Exploration of Neuroprotective Therapy

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ADHD and alexithymia comorbidities impact on developmental language disordered and autistic youths: a dimensional treatment approach

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Academic Editor: Michele Roccella, University of Palermo, Italy
Received: December 27, 2024 **Accepted:** May 1, 2025 **Published:** June 22, 2025

Cite this article: Hus Y, Segal O. ADHD and alexithymia comorbidities impact on developmental language disordered and autistic youths: a dimensional treatment approach. Explor Neuroprot Ther. 2025;5:1004110. https://doi.org/10.37349/ent.2025.1004110

Abstract

Neurodevelopmental disorders form a considerable group in the DSM-5, the diagnostic mental disorders manual employed in numerous regions. Some disorders are identified with biomedical tests while those from unknown sources are verified with behavioural scales. They are ubiquitous in youths, significantly impacting their behaviours and lives. They begin in early development and persist mostly throughout their lifespan with chronogeneity, i.e., changes over time. They often form comorbidities, adding to the complexity by creating "new" phenotypes at the intersection. The article aims to provide clinically critical views of ADHD and the added burden of alexithymia comorbidities with profound effects on developmental language disorder (DLD) and autism. The noted problem is the DSM-5's mental health categorical measure of disease identification of the disorders' symptoms, but the neglect of comorbidity. The article's guiding theory is the adoption of the dimensional approach in addressing the target disorders, and the Vygotskian social interactional and linguistic-cognitive learning theory in proposing dimensional treatments. The ADHD including alexithymia in these disorders exhibit commonalities: 1. all are dimensional conditions rather than categorical ones requiring dimensional approaches as these include the entire continuum; 2. all show accompanying developmental language and learning limitations, and 3. all have histories of literacy acquisition problems that impact their academic trajectory while sabotaging their executive functions (EFs) development and undermining the affected individuals and the clinicians' treatment efforts. The suggested interventions target multiple ages based on the Vygotskian social-interactional learning theory acknowledging cognitive development as language and knowledge transmitted via psychosocial interactions facilitating the internalization of education that actively forges learners' character, psychology, and behaviours. They are meant to address their conditions' dimensionality, remediate cognitive linguistic lags, alleviate symptoms, and substitute ineffective learning and thinking habits with more functional ones. Issues to be addressed in developing a clinical plan complete the review.

Keywords

Neurodevelopmental disorders, co-occurrence, emotion unawareness, dimensionality, psychosocial interventions

Introduction

The examination of the neurodevelopmental disorder ADHD, a highly "*intrusive behaviour influencer*" that tends to add to the complexity of any disorder in research and clinically is especially noted when in a comorbid role with other disorders, or when straddling neuropsychiatric disorders and personality traits. The article's formidable complexity is inevitable when framed in a prospective view, especially since it spans developmental and psychiatric domains, as well as learning theory in conjunction with suggested possible treatments to address affected individuals' quality of life and future. As a *prelude* to the main event, and for ease of reading, explanatory and facilitative information is provided via a closer look at comorbidities, ADHD and alexithymia (from Greek meaning a paucity of words for feelings) and their entanglement with other neurodevelopmental disorders (NDDs).

The review type

Here we present a *nonsystematic review with a particular focus* based on relevant reference articles and government data bases, for example. This type offers readers a specific topic and relevant scientific results and discussion as well as treatment suggestions to help respond to specific issues in populations of interest at an economical cost, time, and effort in contrast to systematic reviews that are costly in all these parameters. In addition, it provides essential background knowledge to enhance context comprehension in the critical issues raised by the authors, and permits evaluation and further explanation of recommendations that are estimated to be most beneficial to the population of focus [1]. Reference articles and data employed here were collected from legitimate and trustworthy sources. To help avoid deceptive or predatory publications, the *Think Check Submit* (TCS) approach was applied. In point of fact, the TCS is the offspring of an "international cross-sector initiative representing a consortium of publishers and other stakeholders". Their main concern is the increase in predatory journals, and the inevitable corollary of authors submitting their articles to these "*untrustworthy sources*". Their major aim, therefore, is to educate researchers on how to recognize authentic publishers and "credible research publications" [2]. They facilitate making wise choices by providing easy-to-use checklists that researchers can refer to when they are investigating whether a journal or publisher can be trusted; they do not endorse any journals or publishers, in lieu, the checklists provided in many languages, are designed to help identify which journals or publishers in one's discipline are trustworthy. Researchers are encouraged to use a word-of-mouth approach by soliciting recommendations from colleagues and their publication experiences. They also encourage researchers to get involved by spreading the news of the consortium's newsletters, and visits to their website replete with helpful information (https://thinkchecksubmit.org).

Populations of interest and terminology clarification

A plethora of disciplines, each with its own terminology, contribute to the growing knowledge encompassing complex bio-neuropsychological, neurodevelopmental, and psychiatric challenges in groups of youths. Although these are the main populations of focus in this review, young adults or adults are included at times to emphasize longitudinal aspects of a disorder or when discussing treatment. To circumvent misunderstandings due to term differences, clarification of the terminology used is included here while a section with abbreviations and meanings follows the Conclusion (Issues to consider when addressing a clinical plan).

The population of interest, "youths", refers to both children and adolescents, and at times young adults or adults when highlighting the trajectory of the disorder since NDDs tend to morph along the lifespan requiring novel solutions to address the affected individual's changing life needs. The term ADHD here

refers to a generic application in which both attention and hyperactivity are implied with the understanding that one aspect may be more dominant in a given individual while the other is still present [3]. The identity-first term autistic is used here in line with autistic adults' multinational study confirming preference for language that acknowledges autism as a core part of identity similarly to the use of an ethnic identity, note the authors [4]. Furthermore, the term is employed here interchangeably with autism spectrum disorder (ASD) to emphasize its spectral nature, while utilizing its convenient acronym.

In addition, the term developmental language disorder (DLD) was meant to replace specific language impairment (SLI) and a host of other terms, following a multinational and multidisciplinary consensus study intended to harmonize the assorted terms used in research and clinically [5, 6]. DLD, however, does not appear in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders [7] or in its subsequent text revision [8]. In lieu, the term language disorder is included in both versions. It is defined as: "persistent difficulties in the acquisition and use of language across modalities, i.e., spoken, written, sign language, or other, due to deficits in comprehension or production", and onset in early development, and reduced language abilities, i.e., decreased sentence structure, vocabulary, and discourse, with results "well below age expectations" [9]. In fact, the terms language disorder and DLD are employed in the same sense. A noted difference, however, is the DSM-5's separate category for the associated social pragmatic communication disorder (SPCD) while DLD encompasses SPCD [10]. Lastly, when searching the DSM-5 for language disorder, the selection specification "without associated biomedical condition" is advised as this is a differentiating category from language issues that are a basic component of various genetic conditions, such as intellectual disability.

It is important to note that although both the American Psychiatric Association (e.g., DSM: APA, 5th edition, 2013) and the World Health Association's (ICD-10 and 11: classification system 2004) are the most used diagnostic systems, this article focuses on the APA's DSM exclusively due to the article authors' greater familiarity with this system. The following sections explain the complexity of NDDs, their comorbidity, and the dimensional theoretical approach adopted here in lieu of the traditional categorical approach to the NDDs of focus in this review, namely, ASD and DLD, in the context of ADHD comorbidity, the most frequent NDD that is entangled with others, and with developmental alexithymia comorbidity, a psychological trait that is found in the general population but is comorbid in psychiatric diseases and some NDDs.

The complexity of NDDs

NDDs were historically treated as separate clinical categories with overlapping boundaries that tend to be fraught with error, tend to shift between samples, and known to produce multiple phenotypes with overlapping symptoms. According to the DSM-5, NDDs are a group of complex disorders with origins in the early developmental period (see reference [11] Wiregrass, for an extended NDD list) mostly prior to formal education. NDDs' complexity encompasses genetic and neurological structures resulting in symptomatology that varies in severity and expression, forming a myriad of complex phenotypes, with a tendency to "morph" along their life span [12]. They are accompanied by developmental lags "with consequent impairments in personal, social, academic, or occupational functioning" [11]. They are often burdened with additional medical conditions encompassing physical and mental health functions such as sleep, gastric disturbances, feeding issues, anxiety, and depression, among others, requiring close monitoring, and eventually leading to extensive and extended needs and resources [13]. In addition, NDDs tend to "partner up" with other NDDs (e.g., ADHD and intellectual disabilities), resulting in yet more phenotypes with exponential effects on complexity, severity, and increasing uncertainty of a treatment path when attempting to respond to both NDDs in the affected individual. Furthermore, NDDs' prominent features are difficulties in communication, social-emotional issues, and inherent language development shortcomings, frequently manifested with literacy acquisition problems (described in the DSM-text revision 2022) such as specific learning disorder (SLD) [14]; in fact, SLD tends to co-occur with DLD but the focus in SLD is on acquisition of literacy, while DLD's challenge is oral language (described in the UWO DLD Toolbox, 2022: https://www.uwo.ca/fhs/lwm/news/2022/index.html). These impact affected individuals' quotidian lives

at home, school, and community by derailing their social lives, academic trajectory, and eventually impacting their occupational futures, consequently, increasing their high-risk for fostering anxiety, depression, and at times leading to suicide [15]. Numerous categories are included in this group, however, the focus in this review is on ADHD comorbidity with autism (ASD) and DLD. Each disorder is accompanied with inherent language development and social-emotional issues, constituting high-risk for engendering alexithymia. Their shared features portray significant variability in genetic and clinical presentations, high heritability, as well as persistence into adulthood, as shown by recent studies [16]; as a matter of fact, since they were considered childhood disorders, their continued existence into adulthood was acknowledged only recently. Although their impact on adults' functioning is undeniable as is the erosion of their quality of life these are rarely addressed or managed in adulthood. NDDs' dynamic character with changes over time in symptom severity impacts their management and choice of appropriate treatment to match their changing needs. This attests to the need and benefit of intermittent surveillance along their lifespan.

