye strain, and headaches*. UK, Chichester: Wiley, 2003.
[106] I. Kriss, & B. J. Evans. (2005). The relationship between dyslexia and Meares-Irlen Syndrome. *Journal of Research in Reading*, *28*(3), pp. 350-364.
[107] P. Harries, R. Hall, N. Ray, & J. Stein. (2015). Using coloured filters to reduce the symptoms of visual stress in children with reading delay. *Scandinavian journal of occupational therapy*, *22*(2), pp. 153-160.
[108] B. J. Evans, & F. Joseph. (2002). The effect of coloured filters on the rate of reading in an adult student population. *Ophthalmic and Physiological Optics*, *22*(6), pp. 535-545.
[109] J. Rose, *Identifying and teaching children and young people with dyslexia and literacy difficulties: An independent report*. DCSF, 2009.
[110] R. Jeanes, A. Busby, J. Martin, E. Lewis, N. Stevenson, D. Pointon, & A. Wilkins. (1997). Prolonged use of coloured overlays for classroom reading. *British Journal of Psychology*, *88*(4), pp. 541-548.
[111] N. Northway, V. Manahilov, & W. Simpson. (2010). Coloured filters improve exclusion of perceptual noise in visually symptomatic dyslexics. *Journal of Research in Reading*, *33*(3), pp. 223-230.
[112] G. L. Robinson, & P. J. Foreman. (1999). Scotopic sensitivity/Irlen syndrome and the use of coloured filters: a long-term placebo-controlled study of reading strategies using analysis of miscue. *Perceptual and motor skills*, *88*(1), pp. 35-52.
[113] A. Wilkins. (2002). Coloured overlays and their effects on reading speed: a review. *Ophthalmic and Physiological Optics*, *22*(5), pp. 448-454.
[114] A. Wilkins, E. Lewis, F. Smith, E. Rowland, & W. Tweedie. (2001). Coloured overlays and their benefit for reading. *Journal of Research in Reading*, *24*(1), pp. 41-64.
[115] A. J. Wilkins, B. J. W. Evans, J. A. Brown, A. E. Busby, A. E. Wingfield, R. J. Jeanes, & J. Bald. (1994). Double-masked placebo-controlled trial of precision spectral filters in children who use coloured overlays. *Ophthalmic and Physiological Optics*, *14*(4), pp. 365-370.
[116] Y. Xiao, Y. I. Wang, & D. J. Felleman. (2003). A spatially organized representation of colour in macaque cortical area V2. *Nature*, *421*(6922), pp. 535-539.
[117] B. J. Evans, R. Patel, A. J. Wilkins, A. Lightstone, F. Eperjesi, L. Speedwell, & J. Duffy. (1999). A review of the management of 323 consecutive patients seen in a specific learning difficulties clinic. *Ophthalmic and Physiological Optics*, *19*(6), pp. 454-466.
[118] R. Tyrrell, K. Holland, D. Dennis, & A. Wilkins. (1995). Coloured overlays, visual discomfort, visual search and classroom reading. *Journal of Research in Reading*, *18*(1), pp. 10-23.
[119] A. J. Wilkins, R. J. Jeanes, P. D. Pumfrey, & M. Laskier. (1996). Rate of Reading Test®: its reliability, and its validity in the assessment of the effects of coloured overlays. *Ophthalmic and Physiological Optics*, *16*(6), pp. 491-497.
[120] G. L. Robinson, & R. N. Conway. (2000). Irlen lenses & adults a small scale study of reading speed, accuracy, comprehension & self-image. *Australian Journal of Learning Difficulties*, *5*(1), pp. 4-13.
[121] M. C. Williams, K. LeCluyse, & A. Rock-Faucheux. (1992). Effective interventions for reading disability. *J. Am. Optom. Assoc., 63*, pp. 411–417.
[122] A. Maclachlan, S. Yale, & A. Wilkins. (1993). Open trial of subjective precision tinting: A follow-up of 55 patients. *Ophthalmic and Physiological Optics*, *13*(2), pp. 175-178.