Mixed neuropathological trends

Genetic studies revealed identical genetic variants taking part in diverse distinct diagnoses of NDDs (e.g., autism and schizophrenia) [17]. This and other genomic findings provided the impetus for questioning the use of a categorical approach, i.e., use of diagnostic boundaries for NDDs. The researchers suggest there is a need to search for an alternative, and "a more biologically relevant classification system". The authors propose that epidemiological samples may provide important new insights into the genetics and diagnosis of NDDs while other medical domains may harbour useful models for developing a new diagnostic system that is able to simultaneously incorporate categorical diagnoses and dimensional variables.

NDDs are marked with wide heterogeneity and great variability in symptom severity, factors that are not accounted for by categorical diagnostic instruments. In addition, students with challenges may present with more than one NDD, and their requirements often span language knowledge, academic function, behaviour, and challenging lives, representing needs that are beyond the accommodation scope of their academic settings. Moreover, the presence of additional NDDs contributes to the complexity and severity of their condition. Given the shortcomings of categorical classifications (CCs), their continued use is rather puzzling. Researchers [18] identify the key factor for the continued reliance on categorical measures as "the belief that these measures represent reality". However, state the authors [18], given the reality of affected individuals, CCs do not answer the challenges of these groups for the following reasons: first, they don't capture the entire continuum of needed supports in their learning, behaviour, and social function, a reality that may be exacerbated by inequalities due to ethnic-cultural and socioeconomic status factors; second, there exist high levels of symptom variability within categories, i.e., the same label varies greatly in scope and nature of the symptoms, hindering the choice of intervention; third, the current systems cannot accommodate the overlap across the discrete disorders. In fact, far from being discrete, a majority of individuals experiences co-occurrence of another disorder, e.g., 44% of youth with ADHD exhibit co-occurring learning difficulties, 65%–85% of autistic children have learning problems, and 30%–70% of autistics exhibit co-occurring ADHD. Consequently, state the authors [18], encountering a unitary disorder is rare while those with co-occurring conditions are understudied since they are often excluded from studies. Given these obstacles, what is needed is an alternate diagnostic approach.

While mental health clinicians rely on accurate diagnosis for providing essential care to affected individuals, traditional diagnostic systems have well-known deficiencies delineated earlier. In fact, researchers found that CCs mental health systems, e.g., the DSM-5 (APA, 5th edition, 2013), fail to address these issues, producing inaccurate profiles of the psychopathology, thus limiting their usefulness in research and clinically, assert researchers [19]; as an alternative to CCs, a "consortium" of mental health experts in classification of diseases proposed a dimensional approach, the Hierarchical Taxonomy of Psychopathology (HiTOP). The group aimed to address the shortcomings of the CCs by first reaching consensus on the following premises meant as the basis upon which to build their model. They agreed that: 1. CCs pose serious limitations, 2. there is a need for statistically derived hierarchically organized constructs, 3. there is a need for an open system that includes constructs with ample evidence at first, and

more added as the field progresses, and 4. it should be made available for immediate clinical and research application since many constructs can be operationalized with their existing measures. In short, the hierarchical dimensional framework, HiTOP, is a work in progress and aims to continue improving and expanding the model so to extend its ability "to predict and explain their source as genetic, environmental, or neurobiological, as well as uncover risk factors, outcomes, and treatment responses".

To date, there is a significant rise in the number of studies that utilize the HiTOP model. As the model authors state, "HiTOP is of practical utility already". Employing dimensional approaches in childhood onset neurodevelopment and neuropsychiatric disorders and their ongoing development will produce a "transformative map" of psychopathology, assert "the researchers for change" [19, 20]. In fact, studying and adopting this approach is encouraged by some editors and publishers. For example, a recent "call for papers" (2024) advises: [JAACAP and JAACAP Open] will publish a special series of review and empirical articles devoted to examining the utility of dimensional alternatives to categorical diagnostic approaches for improving research insights and clinical practice in the field of child and adolescent neurodevelopmental and neuropsychiatric conditions [21]. The "call for papers" editors expound on the role of the model: HiTOP model is seen as providing solutions that are most likely to overcome the limitations built into categorical approaches such as "symptom overlap between diagnostic categories, heterogeneity, instability, unreliability, and a limited capacity to quantify individual variations", explain the editors.

Comorbidities in NDDs and neuropsychiatric conditions

A noted characteristic of NDDs is their tendency to form comorbidities with other NDDs as well as psychiatric traits. The present review follows the impact of ADHD and alexithymia as a comorbid NDD with DLD, ASD, and a possible involvement with alexithymia, a psychiatric disorder. Researchers define comorbidity as "the presence of a chronic disorder that co-occurs, at the same time or in tandem, with a primary disease" [22]. An additional chronic disorder increases the load of challenges individuals carry and so exacerbates the symptoms, consequently, it is associated with poorer outcomes, state the researchers in their examination of ASD comorbidity [22]. The following pages describe alexithymia, the psychiatric trait's presence and comorbidity in the stated NDDs.

Alexithymia, the insidious personality trait

Alexithymia, a term derived from Greek, literally means "without words for emotions". It is viewed as a personality trait rather than a mental disorder since it does not meet the definition for a mental disorder, as defined by psychiatrists in their ongoing preparation of DSM-5 revisions: "A mental disorder is a syndrome characterized by clinically significant disturbance in an individual's cognition, emotion regulation, or behavior that reflects a dysfunction in the psychological, biological, or development processes underlying mental functioning… [they] are usually associated with significant distress or disability in social, occupational, or other important activities" [23]. The definition differentiates normal responses such as grief following the loss of a loved one, and clarify it does not constitute a mental disorder, and neither are *socially deviant behaviors* motivated by political, religious, or sexual conflicts as they are based on disputes that are *primarily between the individual and society*, providing the deviance or conflict does result from a dysfunction in the individual.

The existence of comorbidities is pervasive in psychiatric and neurological conditions. These complicate the disease expression and obscure the most appropriate treatment route when attempting to address both conditions. Interestingly, although genetic and neurobiological as well as social environmental elements are known to affect ADHD, ASD, and DLD, there are no verifying biomedical tests for the presence of any of these [5]. Consequently, there are no specific pharmacological solutions for autism. Nonetheless, a slew of medications are employed to treat symptoms and address comorbidities as shown by a USA retrospective six-year population-based study of a large autistic cohort, 26,722 with 78% males, and 14.45 mean age [24]. The authors examined a nationwide health plan claims database to expose trends in use of medication. It showed 24 different prescription drugs were employed to address the most frequent

comorbidity, ADHD, with some patients prescribed antipsychotic drugs for comorbid autism with ADHD and anxiety. The study unveiled polypharmacy (three or more medications) was frequent, highly variable, and mostly a temporary use of medications was evident. These findings suggest that managing comorbid ASD with medication was challenging as ASD complexity, i.e., heterogeneous phenotypes, with chronogeneity, i.e., longitudinal changes with increasing and decreasing symptoms [25], are not conducive to the use of medications. The study authors [24] voice their concern about the impact of pharmacological management of comorbidities on this population, and advise future research and policy construction focus on "quality of life and functioning in patients with ASD so to ensure their ultimate care quality". They conclude that effective research and optimal guidelines are needed when employing medication for this comorbid population.

The existence of yet another NDD in an affected individual may complicate the scenario further with the formation at the intersection of a unique complex subtype (phenotype), or result in a clinical alteration of the NDD as in the following study of autism comorbidity with alexithymia, a case where the cognitive psychiatric trait impacts the clinical picture of autism, the NDD. The importance of studying this comorbidity is for planning treatment to benefit affected individuals as well as guiding future research. In their investigation of the impact of alexithymia in autism, authors raise the possibility that emotional processing challenges in autism, specifically, in recognizing emotions in others, may not form a core autistic feature [26]. They based their evidence on research reporting inconsistencies with emotional recognition in others. These, they posited, suggested emotion processing difficulties may not be native to autism, i.e., they may not form part of the core features of autism, but rather may provide evidence for the presence of alexithymia, in which case, all autistics should show this trait.

In reality, an alexithymia prevalence study in autistic adolescents showed only 55% with this trait, confirming not all autistics exhibit alexithymia, and the ones that do, form an autistic "subgroup". Moreover, ~5% neurotypical (NT) groups showed presence of alexithymia, confirming it is a common trait as it was present in a nonclinical population. The *Alexithymia hypothesis* of ASD (p. 81) [26], i.e., ASD emotion processing is due to the comorbidity of alexithymia rather than forming a core feature of ASD was supported by a study that found alexithymia rather than ASD was predictive of emotion processing difficulties. The study offered a vista into what may happen at the intersection of co-occurrence of two conditions that probably share endophenotypic elements that give rise to a unique phenotype. It seems that autism and alexithymia comorbidity spawned a "new" autism subgroup or "phenotype". The advantages of the knowledge the authors note that alexithymia is involved in autism are: firstly, awareness of alexithymia's poor response to psychotherapeutic treatments necessitating clinicians searching for effective targeted treatments that may alleviate symptoms. Secondly, knowing that alexithymia may be present, will require its control in any research design as well as the analyses, warn the authors.

Alexithymia is absent from the DSM-5

Unlike NDDs, alexithymia is not included in the DSM-5 since it does not meet the mental health disorder defined characteristics as noted earlier, but rather considered a neuropsychological personality trait that can be detected with interviews and measured with questionnaires or scales. Similarly to NDDs, its presence cannot be verified by biomedical tests [27]; furthermore, while NDDs' etiology is rooted in their incredibly complex genetic makeup and high heritability, e.g., infants with a first relative with either ADHD or ASD have a 20% chance of developing either disorder [28], Alexithymia's genetic heritability of all its dimensions is significantly higher at 30%–33% [29]. However, its origin is in psychosomatic medicine. Moreover, it was based on sparse research, and its systematization is quite recent. Nonetheless, it is considered "a good descriptive and comprehensive framework rather than a diagnostic model" [27]. The researchers confirm that alexithymia is often comorbid in various psychiatric and neurologic disorders, as are NDDs.

Investigators expound on alexithymia's role in NDDs: individuals are endowed with "emotional awareness" (EA) [30], "a state of consciousness that permits recognizing, responding to, and managing one's emotions, an explicit crucial adaptive function". The disruption of EA has serious impact on

individuals' mental health. The presence of alexithymia renders individuals unable to identify or explain their emotions, as though "they become blind to their feelings". Moreover, explain the researchers [30–34], emotions are known to play an adaptive function. They form a type of "internal alarm system" to help make adaptive choices. In unaffected individuals, physical indicators such as physiological arousal and self-reported emotion intensity are intact, but these are disrupted in alexithymia-affected individuals. The researchers adopted the 20-item Toronto Alexithymia Scale (TAS-20) theoretical model in their studies. The instrument measures three dimensions of alexithymia: 1. ability to identify feelings 2. ability to describe feelings, and 3. presence of external thinking (in lieu of ability to think about one's feelings). It is a dimensional trait, present in the general population at low to high ranges, and at *clinically pathological* ranges when alexithymia is present. It is associated with generalized anxiety, panic disorder, posttraumatic stress disorder, and depressive disorders. Some evidence exists that elevated alexithymia is associated with impaired emotion regulation and negative impact on treatment for anxiety and mood disorders. Furthermore, alexithymia seems to be associated with increase in addictive behaviour such as pathological gambling, and more. In sum. it is a powerful insidious trait when in the pathological range of the continuum. Individuals with alexithymia, it seems, exhibit difficulties with regulating their emotions and specifically recognizing and describing feelings, and preoccupation with things in their environments rather than "thinking introspectively".

Previous studies, with limited sample sizes, note others [29], were unable to determine whether individuals' alexithymia etiology was due to genetic or shared environmental factors. Their own very large Danish population-based adult twin study [31] (8,785 twin pairs) compared dizygotic (~50% gene share) with monozygotic twins (~100% gene share), and presence of alexithymia was determined with the TAS-20. It provided the three measures, and allowed prevalence calculation of monozygotic versus dizygotic twins. TAS scores > 60 were considered showing "definite" alexithymia, while > 50 (broad definition) were intermediate scores. All measures showed the primacy of the genetic factor in alexithymia. Heritability of definite alexithymia in monozygotic twins was 23% versus 14% in dizygotic twins while in the broad definition, monozygotic twins had a 41% risk of developing the trait, and 36% risk in dizygotic twins. The authors concluded that there was "a strong genetic/neurobiological contribution to the facets of emotional dysregulation associated with the alexithymia construct".

Furthermore, researchers noted [33] that in addition to genetic correlates, neurobiological factors are at play as well, especially in the central nervous system (CNS) regions involved in emotion regulation, i.e., frontal lobe and limbic system, interconnected structures, while the amygdala, part of the limbic system, is closely situated next to the hippocampus and provides emotional content to memories the hippocampus forms [33]. In addition, it is involved in facial emotion recognition (FER) as is the fusiform gyrus; FER deficits are attributed to ASD (the skill seems to be associated with CNS maturation and IQ). The authors note a study suggested that the cognitive rather than the affective component of alexithymia is associated with deficits in emotional attention and recognition (the cognitive dimension produces issues in identifying, verbalizing, and analyzing emotions, while the affective reduces "levels of emotional experiences and imagination", doi: 10.1093/scan/nsu056). Some environmental factors such as low socio-economic status (SES) and early child neglect were found to be associated with alexithymia. Regarding low SES, when considering the 10% ratio of alexithymia prevalence in the general population while low SES and severe poverty encompass millions of people around the globe, the low SES factor is simply irrational as a direct factor; a more plausible explanation is that low SES is responsible for anxiety and depression and consequently may give rise to alexithymia. A response to "unbearable stress", such as a history of early neglect, on the other hand, is a confirmed strong variable for the appearance of alexithymia. Furthermore, it was suggested that it should be considered a state; however, as it is multifaceted, it most likely includes both constructs, *trait and state* with increases and decreases in alexithymic features concurrently with the symptoms of the mental disorder. The authors suggest that future longitudinal studies with younger cohorts may help resolve the issue of the source of alexithymia in adults, i.e., as a continuation of infantile inability to identify and describe emotions that tend to persist into adulthood.

In sum, alexithymia has known relation to mental disorders (anxiety and depression), somatic diseases (hypertension, diabetes), and ~10% prevalence in non-clinical general population [34]. Similarly to other psychological traits, alexithymia is a dimensional trait rather than a categorical one, and clearly exhibits heterogeneity.

Alexithymic source of emotion vocabulary deficits

An investigation of the source of emotion vocabulary deficits in alexithymia [34] raised the possibility of a disruption in the development of discrete emotion concepts which are more likely to victimize language-impaired individuals. Indeed, those with language impairment showed higher alexithymia and especially reduced "emotional granularity" (precisely expressing feelings in words). Alexithymia was highly prevalent in both autistic adults and adolescents at 50%–55% respectively. However, it tended to correlate with socioemotional factors rather than ASD or its severity. Moreover, patients with injuries to the language areas had higher alexithymia levels, i.e., associated with lower language functioning. In their systematic review and meta-analysis, the researchers [34] disengaged (statistically) the language domains from the alexithymia to facilitate interpretation of results. They examined mixed-age samples [35] to detect the role of language as a mediator between "psychological representation and conceptualization of emotions" in metanalyses. Those with language impairments demonstrated higher alexithymia levels than those with no language impairments. In addition, only *externally oriented thinking* and *difficulty identifying feelings* were related to syntax (structural language difficulties). In all, the language hypothesis of alexithymia [36] was supported by the systematic review and metanalyses: "Alexithymia is associated with cross-domain language difficulties" although the associations are "modest" since they were present in a subgroup with language difficulties rather than all individuals. It is also associated with low emotional granularity, thus confirming the language link is indeed a result of *disrupted conceptualization of ambiguous affective states*. The researchers concluded that alexithymia may be both: a consequence of linguistic and non-linguistic factors, i.e., due to poor introspection ability. They found that poor language may lead to alexithymia [36] but not vice versa: the presence of alexithymia does not lead to poor language, provided the alexithymia is not critically severe, and the child is not socially isolated.

In sum, alexithymia's actions in victimizing those who have language challenges epitomizes the Matthew Effect: "the rich get richer and the poor get poorer" (from the biblical passage Matthew 25:29); interpreted here in the context of vocabulary acquisition: Knowledge of words assists reading comprehension and acquisition of more words while a poor word repertoire hinders further acquisition of words, making the individual "word poorer". The following section delves into ADHD which tends to be ubiquitous in other NDDs.

ADHD the omnipresent NDD

The DSM-5 (2013) refers to ADHD's three behaviour clusters as *presentations* rather than subtypes (due to their instability), explain researchers [37]. Individuals may present as 1. predominantly hyperactive/impulsive, 2. inattentive, or 3. hyperactive/impulsive/inattentive, a combined form. The descriptor specifies that evidence for the disorder must be present before age 12, with symptoms lasting for at least 6 months and demonstrated in at least two settings with impact on academic, social, or occupational functioning. Clinicians are advised to exclude the diagnosis if other disorders that better explain the present symptoms are identified (exclusionary criteria), however, since comorbidities are common in ADHD, it follows that these need to be identified first. Despite a tremendous increase in research studies on ADHD in the past decades, noted researchers [37], it remains without "a concrete verifiable etiology" (similarly to ASD and DLD) while the identified greater heterogeneity continues to present clinicians with diagnostic and treatment challenges. Moreover, the construct was riddled with controversies before it was accepted that it is a dimensional disorder. Although emotion dysregulation is regarded as part of oppositional defiant disorder (ODD), and disruptive mood dysregulation (DMD), about 50%–75% of those with ADHD also exhibit behaviours expected in ODD such as "anger, irritability, low tolerance for frustration, and outbursts". Discussions regarding its possible role as a core symptom in

ADHD remained. Nonetheless, their presence increases the risk of comorbid ODD, and anxiety, note the researchers [37]; in fact, emotional irritability is a definite "primary" ADHD identifier in adults. ADHD, they note, is one of the most frequent NDDs seen in child and adolescent clinics, with a prevalence at > 5%. Since it has no biomedical tests to ascertain its presence, it continues to be defined by behavioural criteria and observer reports.

ADHD frequently comorbid in NDDs

Various disorders are found to be comorbid in ADHD [38]. The most frequent are the following: ASD (70%–85%), learning disabilities (reading 15%–50% and math 5%–30%), developmental coordination disorder (30%–50%), Tourette (20%), obsessive compulsive disorder (5%), ODD and conduct disorder (27%–55%), and depressive and anxiety disorder (0–45%). In addition, those with ADHD exhibit vulnerabilities such as higher risk for addictive behaviours, sleep and feeding disorders, migraines, epilepsy, and more. ADHD is also in a comorbid position in various disorders with different etiologies. The authors note that research does not usually differentiate phenotypic ADHD from varied etiologies, from developmental ADHD, or the primary type. However, it was agreed that acquired ADHD constitutes a "secondary" ADHD.

Indeed, the ADHD picture that emerges is patently complex and represents a true challenge in trying to disengage comorbidities and form a cohesive view with a clear path to treatment that will lead to reduction of symptoms in affected individuals and improved function in their endeavors. In most European and North American countries, the greater portion of treatment relies on medication, although in comorbidity, it may not be effective for the present "partner" disorders. Nonetheless, the authors [38] encourage a thorough clinical interview as a first step assessment of the child/adolescent, and the family: "Clinical assessment in children should mainly be based on a clinical interview with parents, including an exploration of the problems, the detailed developmental history of the child including medical or psychiatric antecedents, information on family functioning, peer relationships, and school history." (p. 318). Individuals with ADHD present not only great group heterogeneity but also individually, and so perhaps ADHD should be considered as a "spectrum" disorder, suggest the researchers.