[123] N. J. Ray, S. Fowler, & J. F. Stein. (2005). Yellow filters can improve magnocellular function: motion sensitivity, convergence, accommodation, and reading. *Annals of the New York Academy of Sciences*, *1039*(1), pp. 283-293.
[124] M. W. Hankins, S. N. Peirson, & R. G. Foster. (2008). Melanopsin: an exciting photopigment. *Trends in neurosciences*, *31*(1), pp. 27-36.
[125] R. Hall, N. Ray, P. Harries, & J. Stein. (2013). A comparison of two-coloured filter systems for treating visual reading difficulties. *Disability and rehabilitation*, *35*(26), pp. 2221-2226.
[126] G. L. Robinson, & P. J. Foreman. (1999). Scotopic sensitivity/Irlen syndrome and the use of coloured filters: a long-term placebo controlled and masked study of reading achievement and perception of ability. *Perceptual and motor skills*, *89*(1), pp. 83-113.
[127] P. M. Allen, B. J. Evans, & A. J. Wilkins. (2012). The uses of colour in optometric practice to ameliorate symptoms of visual stress. *Optometry in Practice*, *13*(1), pp. 1-8.
[128] American Academy of Pediatrics. (2009). Learning disabilities, dyslexia, and vision. *Pediatrics*, *124*(2), pp. 837-844.
[129] S. J. Menacker, M. E. Breton, M. L. Breton, J. Radcliffe, & G. A. Gole. (1993). Do tinted lenses improve the reading performance of dyslexic children?: a cohort study. *Archives of Ophthalmology*, *111*(2), pp. 213-218.
[130] P. Tallal. (1980). Auditory temporal perception, phonics, and reading disabilities in children. *Brain and Language, 9,* pp. 182-198.
[131] M. A. Reed. (1989). Speech perception and the discrimination of brief auditory cues in reading disabled children. *Journal of Experimental Child Psychology, 48*, pp. 270–292.
[132] P. Tallal, "Experimental studies of language learning impairments: From research to remediation", in *Speech and language impairments in children*, D. M. V. Bishop, & L. B. Leonard Ed. Hove: Psychology Press, 2000, pp. 131–155.
[133] P. Tallal, S. Miller, & R. H. Fitch. (1993). Neurobiological basis of speech: A case for the pre-eminence of temporal processing. *Annals of the New York Academy of Science, 682*, pp. 27–47.
[134] P. Tallal, S. L. Miller, G. Bedi, G. Byma, X. Wang, S. S. Nagarajan, C. Schreiner, W. M. Jenkins, & M. M. Merzenich. (1996). Language comprehension in language- learning impaired children improved with acoustically modified speech. *Science, 271*, pp. 81–84.
[135] J. M. Thomson, V. Leong, & U. Goswami. (2013). Auditory processing interventions and developmental dyslexia: a comparison of phonemic and rhythmic approaches. *Reading and Writing*, *26*(2), pp. 139-161.
[136] M. M. Merzenich, & W. M. Jenkins, "Cortical plasticity, learning, and learning dysfunction", in *Maturational windows in adult cortical plasticity*, B. Julesz, & I. Kavocs Ed. New York: Addison-Wesley, 1998, pp. 247–272.
[137] A. W. Alexander, & A. M. Slinger-Constant. (2004). Current status of treatments for dyslexia: Critical review. *Journal of child neurology*, *19*(10), pp. 744-758.
[138] Scientific Learning Cooperation. *Fastforword.* Berkley, CA: Scientific Learning Cooperation, 1996.
[139] Cognitive Concepts. *Earobics auditory development and phonics reading program.* Evanston IL: Cognitive Concepts, 1998.

[140] S. F. Diehl. (1999). Listen and learn? A software review of Earobics®. *Language, Speech, and Hearing Services in Schools*, *30*(1), pp. 108-116.
[141] S. Morrison. (1998). Computer applications: Earobics Pro. *Child Language Teaching and Therapy*, *14*, pp. 279-284.
[142] G. D. Chermak, & F. Musiek, *Handbook of (Central) Auditory Processing Disorder: Comprehensive Intervention, Vol II.* San Diego: Plural Publishing, 2007, pp. 792.