A vast bank of knowledge exists on ADHD, state authors [38]; for example, ADHD is a chronic disorder, exhibiting "developmentally inappropriate" attention, hyperactivity/impulsivity, or both, lasting some years, and impacting many vital aspects of the affected individuals' lives. The disorder increases the risk for school failure, antisocial behaviour, and at times results in injury or even suicide. ADHD is known for its comorbidity and often involves other psychiatric disorders. Studies show that it responds better to medication than non-medication treatments for reducing all three symptoms: inattention, hyperactivity, and impulsivity. An update of a 20-year-old international consensus [38] regarding ADHD involved examining massive numbers of studies from 27 countries with reported large numbers of participants or meta-analyses. This resulted in 208 empirically verified statements about ADHD. Some of these are added here to form a picture of the recent ADHD accepted statements.

One may ask whether ADHD constitutes a new disorder. In fact, its history shows that it is an "old bride with a new dress", as descriptions of children with ADHD symptoms were found in European countries over two centuries ago [39]. However, to date, the diagnosis of ADHD has well-defined criteria, agreed on by professionals from across the globe, endorsed by professional associations with published diagnosis guidelines, and performed by well-trained professionals. The authors reassure readers that a diagnosis is highly useful: diagnostic criteria for ADHD evolved based on research showing that the diagnosis predicts treatment response, clinical course, and family history of the disorder.

ADHD can occur in children with any IQ level, and accompanied by equal rates of learning and psychiatric disorders. Many individuals with a history of childhood ADHD continue to be impaired by the disorder in adolescence and young adulthood, although they often show reduced hyperactivity and impulsivity while continuing to exhibit symptoms of inattention. Interestingly, a study found [40] that ADHD symptoms are context-dependent. That is, as children, their choice of environment is restricted to a classroom, e.g., an environment that is (often) antithetical to their neurological tolerance, but as young

adults they are able to choose the type of context that accommodates their "neurology" and their interests, and so seemingly appear to show reduced ADHD symptoms [40].

Various large epidemiologic and clinical studies demonstrated that ADHD often co-occurs with other psychiatric disorders, especially depression, bipolar disorder, autism, anxiety disorders, ODD, conduct disorder, eating disorders, and substance use disorders. Furthermore, research with large cohorts of youths showed the younger classmates were probably diagnosed with ADHD [41] attesting to the rise in frequency of ADHD diagnoses in the last decade [42, 43]. Although both varied genetics and environmental factors combine to produce ADHD, they are partially shared between ADHD and other psychiatric disorders (e.g., schizophrenia, depression, ASD, conduct disorder, and more), and with somatic disorders (e.g., migraine and obesity, among others). The prevalence of ADHD is about equally distributed between the continents, however, it occurs more often in boys than girls. The prevalence in adults is lower than in youths as only ~17% of youths retain their ADHD diagnosis by age 25. In addition, treatment for ADHD centres on medication, with varied behaviour or skill-enhancing programs depending on the child's age, however, they were found to be less effective than medication in reducing the major symptoms.

ADHD comorbidity with ASD

Studies show 50%–70% of autistic individuals also have comorbid ADHD. This high incidence raised questions regarding the origin of this phenomenon. Researchers [44] questioned whether the ADHD symptoms may actually be due to impairments inherent in ASD such as *impaired joint attention*, rather than ADHD contribute to attention weaknesses. About a decade earlier, a study of toddler [45] *attention impairments* noted a two-pronged problem as both joint attention and sustained joint engagement were significantly impaired. In addition, those with the impairment went on to be recognized as autistic with delayed communication and language. They concluded that the ability to engage others is related to the ability to talk, and herein lies the significance and contribution of "joint and sustained attention". It is clear that the two NDDs are distinct, affect children differently, and cause different behaviours, e.g., ADHD results in distracted, inattentive, and "talkative in class" behaviours versus ASD exhibiting "shunning" others, and difficulty interacting and communicating. While ASD children can be diagnosed by ~age 3, ADHD children are diagnosed significantly later, i.e., between ages 6–12 (see www.healthlinkbc.ca/health-hyperactivity-disorder-adhd). The researchers examined basic processes such as memory and EFs. They found that rather than memory per se they tend not to listen to instructions, or be distracted, and at times their attention seems hyper-focused so that they have a problem shifting and integrating new information. These behaviours tend to be inherent in ASD. Those with both NDDs showed significantly more severe symptoms in social interaction. It appears that the two NDDs combine to form a unique phenotype rather than simply having an additive effect. Their underlying deficits exhibit similarities as do some genetic overlaps between them which may harbour shared endophenotypes accounting for the similarities.

Investigations [45] of the source of altered attention to social stimuli in both ASD and ADHD revealed the answer by using prospective studies of infants who later developed ASD and ADHD. The investigators posit the affected children's complex neurology resulting from ongoing interactions of their genetics and environment eventually led to bidirectional results, while the measurable component that exists between the genetic level and a psychiatric condition, the endophenotype, explains the existence of early neurocognitive features that are present and related to later symptoms despite the absence of the disorder. Disrupted attention, they suggest, is such an endophenotype. In fact, shared genetic factors were found to underlie inattention and attentional switching limitation in adults and children with co-occurring ASD and ADHD. The study used infant-siblings in their examination of early social attention developments to ensure a large enough sample and longitudinal access given the high heritability of the two NDDs (~20% of younger siblings of children with ASD develop the disorder). They focused on "attention" as the transdiagnostic element as it is common to many disorders. The significant-sized research showed atypicalities in infants with later ASD spanned both social, as atypical face processing, and nonsocial, as fixated gaze of attention anomalies. Researchers [46] hypothesized a social orienting mechanism, i.e., the

spontaneous allocation of attention to faces, and coordination of attention with other people, i.e., joint attention, a *socially bidirectional development*. These form a continuum with the later social cognition development on the other end. The authors emphasize that in both typical and atypical developments *social orienting* and *joint attention* behaviors and symptoms emerge concurrently: a fact that may assist clinicians in early recognition of possible presence of ASD and ADHD partnership in some vulnerable children.

ADHD and executive functions

EFs is a collective term for complex cognitive processes that serve dynamic ongoing goal-directed behaviours. The processes are sensitive to biological and environmental context variables. They have a long developmental trajectory and reach maturity in late adolescence or early adulthood [47]; many psychiatric disorders have associated executive dysfunctions, including ADHD. Researchers explored the relationship of ADHD and EFs in a young group of clinically diagnosed children with ADHD, a ubiquitous presence in children during their critical learning period whilst they are acquiring literacy and expanding their vocabulary and language skills [48]. Although its presence in adolescents and adults is better known, studies in young children necessitated further exploration due to ambiguous results. The study [48] set out to clarify the EFs' relationship such as inhibition, regulation, and working memory, and their relation to ADHD in children aged 4–6 using a variety of scales and questionnaires and testing them at the start (T1) and end (T2) of the school year. Over the school year period, inhibition and regulation remained rather stable but working memory showed variability. They found that inhibition at T1 predicted ADHD at T2, while ADHD at T1 predicted inhibition at T2. As well, ADHD remained stable as the mild symptoms persisted from T1 to T2. In sum, an interaction between inhibition and ADHD was present heralding future issues. The researchers concluded that preventive training of children in EFs was warranted.

In point of fact, presence of ADHD behaviours and EF dysfunction in school aged children contribute to persisting reading disorders, among other educational problems, despite remediation efforts in school and provision of tutoring at home, as shown by the following retrospective study of a clinical sample consisting of 23 boys and girls (30%) aged 6–16 [47]. The children were examined in language, reading, naming speed, and EFs measured with an ecologically valid instrument, the Behavior Rating Inventory of Executive Function (BRIEF) [49]. The results showed varied language challenges. While the two grade 1 children's reading readiness development was intact, the greater majority exhibited reading (word recognition) and reading comprehension problems. The entire cohort displayed EF issues on the BRIEF [49] in both behaviour regulation factors as well as metacognitive skills. The study confirmed that when high risk ADHD is braided with EF dysfunction in students with weaknesses in language and reading (word recognition and comprehension), the resistance to remediation and persistence of reading issues is a pronounced possibility. It indicates the wisdom in investigating the status of EFs and the presence of ADHD when treatment is not producing the desired results, or better still, making the investigation a routine part of evaluations.

ADHD and DLD comorbidity

Although prevalence of DLD is about 7%, it tends to be understudied and underdiagnosed [44]; as noted earlier, the term and characteristics underwent a morphosis as it replaced SLI and various labels following consensus studies (CATALISE 1 and 2) [5, 6]. Nonetheless, probably due to the DSM-5 publication date and the CATALISE 1 publication results discrepancy, the term failed to be integrated into the manual, and although the diagnostic instrument was revised some years later (2022) [8], DLD remained outside the classification system. Efforts to spotlight the disorder are underway but it is somewhat obscure to the general public (and professionals), and its characteristics remain somewhat foggy [50].

A study [50] used electronic health records and the Human Phenotype Ontology (HPO) computational tool for the Phenome Enrichment Analysis to identify the prevalence of comorbid health phenotypes between DLD individuals and matched controls [51]. HPO is accompanied by a full ontology that uses semantic interpretation and algorithms to match phenomes with genomes in the service of analyzing and describing abnormal phenomes, to help identify various diseases. The process uncovered common

comorbidities such as learning disorder, delayed milestones, acoustic nerve disorders, conduct disorders, ADHD, poor coordination, and so on, as well as rare health phenotypes such as dermatitis, conjunctivitis, weight, and nutrition. These analyses spotlit the complexity of DLD beyond language impairment, as well as demonstrating the usefulness of their methodology to uncover both common and rare comorbidities in a significant number of individuals using electronic records, and the HPO.

DLD is defined by language impairment, and is often comorbid with ADHD and EF dysfunction. Researchers examined [52] 6 to 12-year-olds French-speaking students in each of three cognitive groups, typical development (TD), ADHD, and DLD on two French-sensitive morphosyntax tests, and EFs (selective attention, working memory, attention shifting) in attempting to identify their EF profiles. It demonstrated the ADHD group with higher order EF weaknesses, and a problem on the all-encompassing syntax test, while the DLD group exhibited problems on both upper and lower EFs and great difficulty on both morphosyntactic tests, as well as in working memory. Interestingly, the other groups had no problem with working memory. The ADHD group had a problem with less familiar structures on the comprehensive syntax test, leading to the conclusion of "phenomimicry" as suggested in earlier research with ASD and SLI (DLD) [53]. Equivalent performance in attention shifting was seen in DLD and ADHD, while both were different from the TD group in selective attention; ADHD and TD were similar but DLD had a significantly worse response speed than the TD group, probably because of coordination issues, posit the researchers. In all, the researchers succeeded in providing EF profiles of the two groups, DLD and ADHD, while identifying working memory as an aid in differentiation of DLD from ADHD.

DLD antecedents via SLI contributions

Since language issues are an integral part of each of the NDDs discussed thus far, it is befitting to compare the core of what is meant by DLD with that of SLI, its former construct, and discuss the relevant contributions of SLI research to the current construct of DLD.

With the introduction to the new classification of language problems, DLD, the product of a prolonged consensus effort and bolstered by much debate and profound reflection by researchers and clinicians, it is easily assumed that the prior five decades of studies on SLI yielded "no relevant outcomes", maintained a prolific SLI researcher in a fairly recent paper [54]. The article focused on the "very relevant contributions" SLI made to the nascent DLD, positioning them as antecedents we take for granted. But first, we examine what is meant by each label. Specific language impairment was meant for children with a "language disorder that delays the mastery of language skills in those who have no hearing loss or other developmental delays" and whose "nonverbal IQ is within the average range". DLD is meant for children whose language disorder is not associated with a known biomedical etiology, and with nonverbal IQ placed anywhere on the entire continuum. Those outside the average range were excluded from the SLI studies as were those with an ADHD comorbidity. The upshot is that DLD is significantly more inclusive than SLI was (presents as both a blessing and a bane depending on who the stakeholders are). The author [54] asserts that SLI-designated children form a subgroup and a majority within the DLD group. The author delineates four major contributions to the knowledge trove provided by the SLI studies delineated by the following facts:

Fact 1: Children with SLI are "late talkers"; they exhibit delayed language acquisition but not all those with delayed language acquisition have SLI. Their delay at the start is 1–2 years, but while the language learning pattern parallels TDs, the lag remains in those with SLI, and the gap is not likely to close; their language development resembles that of younger children.

Fact 2: Delayed vocabulary in SLI is possible but not inevitable; when it exists, it lasts for many years; at age 4, those with SLI had fewer words, i.e., they learn new words at the same rate over time as the comparison group, but the gap remains while the rate of learning new words slows significantly between age 10 to 12 and is maintained to adulthood; while girls are at an advantage in vocabulary at age 4, in adolescence their word acquisition is slower than in boys.

Fact 3: Tense and agreement marking of verbs (finiteness marking) is a clinical sign for SLI; these finiteness marker verbs appear early in children's (English) grammar: copula and auxiliary forms of BE,

third-person singular-s, regular and irregular forms of past tense, and the verb do; in SLI, children act as if these rules are optional rather than obligatory, and tend to judge omissions as correct (thereby matching their spoken errors).

Fact 4: SLI children will probably not outgrow their syntax errors; on comprehensive tests, they tend to score at the 15th percentile or below throughout their school years; they perform below typical language developers, a result that tends to persist into adulthood.

The author summarizes the four major facts with this overview: "SLI is a persistent language disorder that is evident early in development and has many similarities to younger language profiles with steady gains in language, leveling off in adolescence. This makes it likely that a child with SLI will become an adult with weak language skills, particularly in some, but not all parts of the grammar. It also increases the likelihood that children with SLI can be perceived as just "immature" or as "not trying hard enough" (p.18) [54].

This completes the section on the complexity of NDDs of the review, and is followed by a concise summary prior to the next section, dimensional treatment approaches.

A concise summary of the complexity of NDDs

The article delved into the nature of ADHD and its entanglement in other NDDs: DLD and ASD. In addition, the presence of alexithymia, the personality trait comorbidity in these NDDs was examined to gauge its role in complicating the severity or symptoms of the NDDs. Individuals are therefore burdened with ADHD, DLD, and alexithymia, a trait that may be noted in individuals with compromised language development, thus producing novel phenotypes with added challenges. It is vital to investigate these comorbidities so to facilitate appropriate treatment choices to avert or minimize negative impacts and elevate the affected individuals' life quality. Alexithymia, with its capacity for diminishing emotive words, seems to echo the finding that in typical vocabulary development emotive words are the last to develop [54]. Although language-impaired children showed capacity to learn new words from flimsy evidence such as fast-mapping provides, repeated exposures hone their production quality [55]; their particular difficulty resided in producing the words, suggesting possible interference from speech motor weaknesses [56]. Interestingly, individuals with language impairment had significantly more severe alexithymia than those with typical language. It seems that this trait is especially tuned into gauging the language wows of individuals.

The treatments' theoretical framework: Vygotsky's mediated learning

In these authors' view, Vygotsky's major contributions to modern psychology and learning theory are the following. His view that brain function was flexible was an attitude that was unique at the time [56]; in this perspective, function was restored when damaged by using various "supplemental stimuli". Furthermore, he embraced culture and history and saw these as contributors to psychological development. In his socio-cultural historical theory, cognitive development was a qualitative transformation of the innate, unmediated, involuntary, and isolated "lower mental functions" (LMFs) of a newborn into the "higher mental functions" (HMFs) of older children and adults. These are socially acquired via mediation by social meanings; they are voluntary and linked in broad systems to other functions. Language, he maintained, is the most powerful player in mediation as it promotes development of agency, i.e., self-determination and control over one's life, and stimulates EFs. HMF, synonymous with logical thinking, is developed from the first interaction with the adult/instructor. The "instructor's" role is to facilitate the transformation. Tasks the child can manage only with an instructor occur in the *zone of proximal development*; when they can do it on their own, the knowledge becomes part of the *zone of actual development*, i.e., performing tasks independently is the sign for cognitive growth. In short, mediated learning is the essential activity for cognitive development. In their journey with their "instructor", children develop "social referencing", such as pointing to others or objects, following another person's gaze direction, and recognizing others' emotions (facial and body expressions).

Scholars disputed Vygotsky's clear dichotomy between lower and higher cognitive functions, pointing out that the lower psychological processes are not content poor, i.e., Vygotsky's separation of lower and upper was judged as too drastic. In light of current knowledge, instead of a categorical separation, a dimensional view of the processes (as a continuum) would have helped circumvent this error. Nonetheless, his observation that children from different cultures respond differently on psychological tasks, led to his astute conclusion that socio-cultural aspects operate in the formation process of psychological content (adopted by Transcultural Psychiatry, a discipline concerned with the cultural context of mental illness). This awareness contributed to consideration of ethnic sociocultural contexts of individuals that is built into virtually all modern assessment instruments when trying to accommodate the diversity of humanity that is found in clinics and schools.

This article adopts the Vygotskian approach to mediation of "instructor" scaffolded learning experience and language as the major necessary ingredients in acquisition of cognitive and social linguistic skills that are the mainstay of development and social function in societies worldwide.

The supporting research in early language development

The attention NDDs garnered in the recent past shifted considerably from near anonymity about half a century ago to modern popularity in the media, note researchers [57]. The authors attribute this drastic change in perspective to the worldwide reduction in mortality rates due to advances and improvements in medical availability, spurring a perspective change from *preserving life to enhancing life quality*. Society was consequently attentive to serious issues such as NDDs that plague individuals in all geopolitical and economic regions at all ages, from early on across the entire lifespan. The professional attitude accompanied the concern with the establishment of disease assessment inventories such as the DSMs, among others. In fact, the sheer name, NDDs, acknowledges "an early origin and a neurobiological correlate", state the authors [57].

Although researchers' interest centred on early language development, or preschool years, the focus at that time was on grammar and pragmatics while the state of vocabulary acquisition or lexicon was barely known. What was known, however, is that between age 1.6 to 6 years, most preschool children comprehend about 14,000 words, and gain nine new words each day, a skill exhibited by children who fare well in lexicon acquisition; however, the outcome is different for preschoolers who exhibit late word emergence, and a consequent language delay [58]. This was intriguing since in the preschool years, children acquire words at an impressive rate and seemingly effortlessly. The ability to acquire words at this rate was due to "fast mapping": a skill that permits gaining a rudimentary word based on minimal information (acts as "a special kind of partial meaning") while consequent encounters, or *extended mapping*, expand the word's meaning [59].

Earlier studies [58] of typical 3 and 5-year-olds examined their word learning of objects, actions, attributes, and affective state words via video presentations. Both age groups were able to learn objects, actions, and attributes, but interestingly, they had an unexplained difficulty with affective state words. Their fast mapping involved the children adhering to the following procedure: "1. attention to the stream of speech, 2. recognizing the new word, 3. rapid evaluation of the linguistic and nonlinguistic context for a probable meaning, 4. entering the hypothesized meaning into the appropriate slot in the available lexicon, 5. storing it for immediate or eventual use". Remarkably, merely a rapid encounter with minimal information succeeded in spotlighting the novel words in these typically developing preschoolers.

A fast map study of language-impaired 5-year-olds during ongoing dialogue yielded varied results. Their performance was compared to same-age peers matched for utterance length (grammar). Word presentation appeared in their ontogenetic order: objects first, then action words, modifiers, and lastly affective words (angry, sad) [58]. A subset of children with SLI was included in the study. Results showed the lowest word learning occurred in the SLI group. The authors posited that young language-impaired children have "limited fast mapping ability relative to their typically developing same-age peers in naturalistic language processing circumstances". In short, a limited ability to quickly comprehend new

words is strongly implicated as a determinant for the limited vocabularies of SLI children (independent of existing vocabulary or grammatical elements). Another study [60] showed that total vocabulary size at age 2 predicted language and literacy achievement up to grade 5, regardless of type of words; lexicon size appeared as a powerful predictor indeed.