[143] E. A. Hayes, C. M. Warrier, T. G. Nicol, S. G. Zecker, & N. Kraus. (2003). Neural plasticity following auditory training in children with learning problems. *Clinical neurophysiology*, *114*(4), pp. 673-684.
[144] C. M. Warrier, K. L. Johnson, E. A. Hayes, T. Nicol, & N. Kraus. (2004). Learning impaired children exhibit timing deficits and training-related improvements in auditory cortical responses to speech in noise. *Experimental Brain Research*, *157*(4), pp. 431-441.
[145] N. M. Russo, T. G. Nicol, S. G. Zecker, E. A. Hayes, & N. Kraus. (2005). Auditory training improves neural timing in the human brainstem. *Behavioural brain research*, *156*(1), pp. 95-103.
[146] J. H. Y. Loo, D. E. Bamiou, N. Campbell, & L. M. Luxon. (2010). Computer-based auditory training (CBAT): benefits for children with language-and reading-related learning difficulties. *Developmental Medicine & Child Neurology*, *52*(8), pp. 708-717.
[147] M. M. Merzenich, W. M. Jenkins, P. Johnston, C. Schreiner, S. L. Miller, & P. Tallal. (1996). Temporal processing deficits of language-learning impaired children ameliorated by training. *Science, 271*, pp. 77–81.
[148] W. Serniclaes, G. Collet, & L. Sprenger-Charolles. (2015). Review of neural rehabilitation programs for dyslexia: how can an allophonic system be changed into a phonemic one?. *Frontiers in psychology*, *6*.
[149] G. K. Strong, C. J. Torgerson, D. Torgerson, & C. Hulme. (2011). A systematic meta-analytic review of evidence for the effectiveness of the 'Fast ForWord'language intervention program. *Journal of Child Psychology and Psychiatry*, *52*(3), pp. 224-235.
[150] S. S. Nagarajan, X. Wang, M. M. Merzenich, C. Schreiner, P. Johnston, W. M. Jenkins, S. Miller, & P. Tallal. (1998). Speech modification algorithms used for training language learning-impaired children. *IEEE Transactions on Rehabilitation Engineering, 6*, pp. 257–268.
[151] F. M. Cirrin, & R. B. Gillam. (2008). Language intervention practices for school-age children with spoken language disorders: A systematic review. *Language, Speech and Hearing Services in Schools, 39*, pp. S110–S137.
[152] Scientific Learning Corporation. National field trial results: *Results of Fast ForWord training for children with language and reading problems.* Berkeley, CA: Scientific Learning Corporation, 1999.
[153] Scientific Learning Corporation. (2003). Scientifically based reading research and the Fast ForWord Products: Research implication for effective language and reading intervention. *MAPS for Learning: Research Report, 7*, pp. 1–7.
[154] R. B. Gillam. (1999). Computer-assisted language intervention using Fast ForWord: Theoretical and empirical considerations for clinical decision-making. *Language, Speech, and Hearing Services in Schools, 30*, p.p. 363–370.
[155] M. Studdert-Kennedy, & M. Mody. (1995). Auditory temporal perception deficits in the readingimpaired: A critical review of the evidence. *Psychonomic Bulletin & Review, 2*, pp. 508–514.
[156] T. K. Veale. (1999). Targeting temporal processing deficits through Fast ForWord: Language therapy with a new twist. *Language, Speech, and Hearing Services in Schools, 30*, pp. 345–352.
[157] What Works Clearinghouse. (2007, July). *Fast ForWord: Beginning reading*. US Department of Education, Institute of Education Sciences. Available http://ies.ed.gov/ncee/wwc/
[158] G. M. McArthur. (2008). Does What Works Clearinghouse work? A brief review of Fast ForWord. *Australasian Journal of Special Education, 32*, pp. 101–107.
[159] W. Cohen, A. Hodson, A. O'Hare, J. Boyle, T. Durrani, & E. McCartney. (2005). Effects of computer-based intervention through acoustically modified speech (Fast ForWord) in severe mixed receptive-expressive language impairment: Outcomes from a randomized controlled trial. *Journal of Speech, Language, and Hearing Research, 48*, pp. 715-729.