While there exists great variability in size and speed of vocabulary development, the significance of restricted vocabularies or delays in acquisition of words is that they too have predictive power in later development, as shown in the following study [61]. Delayed verbal processing efficiency in infancy predicted vocabulary growth between ages 18 to 30 months in typical as well as late talking children. Longitudinal analyses showed that language comprehension speed and accuracy of 2-year-old typically developing children predicted comprehension at 2 years and expedited vocabulary growth across age 2. In addition, it predicts better language and cognitive performance at age 8 years. The authors' goal was to determine whether real-time language comprehension of late talkers also predicts vocabulary growth. There is evidence that such children appear to catch up later, however, they were found to demonstrate some lags compared to typically developing peers without early delay. Online processing measures of accuracy and reaction time were obtained, and vocabulary measures at ≥ 20% formed the typical developing group, while those who scored ≤ 20% were assigned to the late talker group. A re-examination at 21, 24, and 30 months showed those who remained < 20% were named "delayed" while those who achieved > 20% were named "bloomers". The late talker group was significantly slower and produced more errors in understanding spoken language. In sum, the 18-month result was correlated with the rate and accuracy across all children. The links between vocabulary and spoken language processing found these were consistent with earlier findings. The authors concluded that "vocabulary at 18 months predicted continued language delay". The response rate showed that those with better rates at 18 months had better outcomes at 30 months. These findings suggest that late talkers' reduced efficiency of real-time speech processing at 18 months predicts increased risk for poor language outcomes at 30 months. The study confirmed "robust relationships between early efficiency in real-time language interpretation and individual differences in lexical development". The relationship persisted through to the third year, confirming that retrospective predictive validity of infants' skill included "real-time" speech processing in prospective time as well.

In effect, a longitudinal study of a large cohort (> 2,000) of 16 to 30-month-old children [62] from mid SES families was examined to determine associations between expressive vocabulary, reading, and math (results not reported here) in grade 6. The authors noted that early language development is of concern since it impacts reading acquisition, and reading is "the most important determinant of educational success". The children were examined on language comprehension (the task included picture naming with little reading), decoding, and reading comprehension in language and literacy: the lowest 10% group, tended to show low scores later, while those in the upper 10% showed high scores later. However, a subgroup of these children did not show better performance later, i.e., their early high scores did not guarantee high scores later. Nonetheless, one-third of the group succeeded in moving to the midrange. Interestingly, syntax was later more predictive of school performance than vocabulary. The study highlighted the importance of addressing early development to facilitate a successful track to school performance.

Suggested treatment for early development

Shared reading

Vocabulary and language stimulation for preschool and kindergarten children (using evidence-based treatments) are suggested, but first, an explanation is needed on how children acquire words. A highly simplified but effective description of children's word acquisition [63] characterizes the procedure as a dynamic process in which continuous multiple encounters of words in varied contexts and meanings evolve from "novel" when first met, to "known words". That is, with time and exposure, their familiarity increases, their meanings are expanded, and the learner's ability to produce and use them is simultaneously honed. The resulting progression is in essence a "continuum of familiarity" in which "time and exposure" underlie

the evolution of words from "novel" to "known", explains the author [63]. What happens to them then? Once processed as known words, they join the learner's "mental lexicon", i.e., the trove of known words. This continuous recurring dynamic process depends on repeated exposures and contexts in which the words are encountered. This transformational process highlights the importance of exposing children to vocabulary continuously and often from very early on as the size and variety of children's vocabulary have import for all life skills and their functions including affective or emotional needs [61].

The importance of context for comprehension is highlighted for both "reading faces" (contexts are especially needed in recognizing emotions and "reading faces" to accurately gauge the other's feelings) and word and text comprehension [64]. The author highlights the use of "shared storybook reading" as an ideal activity that offers the child new vocabulary. Children enjoy listening to repeated readings of stories, while it is simultaneously effective in increasing children's opportunities to activate memory of the words and cement them into their "known words treasure". The author cites a study in which "contextual repetition", i.e., repeated readings of the same three books, facilitated these words' integration into the children's "known words", while the group that was offered shared reading by listening to varied books at each trial did not show this transformation of words. In short, contextual repetitions facilitated the process of transforming novel words into "known words" by reducing the requisite attentional efforts, conclude the authors, and advise using books that are with an end-goal theme as the theme and words' familiarity act synergistically, state the authors [64], to amplify the process of transforming novel words into known ones while honing their joint attention skill (desirable since the shared reading process relies on joint attention) [64].

Shared reading may be especially beneficial for children with NDDs and comorbidities when using targeted books and vocabulary. For example, in alexithymia young children and youth fail to recognize and name emotion words and emotion word awareness in themselves or in others. These children may be responsive to targeted shared repeated reading activities intended to succeed in reversing this tendency. The choice of emotion-based thematic stories, with emphasis on targeted emotion words destined to become "known words", in specific familiar contexts, while depicting their use by either children or animals, may succeed in contributing the needed vocabulary and concepts to children who are known to exhibit this complex clinical condition. The use of thematic shared reading is an approach that could clearly benefit NDDs with comorbid conditions [65]. For the greatest impact on these comorbid children, choosing books' encompassing themes related to their life skills needs such as increasing their affective or emotion words for friendship, kindness, empathy, generosity, resilience, social communication contexts, etc., would be valuable in light of the fact that they are most vulnerable to alexithymia. The target words should consist mainly of verbs and adjectives, as these are more challenging for young children to learn compared to nouns, warns the author [66].

Dialogic reading

A highly facilitative approach is the use of dialogic reading (DR) [67], (for a thorough description of the DR approach and strategies see: https://www.readingrockets.org/topics/early-literacy-development/articles/dialogic-reading-effective-way-read-aloud-young-children). DR is an evidence-based picture book (with text) shared reading approach that contains embedded strategies for stimulating language and vocabulary. In DR, "the adult helps the child become the teller of the story; the adult becomes the listener, the questioner, and the audience for the child". The approach is based on the fact that children learn most from books when they are actively involved. The procedure is a short interaction between adult and child using a prompting sequence, PEER—the adult: 1. Prompts the child to say something about the book: tell me about this picture, 2. Evaluates the child's response: that's right, it is a cave, 3. Expands the child's response by rephrasing and adding information: it is a large cave so the whole bear family could fit in it; and 4. Repeats the prompt to make sure the child has learned from the expansion: tell me why the cave is large. Five prompt types are used in executing the PEER sequence: 1. Completion prompts: the adult leaves a blank at the end of a sentence and the child fills it in: the bear lives in the ____. 2. Recall prompts: these are questions about what happened in a book a child has read previously. "Do you remember where the polar bear lives

in the story we read yesterday?" 3. Open-ended prompts: these focus on the pictures in books; the adult may say, "tell me what's happening with the baby bear in this picture". 4. Wh- prompts: these begin with what, where, when, why, and how questions: Where does the bear family sleep in the winter? 5. Distancing prompts: here children are asked to relate the pictures or words to earlier experiences, outside the book: "Remember when we saw the video about bears, tell me where they live in the summer…"; these help "bridge the book to the real world".

The DR approach was used successfully with a variety of children with serious challenges, e.g., with hard-of-hearing [68], ADHD kindergartners- both parents and siblings delivered the task successfully [69], with autistic preschoolers [70], and a myriad of others including typically developing. The use of this approach with NDD challenged young children should be accompanied by a robust study to measure its impact on targeted vocabulary harvested for emotional expression and socioemotional behaviour needs. In parallel, with choice of age-appropriate books for older children and young adolescents should be used with a modified DR to match their age, grade and cognitive development, delivered by trained parents and tutors at school [71].

Suggested treatment for adolescents and young adults: self-regulation and executive functions

EFs are a set of self-regulating processes and systems with a long developmental trajectory. Their roots are in social interaction and language. These are responsible for deliberate actions and inhibition of those that distract from achieving a set goal. They are active in problem-solving, and regulating social relationships. EFs start developing in preschool where, e.g., they learn to wait their turn, curb their aggression, avoid grabbing toys from others, remember class routines, and determine if something is just and correct or wrong. All developments are interconnected hence each gained skill contributes to the foundation for developing effective healthy relationships, successful learning, and EFs. An important aspect in the early stages is the development of "emotional resilience", i.e., a child's ability to recover and produce positive emotions when faced with adversity. It forms a shield against later anxiety and depression. A significant milestone in child development is achieving self-regulation. Those who exhibit self-regulation issues are of concern as these individuals may produce a host of difficulties that impact social and academic life. Children who exhibit attention and behaviour issues such as hyperactivity, and impulsivity, i.e., ADHD, are candidates for failing to develop healthy EFs.

In actuality, executive functioning can be taught [72]. A preschool program, Tools of the Mind, is based on a curriculum for stimulating and improving EF in children. The authors note that programs that teach EFs produce better learners, better problem-solvers, and better-behaved children, more cooperative and sociable, more independent, and better ready for academic function in school programs. Children whose life experiences are difficult often have difficulties with self-regulation and poor EFs- both behaviour regulation and metacognitive skills may be affected. The curriculum, established in regular classes, focuses on: 1. inhibitory control (resisting habits, temptations, or distractions), 2. working memory (mentally holding and using information), and 3. cognitive flexibility (adjusting to change). In fact, the authors [72] note that EFs are strongly associated with school readiness and are ranked by teachers as more important for academic success prediction than IQ tests. Studies showed that working memory and inhibition independently predicted math and reading scores in preschool through high school.

Is it ever too late to be taught EFs? The following section spotlights some treatment solutions meant for high school students and young adults with high risk for school dropout or failure.

Group treatment in later school settings: Branching Minds

Branching Minds [73] is a support platform for providing guidance and technology for implementing multi-tiered system of supports (MTSS), a framework used in numerous USA schools and in some Canadian provinces to give targeted support to struggling students. Although meant for elementary school support, the program can be modified for use in secondary schools [74]; for example, it can be used "as a framework for drop-out prevention and content recovery to ensure that students pass core courses and exams and ultimately graduate". The brief (provided at https://region6cc.uncg.edu/resources/) delineates the

strategies and challenges presented in implementing Branching Minds in an MTSS effort at the secondary school to identify and act as a resource for high-risk students.

The Branching Minds mission is the following: "To empower all educators to effectively, efficiently, and equitably support the holistic needs of their students; and to create a path to academic and personal success for every learner". The Branching Minds protocol is the use of the Student Risk Screening Scale-Internalizing and Externalizing (SRSS-IE): the "I" refers to behaviours students direct inwardly, away from the social environment, while the "E" pertains to externalizing behaviours directed externally toward the social environment. (see: https://www.branchingminds.com/ and https://www.branchingminds.com/blog/executive-function-toolkit); the screener is a universal evidence-based instrument that systematically identifies at-risk students for "challenging behaviour and poor academic outcomes…requiring behavior support". The data to support a screening decision is based on three indicators: office discipline referrals, suspensions, and academic failure. Studies showed the screener has "high internal consistency and test-retest stability", i.e., consistent results were obtained across rural, urban, and suburban settings; all three indicators showed risk-level predictive validity. Goals and procedures are based on integration of data easily accessible to stakeholders in the student's curriculum, but also contain other materials needed for decision-making.

Furthermore, the Branching Minds website promotes teaching and learning EFs [75, 76]. Instructors are encouraged to highlight for students how to apply EFs in real life, arm them with scaffolds at all teaching opportunities, help them construct routines and practices in their daily lives, and show a belief "they are trying their best". By concentrating on these: working memory, flexible thinking, self-control, focus, following directions, and regulating emotions, they are transformed into effective "learners". In short, these are the "how-to-be-a-successful-learner skills". The author goes on to identify EFs used habitually in the classroom as those that enable us to plan, focus attention, remember instructions, and juggle multiple tasks successfully. Without these, learning is disrupted, and students' EFs remain untransformed. The article harbors an EF toolkit (see: https://www.branchingminds.com/blog/executive-function-toolkit), and valuable advice on when and how to teach EF skills. The article/blog is well written and certainly accessible to educators and intervention staff as well as parents who express their desire to participate in practicing EF skills to help improve their students' daily lives.

UCLA Program for the Education and Enrichment of Relational Skills

The UCLA Program for the Education and Enrichment of Relational Skills (PEERS) [77] is a parent-assisted social skills group program that focuses on autistic adolescents who are "high-functioning" (a descriptive term). These students have milder challenges in language and intellectual abilities, while they exhibit the characteristic autism behaviours: restricted interests and repetitive behaviours, sensory sensitivities, communication issues, social challenges, and problems with executive functions. Social situations are challenging as they often misunderstand nonverbal cues, communication, problem maintaining eye contact, engaging in reciprocal communication, misunderstanding social situations and social norms. In communication, despite mainly intact language skills, they fail to understand sarcasm, humour, and show poor inferencing skills. These interfere with pragmatic aspects and may involve "monotonic speech". Their difficulties with EF may affect their ability to "manage time, set goals, and initiate and complete tasks". Importantly, social skills, tendency to perseverate on topics, problems in expressing emotions and understanding others' feelings are some of the obstacles to achieving satisfying friendships, note the authors [78]; so that challenges continue to interfere with their life enjoyment. The importance of social skills with all their components is vital, and the PEERS program focused on these as the goal of the 14-week treatment program. The group included 12–17-year-old autistic adolescents, and some with comorbid psychiatric disorders (ADHD, depressive disorder, and anxiety). Their results showed significant changes in social skills as measured by teacher and parent feedback. Increases in social skills knowledge, social responsiveness, social communication, social cognition, social awareness, social motivation, assertion, cooperation, and responsibility, and increase in the frequency of peer interactions were prominent, while autistic mannerisms decreased.

In fact, a replication study with caregiver-assisted social skills program successfully treated high-function autistic young adults aged 18–24 [78, 79]. The treatment group improved significantly in overall social skills, frequency of social engagement, and social skills knowledge, and significantly reduced ASD symptoms related to social responsiveness. In addition, a great portion of the gains were maintained at a 16-week follow-up assessment, and new improvements were noted.

A study that included autistic adolescents and young adults and a group with cognitive impairments at a private institution [79] delivered the program bi-weekly. Pre and post-tests showed all participants experienced significantly improved knowledge of appropriate social etiquette. Students with cognitive deficits reported a significant increase in friendship engagement, while those with autism did not and additionally they exhibited difficulty generalizing their new social skills beyond the program. Overall, the PEERS school curriculum benefited young adults with cognitive deficits, but the students with ASD experienced more challenges applying their new social skills outside of the program.

It appears that social skills program that is intensive and all-inclusive as the UCLA PEERS program is beneficial and transformative for all age groups and for those with comorbid psychiatric disorders [80]. However, those with lower functioning autism obviously require additional treatment to generalize their new found social skills. Nonetheless, it was heartening to find evidence that those with cognitive challenges, usually excluded from studies, do benefit from these programs. A fact that should sway researchers toward inclusion in prospective studies.

Complex task: children's cooking task: an adolescent potential EF training paradigm

This account reports on a performance-based examination of 10–14-year-olds with EF deficits on ecologically valid children's complex cooking task (CCT) used in occupational therapy [81]. Since EFs are needed for daily function, it is paramount that in addition to standardized tests, they are examined within the context of complex tasks that can inform on their EFs, explain the authors. EFs inhibition, working memory, and shifting or cognitive flexibility are essential components needed in daily life activities, in school, and vocations. EF assessment tools must show ecological validity, i.e., 1. test demands, and context resembling the child's actual world, and 2. the test must predict some aspect of the child's quotidian life. The main aim of the study was to describe the performance of a group of adolescents with EF deficits on a CCT and compare their results to same-age peers without EF lags. The BRIEF [50] parent results were used to measure daily EF function, and CCT was an authentic task performed in a kitchen, with real ingredients, and authentic cooking instruments and equipment. Their goal was to create "an edible cake and a fruit cocktail" (the CCT analysis and all results are compiled in the appendix at the end of their article) [81]. In short, the typical adolescents (TD) group, outperformed the EF deficit group, a significant difference between them was shown on the CCT assessment—the EF deficit group was two standard deviations above the TD group in error cut-off scores; a positive correlation was present on the Plan-Organize variable of the BRIEF (Self-Report) pointing to this EF as the most compromised; > 99% of the participants were correctly classified with the CCT task descriptors. The task was valuable in spotlighting the real-life challenges EF deficits cause in accomplishment of the CCT.

While its value lies in its ability to expose the EF deficits, in tandem it presents as highly appropriate to be transformed into a training course to improve the adolescents' EF deficits so to increase the possibility of successful skill acquisition to stack their chances for acquiring a vocation/profession in which they can excel.

Complex task, gardening: traumatic brain injury in young adults in social care, and some with failed education

A study set out to examine the effect of gardening as "a physical activity with capacity to promote neuroplasticity and cognitive functioning" in people with brain issues related to aging, disease, or injury acquired brain issues [82]. Data collected included a 10-year period; although relatively few studies were collected, they confirmed the potential of gardening to improve brain health. The authors [82] emphasize more well structured studies are needed to determine the mechanism of the impact of gardening on brain

health. Adolescents and young adults with NDDs who also suffer from brain injury due to engagement in risky activities could potentially be great candidates for gardening as it is a complex task, and would certainly improve their EFs while simultaneously stimulate brain function improvement. Those with traumatic brain injury (TBI) exhibit brain damages that correspond to the sustained impairments, and produces much grief as they include learning issues, attention, and information processing speed. A training program with gardening as the centre complex task would certainly answer the complex task cognitive effort; it may alleviate some of the problems while improving their cognitive deficits and their EFs.

A gardening study [83] with a focus on six young adults ages 18–24 from difficult family circumstances, including severe educational, social, and economic contexts, who were due to move on from a formal social care system to independent living in the larger community. The "Care Leavers", all with difficult histories, are at an increased risk for "social exclusion, mental illness, poverty and future long-term unemployment". A government program designed to offset their lived deprivations offered community-occupation-based social interventions such as a gardening program that had some evidence of physical and mental health benefits. The group selection was based on a period of regular participation in the gardening experience; the event was accompanied by a qualitative study, with participant data obtained via a digital video conferencing application using semi-structured interviews, and thematic analysis applied to the transcribed data. These provided the "lived experience of the gardening program". Participant data revealed four key themes: 1. social belonging and connection, 2. a safe space, 3. a sense of achievement from active engagement, and 4. the facilitatory aspects of nature. These suggested the nature-based collaborative occupation (co-occupation) within a local group, enhanced their shared social values that benefitted their working together, while affirming self-identity, and resulted in an improved sense of wellbeing. The authors [83] concluded that the study supports the use of community occupation-based interventions with young adult "care leavers" and additionally, offers insight into their individual needs.

In sum, by and large, the suggested treatments focused on group and complex tasks that showed positive effects and potential for alleviating EF deficits and improved function in various age groups of individuals with NDDs including ADHD, with no reference to medication involvement. Interestingly, a study based on a systematic review and meta-analysis [84] was employed in the examination of the efficacy of non-pharmaceutical interventions on EFs in children and adolescents with ADHD. Findings confirmed non-pharmacological interventions such as physical exercise, cognitive training, and an EF-specific curriculum had positive moderate to large effects on overall EFs, leading authors to conclude that non-pharmacological treatment seemed to have beneficial effects on EFs in children and adolescents with ADHD. A result worthy of keeping in mind when planning treatment for individuals experiencing the effects of NDDs and their comorbidities. Nonetheless, a treatment may be supplemented with medication by the attending physicians if a need arises.