[160] R. B. Gillam, D. F. Loeb, L. M. Hoffman, T. Bohman, C. A. Champlin, L. Thibodeau, … S. Friel-Patti. (2008). The efficacy of Fast ForWord Language intervention in school-age children with language impairment: A randomized controlled trial. *Journal of Speech, Language, and Hearing Research, 51*, pp. 97-119.
[161] P. E. Hook, P. Macaruso, & S. Jones. (2001). Efficacy of Fast ForWord training on facilitating acquisition of reading skills by children with reading difficulties—A longitudinal study. Annals of Dyslexia, 51, pp. 75–96.
[162] G. A. Troia, & S. D. Whitney. (2003). A close look at the efficacy of Fast ForWord Language for children with academic weaknesses. *Contemporary Educational Psychology*, *28*(4), pp. 465-494.
[163] G. M. McArthur, D. Ellis, C. Atkinson, & M. Coltheart. (2008). Auditory processing deficits in children with reading and language impairments: Can they (and should they) be treated? *Cognition, 107*, pp. 946–977.
[164] C. B. Sisson. (2009). A meta-analytic investigation into the efficacy of Fast ForWord intervention on improving academic performance (Doctoral dissertation, Regent University, 2009). *Dissertation Abstracts International Section A: Humanities and Social Sciences, 69*(12A), pp. 4633.
[165] A. G. Bus, & M. H. van IJzendoorn. (1999). Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology, 91*, pp. 403–414.
[166] National Institute of Child Health and Human Development. *Report of the National Reading Panel. Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups (NIH Publication No. 00-4754)*. Washington, DC: US Government Printing Office, 2000.
[167] E. Flaugnacco, L. Lopez, C. Terribili, M. Montico, S. Zoia, & D. Schön. (2015). Music training increases phonological awareness and reading skills in developmental dyslexia: a randomized control trial. *PLoS One*, *10*(9). Available https://doi.org/10.1371/journal.pone.0138715
[168] J. Hamalainen, P. Leppanen, K. Eklund, J. M. Thomson, U. Richardson, T. Guttorm, … H. Lyytinen. (2009). Common variance in amplitude envelope perception tasks and their impact on phoneme duration perception and reading and spelling in Finnish children with reading disabilities. *Applied Psycholinguistics, 30*, pp. 511-530.
[169] E. S. Pasquini, K. H. Corriveau, & U. Goswami. (2007). Auditory processing of amplitude envelope rise time in adults diagnosed with developmental dyslexia. *Scientific Studies of Reading, 11*, pp. 259-286.
[170] H. Poelmans, H. Luts, M. Vandermosten, B. Boets, P. Ghesquière, & J. Wouters. (2011). Reduced sensitivity to slow-rate dynamic auditory information in children with dyslexia. *Research in Developmental Disabilities, 32,* pp. 2810-2819.
[171] Z. Suranyi, V. Csepe, U. Richardson, J. M. Thomson, F. Honbolygo, & U. Goswami. (2009). Sensitivity to rhythmic parameters in dyslexic children: a comparison of Hungarian and English. *Reading and Writing: An Interdisciplinary Journal, 22*, pp. 41-56.
[172] J. M. Thomson, & U. Goswami. (2010). Learning novel phonological representations in developmental dyslexia: Associations with basic auditory processing of rise time and phonological awareness. *Reading and Writing: An Interdisciplinary Journal, 23*, pp. 453-473.
[173] M. Huss, J. P. Verney, T. Fosker, N. Mead, & U. Goswami. (2011). Music, rhythm, rise time perception and developmental dyslexia: perception of musical meter predicts reading and phonology. *Cortex*, *47*(6), pp. 674-689.
[174] P. Bishop-Liebler, G. Welch, M. Huss, J. M. Thomson, & U. Goswami. (2014). Auditory temporal processing skills in musicians with dyslexia. *Dyslexia*, *20*(3), pp. 261-279.