This completes the review segment on suggested treatments while acknowledging that these are only some of numerous others that may benefit these individuals. The suggested treatments are meant to alleviate or lessen the serious consequences of the disorders individuals may present, and in tandem, prevent these disorders and comorbidities from acting as catalysts for complicating their situations by altering their phenomes further, and thereby fostering additional degradation of their life quality. The treatments, therefore, are meant to disrupt the vicious circle in which individuals are entrapped.

Discussion

EFs are powerful complex and covert verbally-mediated neurocognitive skills with a long developmental trajectory, and they are highly heritable [85]. They refer to an amalgam of dynamic and flexible networks, interrelated complex processes responsible for goal-directed problem-solving behaviour crucial for intentional simple action such as staying focused on a task, or complex action, as pursuing a career goal. Their functions are guiding, directing and managing cognitive, emotional, and behavioural facets of problem-solving activities [50]. They entail expression and storage of explicit action-oriented rules in working memory. They form two broad domains: self-regulation and metacognitive control [50] that interact dynamically during goal-oriented or problem-solving activities. They are recruited as needed: more

for new and complex tasks and less for automatic and familiar tasks. They are housed in the frontal lobe within anatomically and functionally distinct regions as the prefrontal cortex and connected to deep structures and other cortical centres.

Their key self-regulatory functions are inhibitory control: deliberately ignoring a distraction, stopping an impulsive utterance, or overcoming an automatic or highly learned response; working memory: storing information in mind and manipulating it, e.g., in text comprehension when a reader integrates pieces of information/ideas into a logical whole; cognitive flexibility: thinking about something in multiple ways, e.g., considering someone else's perspective on a situation or solving a mathematics problem in multiple ways. Reflection on the other hand is the foundation of attentional control and all sources of EFs; metacognitive and verbally mediated behaviour: pause, consider the options, and put things into context prior to responding.

Reflective learning is a vital function involving reprocessing of information, and results in active and intentional learning involving subjective thinking about the learning experience and what is learned. Some researchers believe that the development of EFs depends on efficiency of reflection increase [85]. Reflection develops through repeated use, in the context of goal-directed problem solving, and in the context of parental support and scaffolding. There exists a symbiotic relationship between EFs and learning: with increase in learning, EFs improve, and improved EFs facilitate learning. Understandably, EF deficits negatively impact academic outcomes in children. They are dynamic, and the prefrontal cortex and EFs are highly malleable and continue to develop across the lifespan [79]. High-quality educational experiences using complex tasks and direct and indirect training of EFs positively influence brain and EFs development. Language facilitates reflective behaviour since it leads to better and greater cognitive flexibility. Researchers point out [86] that the importance of EF continues beyond childhood: they are needed throughout life since they determine school achievement and career success, as well as quality of life. The authors clarify that the evidence thus far shows EF can be improved at any age; however, training EF does not immediately yield results, but rather requires integration and time. In addition to direct training and practice, programs that also address emotional, social, and physical needs of individuals will be the most successful in developing healthy and highly efficient EFs, suggest researchers [86–88].

This article highlighted the importance of addressing early development to facilitate a successful path to school performance. An important aspect in the early stages is the development of "emotional resilience", i.e., a child's ability to recover and produce positive emotions when faced with adversity. It forms a shield against later anxiety and depression. Another significant milestone in child development is achieving self-regulation. Those who exhibit self-regulation issues are of great concern as they may be accompanied by a host of difficulties that impact social and academic life. Children who exhibit attention and behaviour issues such as hyperactivity, and impulsivity, i.e., ADHD, are candidates for failing to develop healthy EFs. Another important concern is the need to examine routinely high-risk individuals for alexithymia and EF integrity: the results can prevent endless suffering in individuals. Since alexithymia's role in NDDs is disruptive and affects "emotional awareness" needed for recognizing, responding to, and managing one's emotions, an explicit crucial adaptive function, the disruption of EA has serious impact on individuals' mental health. The presence of alexithymia renders individuals unable to identify or explain their emotions; As researchers explain [33]: those with language impairments demonstrated higher alexithymia levels making them especially vulnerable.

Emotion regulation issues are ubiquitous in developmental literature and success in self- regulating behaviours and responses is taken as a significant milestone in children's developmental journey, marked by an increase in age-appropriate behaviour' and significant reduction of 'tantrums' and similar behaviours regardless of context or impact on others; persistent issues in this domain, signal the strong possibility that the NDD, ADHD, may be at work, and flags a delay in EF development [50] a problem that calls for immediate action to help nurture healthy EFs so to facilitate the child's or adolescent's educational journey, and their transition to a successful young adulthood.

Conclusion

This review discussed the complexity of NDDs and the comorbidities of ADHD and alexithymia that add to the burden individuals with DLD and autism carry while they go about trying to live their lives. Comorbidities and the complications they present strengthen the argument against the use of a categorical approach to NDDs, one that is fraught with problems [20]. A "transdiagnostic dimensional approach" in which different diagnoses share common processes which may advance and improve treatment options is preferred as it circumvents the well-known categorical approach limitations while simultaneously offering new solutions. The suggested treatments encompass all age groups and respond to the need to expose the most effective route to improvement by addressing EFs. Healthy EFs facilitate education, vocation, and socioemotional well-being, as well as improved quality of life. EFs help in developing resilience so that individuals can cope with life's difficult moments.

An author recently expressed disappointment at the state of understanding and treating mental health problems despite years of research efforts [88]. The author identifies two obstacles: first, mistaking the complex problem for a simple one as a result of treating it by the given diagnosis in the belief they are one and the same. Secondly, the study of individual elements of mental illness while in reality they are outcomes of complex interacting biological, psychological, and social systems. This system's perspective explains the variability within diagnosis, the comorbidity, and transdiagnostic risk factors. The fundamental problem is that resources are devoted to studying diagnostic labels instead of how "biopsychosocial processes give rise to mental health problems". The author clarifies that complex systems are composed of interdependent elements that require "the study of system parts and the relationships among those parts". The imposition of categorical diagnosis on dimensional problems is a dilemma that needs to be resolved as it does a disservice to individuals whose mental health is not addressed effectively. The preference for considering a dimensional approach to the NDDs is shared in this paper as it addresses the entire continuum of severities as well as the debilitating comorbidities.

Issues to be addressed in developing a clinical plan

The identified issues are meant to facilitate constructing a clinical plan.

1. Alexithymia and autism: The presence of alexithymia in autism flags the need to avoid psychotherapeutic treatments since they garner a poor response, and caution clinicians to search for alternate treatments to alleviate symptoms; since poor language may lead to alexithymia, examining individuals with NDDs with pronounced language issues for the presence of alexithymia is a preventative measure to elude poor consequences and more specialized treatment; the presence of alexithymia will require control in any research design and its analyses.

2. Identification of primary ADHD: The presence of emotional irritability is an important clue in identifying definite "primary" (developmental) ADHD in young and older adults.

3. ADHD comorbidity: These are the various disorders that are found to be comorbid, i.e., tend to co-occur with ADHD: the most frequent is ASD (70%–85%), learning disabilities (reading 15%–50% and math 5%–30%), developmental coordination disorder (30–50%), Tourette's (20%), obsessive compulsive disorder (5%), ODD and conduct disorder (27%–55%), and depressive and anxiety disorder (0–45%). Additionally, those with ADHD exhibit vulnerabilities such as higher risk for addictive behaviours, sleep and feeding disorders, migraines, epilepsy, and more; ADHD is also comorbid in various disorders with different etiologies**.**

4. Detection of ASD/ADHD: In both typical and atypical developments social orienting and joint attention behaviours and symptoms emerge concurrently. This fact may assist clinicians in early detection of possible presence of ASD and ADHD partnership in some vulnerable children. Persistent issues in self-regulation alert us to the strong possibility that ADHD may be present, and marks delay in EF development.

5. Differentiation of ASD from ADHD: both joint attention and sustained joint engagement challenges underlie ASD and most probably contribute to difficulties with talking.

6. Contribution of EFs to differential diagnosis: An interaction between inhibition and ADHD heralds future issues, alerting us that preventive training of children in the EFs is warranted.

7. Including EFs investigations in evaluations: There is wisdom in investigating the status of EFs and the presence of ADHD when treatment is not producing the desired results, or better still, making the investigation a routine part of the evaluation by providing valuable EF profiles of DLD and ADHD. Working memory, e.g., was identified as an aid in differentiation of DLD from ADHD.

Abbreviations

ASD: autism spectrum disorder

CCs: categorical classifications

CCT: children's cooking task

DLD: developmental language disorder

DR: dialogic reading

EA: emotional awareness

EFs: executive functions

FER: facial emotion recognition

HiTOP: Hierarchical Taxonomy of Psychopathology

HMFs: higher mental functions

HPO: Human Phenotype Ontology

MTSS: multi-tiered system of supports

NDDs: neurodevelopmental disorders

ODD: oppositional defiant disorder

PEERS: Program for the Education and Enrichment of Relational Skills

SLD: specific learning disorder

SLI: specific language impairment

SPCD: social pragmatic communication disorder

TAS-20: 20-item Toronto Alexithymia Scale

TCS: Think Check Submit

Declarations

Acknowledgments

First and foremost, the authors thank our audiologist colleague, Irene Hoshko, for the invaluable insights and encouragement in writing this article. The authors dedicate this article to all the families and their loved ones who struggle with NDDs and yet maintain their courage and dedication without complaint out of their boundless faith and hope for a better future. Similarly, we acknowledge all those who work tirelessly to provide us with knowledge and solutions that succeed in improving these families' quality of life: "Knowledge is Learning and reasoning whereas the use of knowledge for the good of others is Wisdom".

Author contributions

YH: Conceptualization, Data curation, Writing—original draft, Writing—review & editing. OS: Data curation, Writing—review & editing.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publication

Not applicable.

Availability of data and materials

Not applicable.

Funding

Not applicable.

Publisher's note

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