[175] E. Flaugnacco, L. Lopez, C. Terribili, S. Zoia, S. Buda, S. Tilli, ... & D. Schön. (2014). Rhythm perception and production predict reading abilities in developmental dyslexia. *Frontiers in human neuroscience*, *8*, pp. 392.
[176] K. Overy. (2003). Dyslexia and music. *Annals of the New York Academy of Sciences*, *999*(1), pp. 497-505.
[177] L. Przybylski, N. Bedoin, S. Krifi-Papoz, V. Herbillon, D. Roch, L. Léculier, ... & B. Tillmann. (2013). Rhythmic auditory stimulation influences syntactic processing in children with developmental language disorders. *Neuropsychology*, *27*(1), pp. 121.
[178] J. Slater, A. Tierney, & N. Kraus. (2013). At-risk elementary school children with one year of classroom music instruction are better at keeping a beat. *PLoS One*, *8*(10). Available https://doi.org/10.1371/journal.pone.0077250
[179] A. H. Weiss, R. Y. Granot, & M. Ahissar. (2014). The enigma of dyslexic musicians. Neuropsychologia, 54, pp. 28-40.
[180] M. Habib, C. Lardy, T. Desiles, C. Commeiras, J. Chobert, & M. Besson. (2016). Music and dyslexia: a new musical training method to improve reading and related disorders. *Frontiers in psychology*, *7*.
[181] D. J. C. Hawkey, S. Amitay, & D. R. Moore. (2004). Early and rapid perceptual learning. *Nature Neuroscience, 7*, pp. 1055-1056.
[182] I. Heth, & M. Lavidor. (2015). Improved reading measures in adults with dyslexia following transcranial direct current stimulation treatment. *Neuropsychologia*, *70*, pp. 107-113.

[183] J. Stein, The neurobiological basis of dyslexia: The magnocellular theory. *The Handbook of the Neuropsychology of Language, Volume 1&2*, 2012, pp. 938-962.
[184] O. A. Olulade, E. M. Napoliello, & G. F. Eden. (2013). Abnormal visual motion processing is not a cause of dyslexia. *Neuron*, *79*(1), pp. 180-190.
[185] R. Laycock, D. P. Crewther, P. B. Fitzgerald, & S. G. Crewther. (2009). TMS disruption of V5/MT+ indicates a role for the dorsal stream in word recognition. *Experimental brain research*, *197*(1), pp. 69-79.
[186] A. Au, & B. Lovegrove. (2001). Temporal processing ability in above average and average readers. *Attention, Perception, & Psychophysics*, *63*(1), pp. 148-155.
[187] E. Conlon, M. Sanders, & S. Zapart. (2004). Temporal processing in poor adult readers. *Neuropsychologia*, *42*(2), pp. 142-157.
[188] P. L. Cornelissen, P. C. Hansen, I. D. Gilchrist, F. Cormack, J. Essex, & C. Frankish. (1998). Coherent motion detection and letter position encoding. *Vision Research*, *38*(14), pp. 2181-2191.
[189] M. B. Denckla, & R. G. Rudel. (1976). Rapid 'automatized'naming (RAN): Dyslexia differentiated from other learning disabilities. *Neuropsychologia*, *14*(4), pp. 471-479.
[190] E. S. Norton, & M. Wolf. (2012). Rapid automatized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. *Annual review of psychology*, *63*, pp. 427-452.
[191] L. S. Fuchs, D. Fuchs, M. K. Hosp, & J. R. Jenkins. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. *Scientific studies of reading*, *5*(3), pp. 239-256.
[192] J. Stein. (2001). The magnocellular theory of developmental dyslexia. *Dyslexia*, *7*(1), pp. 12-36.
[193] P. E. Turkeltaub, J. Benson, R. H. Hamilton, A. Datta, M. Bikson, & H. B. Coslett. (2012). Left lateralizing transcranial direct current stimulation improves reading efficiency. *Brain stimulation*, *5*(3), pp. 201-207.
[194] F. Costanzo, D. Menghini, C. Caltagirone, M. Oliveri, & S. Vicari. (2013). How to improve reading skills in dyslexics: the effect of high frequency rTMS. *Neuropsychologia*, *51*(14), pp. 2953-2959.
[195] J. J. Borckardt, Z. H. Nahas, J. Teal, S. H. Lisanby, W. M. McDonald, D. Avery, ... & M. S. George. (2013). The painfulness of active, but not sham, transcranial magnetic stimulation decreases rapidly over time: results from the double-blind phase of the OPT-TMS trial. *Brain stimulation*, *6*(6), pp. 925-928.
[196] M. H. Breteler, M. Arns, S. Peters, I. Giepmans, & L. Verhoeven. (2010). Improvements in spelling after QEEG-based neurofeedback in dyslexia: A randomized controlled treatment study. *Applied psychophysiology and biofeedback*, *35*(1), pp. 5-11.
[197] S. E. Shaywitz, & B. A. Shaywitz. (2005). Dyslexia (specific reading disability). *Biological Psychiatry, 57*, pp. 1301–1309.
[198] K. E. Thornton, & D. P. Carmody. (2005). Electroencephalogram biofeedback for reading disability and traumatic brain injury. *Child and adolescent psychiatric clinics of North America*, *14*(1), pp. 137-162.
[199] J. E. Walker, & C. A. Norman. (2006). The neurophysiology of dyslexia: A selective review with implications for neurofeedback remediation and results of treatment in twelve consecutive patients. *Journal of Neurotherapy*, *10*(1), pp. 45-55.
[200] J. B. Wilmer, A. J. Richardson, Y. Chen, & J. F. Stein. (2004). Two visual motion processing deficits in developmental dyslexia associated with different reading skills deficits. *Journal of Cognitive Neuroscience*, *16*(4), pp. 528-540.
[201] D. J. Bakker, R. Moerland, & M. Goekoop-Hoetkens. (1981). Effects of hemisphere-specific stimulation on the reading performance of dyslexic boys: A pilot study. *Journal of Clinical and Experimental Neuropsychology*, *3*(2), pp. 155-159.
[202] E. J. Kappers. (1997). Outpatient treatment of dyslexia through stimulation of the cerebral hemispheres. *Journal of Learning disabilities*, *30*(1), pp. 100-125.
[203] M. L. Lorusso, A. Facoetti, P. Paganoni, M. Pezzani, & M. Molteni. (2006). Effects of visual hemisphere-specific stimulation versus reading-focused training in dyslexic children. *Neuropsychological rehabilitation*, *16*(2), pp. 194-212.
[204] A. Au, G. S. Ho, E. W. Choi, P. Leung, M. M. Waye, K. Kang, & K. Y. Au. (2014). Does it help to train attention in dyslexic children: pilot case studies with a ten-session neurofeedback program. *International Journal on Disability and Human Development*, *13*(1), pp. 45-54.
[205] J. P. Schuchardt, M. Huss, M. Stauss-Grabo, & A. Hahn. (2010). Significance of long-chain polyunsaturated fatty acids (PUFAs) for the development and behaviour of children. *European journal of pediatrics*, *169*(2), pp. 149-164.
[206] R. V. Gow, & J. R. Hibbeln. (2014). Omega-3 and treatment implications in Attention Deficit Hyperactivity Disorder (ADHD) and associated behavioral symptoms. *Lipid Technology*, *26*(1), pp. 7-10.
[207] D. W. Luchtman, & C. Song. (2013). Cognitive enhancement by omega-3 fatty acids from child-hood to old age: findings from animal and clinical studies. *Neuropharmacology*, *64*, pp. 550-565.
[208] E. Cyhlarova, J. G. Bell, J. R. Dick, E. E. MacKinlay, J. F. Stein, & A. J. Richardson. (2007). Membrane fatty acids, reading and spelling in dyslexic and non-dyslexic adults. *European Neuropsychopharmacology*, *17*(2), pp. 116-121.
[209] M. Laasonen, A. T. Erkkilä, E. Isotalo, J. J. Pulkkinen, M. L. Haapanen, & V. Virsu. (2006). Serum lipid fatty acids, phonological processing, and reading in children with oral clefts. *Prostaglandins, leukotrienes and essential fatty acids*, *74*(1), pp. 7-16.
[210] A. J. Richardson, C. M. Calvin, C. Clisby, D. R. Schoenheimer, P. Montgomery, J. A. Hall, ... & J. F. Stein. (2000). Fatty acid deficiency signs predict the severity of reading and related difficulties in dyslexic children. *Prostaglandins, Leukotrienes and Essential Fatty Acids (PLEFA)*, *63*(1), pp. 69-74.
[211] M. Zelcer, & R. D. Goldman. (2015). Omega-3 and dyslexia Uncertain connection. *Canadian Family Physician*, *61*(9), pp. 768-770.
[212] J. Stein. (2000) The neurobiology of reading difficulties. *Prostaglandins Leukot Essent Fatty Acids, 63*, pp. 109–116.
[213] S. M. Baker. (1985). A biochemical approach to the problem of dyslexia. *Journal of Learning Disabilities*, *18*(10), pp. 581-584.
[214] A. J. Richardson. (2004). Clinical trials of fatty acid treatment in ADHD, dyslexia, dyspraxia and the autistic spectrum. *Prostaglandins, leukotrienes and essential fatty acids*, *70*(4), pp. 383-390.
[215] A. J. Richardson. (2006). Omega-3 fatty acids in ADHD and related neurodevelopmental disorders. *International review of psychiatry*, *18*(2), pp. 155-172.
[216] A. J. Richardson, & P. Montgomery. (2005). The Oxford-Durham study: a randomized, controlled trial of dietary supplementation with fatty acids in children with developmental coordination disorder. *Pediatrics*, *115*(5), pp. 1360-1366.
[217] A. J. Richardson, & M. A. Ross. (2000). Fatty acid metabolism in neurodevelopmental disorder: a new perspective on associations between attention-deficit/hyperactivity disorder, dyslexia, dyspraxia and the autistic spectrum. *Prostaglandins, Leukotrienes and Essential Fatty Acids (PLEFA)*, *63*(1), pp. 1-9.
[218] L. Lindmark, & P. Clough. (2007). A 5-month open study with long-chain polyunsaturated fatty acids in dyslexia. *Journal of medicinal food*, *10*(4), pp. 662-666.
[219] M. L. Tan, J. J. Ho, & K. H. Teh. (2016). Polyunsaturated fatty acids (PUFAs) for children with specific learning disorders. *The Cochrane Library*, *9*, pp. 1-33.
[220] American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR.)*. Washington. *DC:* American Psychiatric Association, 2000.
[221] L. Kairaluoma, V. Närhi, T. Ahonen, J. Westerholm, & M. Aro. (2009). Do fatty acids help in overcoming reading difficulties? A double-blind, placebo-controlled study of the effects of eicosapentaenoic acid and carnosine supplementation on children with dyslexia. *Child: care, health and development*, *35*(1), pp. 112-119.
[222] J. Elliott, & E. Grigorenko, *Western psychological and educational theory in diverse contexts*. Routledge, 2013.
[223] A. L. Giraud, & F. Ramus. (2013). Neurogenetics and auditory processing in developmental dyslexia. *Current opinion in neurobiology*, *23*(1), pp. 37-42.
[224] R. I. Nicolson, & A. J. Fawcett. (2007). Procedural learning difficulties: reuniting the developmental disorders?. *Trends Neurosci., 30* (4), pp. 135–4.
[225] M. K. Sahoo, H. Biswas, & S. K. Padhy. (2015). Psychological Co-morbidity in Children with Specific Learning Disorders. *Journal of Family Medicine and Primary Care*, *4*(1), pp. 21–25.
[226] R. I. Nicolson, & A. J. Fawcett. (2006). Do cerebellar deficits underlie phonological problems in dyslexia? *Developmental Science, 9*, pp. 259–262.
[227] K. S. H. Rochelle, & J. B. Talcott. (2006). Impaired balance in developmental dyslexia: A metaanalysis of the contending evidence. *Journal of Child Psychology and Psychiatry, 47*, pp. 1159–1166.
[228] K. Hyatt. (2007). Brain Gym: Building stronger brains or wishful thinking. *Remedial and Special Education, 28*, pp. 117–124.
[229] L. S. Spaulding, M. P. Mostert, & A. P. Beam. (2010). Is Brain Gym® an effective educational intervention? *Exceptionality, 18*(1), pp. 18–30.
[230] L. M. Henderson, R. H. Taylor, B. Barrett, et al. (2014). Editorials: treating reading difficulties with colour. *Br Med J., 349*, pp. 5160-5260.

[231] A. Uccula, M. Enna, & C. Mulatti. (2014). Colors, colored overlays, and reading skills. *Frontiers in psychology*, *5*, pp. 833.
[232] P. Blaskey, M. Scheiman, M. Parisi, E. B. Ciner, M. Gallaway, & R. Selznick. (1990). The effectiveness of Irlen filters for improving reading performance: a pilot study. *Journal of Learning Disabilities*, *23*(10), pp. 604-612.
[233] J. Fletcher, & G. Martinez. (1994). An eye-movement analysis of the effects of scotopic sensitivity correction on parsing and comprehension. *Journal of Learning Disabilities*, *27*(1), pp. 67-70.
[234] F. Martin, B. Mackenzie, W. Lovegrove, & D. McNicol. (1993). Irlen lenses in the treatment of specific reading disability: An evaluation of outcomes and processes. *Australian Journal of Psychology*, *45*(3), pp. 141-150.
[235] S. J. Ritchie, S. Della Sala, & R. D. McIntosh. (2011). Irlen colored overlays do not alleviate reading difficulties. *Pediatrics*, *128*(4), pp. e932-e938.
[236] L. M. Saint-John, & M. A. White. (1988). The effect of coloured transparencies on the reading performance of reading---disabled children. *Australian Journal of Psychology*, *40*(4), pp. 403-411.
[237] H. A. Solan. (1990). An appraisal of the Irlen technique of correcting reading disorders using tinted overlays and tinted lenses. *Journal of Learning Disabilities*, *23*(10), pp. 621-626.
[238] E. Albon, Y. Adi, & C. Hyde, *The effectiveness and cost-effectiveness of coloured filters for reading disability: A systematic review*. Birmingham, AL: West Midlands Health Technology Assessment Collaboration, Department of Public Health and Epidemiology, University of Birmingham, 2008.
[239] U. Goswami, D. Gerson, & L. Astruc. (2010). Amplitude envelope perception, phonology and prosodic sensitivity in children with developmental dyslexia. *Reading and Writing: An Interdisciplinary Journal, 23*, pp. 995-1019.
[240] J. B. Pierrehumbert. (2003). Phonetic Diversity, Statistical Learning, and Acquisition of Phonology. *Language and Speech, 46*, pp. 115-154.
[241] M. Vihman, & W. Croft. (2007). Phonological development: Toward a 'radical' templatic phonology. *Linguistics, 45*, pp. 683-725.
[242] B. L. Gracious, L. Gupta, & L. E. Arnold. (2015). Essential Fatty Acids for Childhood Mental Health Disorders. *Current Treatment Options in Psychiatry*, *2*(1), pp. 1-13.
[243] F. J. Duff, & P. J. Clarke. (2011). Practitioner Review: Reading disorders: what are the effective interventions and how should they be implemented and evaluated?. *Journal of Child Psychology and Psychiatry*, *52*(1), pp. 3-12.
[244] M. Melby-Lervåg, S. A. H. Lyster, & C. Hulme. (2012). Phonological skills and their role in learning to read: a meta-analytic review. *Psychological bulletin*, *138*(2), pp. 322.
[245] M. J. Snowling, & C. Hulme. (2011). Evidence-based interventions for reading and language difficulties: Creating a virtuous circle. *British Journal of Educational Psychology*, *81*(1), pp. 1-23.
[246] M. J. Snowling, & C. Hulme. (2012). Interventions for children's language and literacy difficulties. *International Journal of Language & Communication Disorders*, *47*(1), pp. 27-34.