Speech-language Pathology Interventions for Children with Executive Function Deficits: A Systematic Literature Review

Reed Senter[1]

ORCiD: https://orcid.org/0000-0002-5852-8057

Jason C. Chow[1]

ORCiD: https://orcid.org/0000-0002-2878-7410

Emma C. Willis[2]

ORCiD: https://orcid.org/0000-0003-0134203283

[1]Department of Counseling, Higher Education, and Special Education,

University of Maryland, College Park, MD

[2]Department of Human Services,

University of Virginia, Charlottesville, VA

Corresponding Author

Correspondence concerning this article should be addressed to Reed Senter.

Email: Reed.Senter@desales.edu

Phone: (610) 282-1100

Address: 2755 Station Ave, Center Valley, PA 18034

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Abstract

Purpose: The purpose of this synthesis was to systematically review the research and guidance for school-based speech-language pathologists (SLPs) who provide intervention to children with developmental executive function (EF) deficits, particularly those children with co-occurring developmental language disorder (DLD).

Method: We conducted a structured search of four major electronic databases, as well as a manual review of references and journals, which yielded 4,571 non-duplicate articles. We first screened titles and abstracts, then full texts, to identify peer-reviewed articles, dissertations, and theses containing research or guidance for SLPs' interventions for children with co-occurring DLD and EF deficits; this process yielded 36 articles for analysis. We categorized these studies by type of publication and synthesized their contents to assess the evidence base for executive function interventions in children with DLD, and to evaluate the guidance for SLP-implemented direct and indirect interventions.

Results: A small body of research explores the efficacy of SLPs' intervention for children with co-occurring DLD and EF deficits, generally finding modest but inconsistent effects of cognitive interventions and strategy training to improve language outcomes. Meanwhile, non-empirical articles (e.g., tutorials) offer guidance to SLPs to support students with EF deficits through direct and indirect services.

Conclusions: A growing body of literature equips SLPs with the principles and strategies of executive function intervention. Many of these papers are sourced from literature about children with EF deficits or ADHD, but few empirical studies measure the efficacy of these interventions for children with co-occurring DLD.

Speech-language Pathology Interventions in Children with Executive Function Deficits: A Systematic Literature Review

Executive function (EF) deficits, often associated with medical conditions (e.g., acquired brain injury) or neurodevelopmental disorders (e.g., Attention-Deficit Hyperactive Disorder [ADHD]), may be more prevalent among children in a school-based speech-language pathologist's (SLP's) caseload than previously realized. EF deficits commonly co-occur with developmental language disorder (DLD) in children (see Graf Estes et al., 2007; Pauls & Archibald, 2016; Vugs et al., 2013). Since about 90% of school-based SLPs serve children with language disorders (ASHA, 2020), it is essential that SLPs be equipped to provide services that are sensitive to the needs of children with co-occurring DLD and EF deficits.

Evidence-based practice is the cornerstone of speech-language services, so SLPs must be mindful of the research supporting their interventions. Certainly, SLPs strive to provide language interventions grounded in evidence-based practice. However, it is unclear the extent to which these interventions are effective in children with co-occurring deficits. Cognitive limitations may lead to poorer outcomes in language intervention, which suggests the need for evidence to support the efficacy of interventions specifically for children with co-occurring DLD and EF deficits (Montgomery et al., 2010). Further, the efficacy of EF interventions may be limited in children with DLD, as many of the most common interventions rely on verbal mediation. There is also a need to explore the SLPs' role in intervention for children with EF deficits, as only half of SLPs report providing cognitive communication therapy (ASHA, 2020).

Executive Functions

EFs are the cognitive skills necessary to plan, organize, and engage in goal-directed behaviors (Miyake et al., 2000). Various models take different approaches to defining and

describing the components of EF. Most models agree on three domain-general ("simple") skills: working memory (WM), shifting attention, and inhibiting competing thoughts (Diamond, 2013; Miyake et al., 2000). In contrast, other models include domain-specific ("complex") skills such as sustained attention, goal-directed persistence, metacognition, organization, emotional regulation, and more (Brown, 2005; Dawson & Guare, 2009; Jones et al., 2016). Complex skills are further characterized as "proximal," indicating skills most closely related to the simple EFs (e.g., planning and problem-solving), or "distal," indicating more abstract applications of EF (e.g., setting goals, decision-making). These complex, functional skills are understood to interact and build upon the foundations of other EFs. For instance, a complex skill such as sustained attention will draw upon the simple skills of WM (to temporarily store information input), inhibition (to maintain attention despite distractions), and perhaps even shifting (to return attention to the speaker in the event of an interruption). The relations between these various models were explored in the Executive Function Mapping Project (Jones et al., 2016), which reviewed and synthesized the research and theory of EF within scientific literature in order to derive the unified model of simple, complex, proximal, and distal EFs described above.

Regardless of the model of EF, these skills are linked to notable child developmental outcomes such as academic achievement (Best et al., 2011), behavior and social competency (Nigg et al., 1998), and social-emotional development (Hughes et al., 2000). Further, EFs have implications for interventions as an outcome (e.g., Diamond & Ling, 2019), mediating mechanism (Raver et al., 2011), or as an intervention component (Bierman et al., 2011). However, some individuals present with deficits in one or more domains of EF, and these deficits may occur for a variety of reasons, including developmental (e.g., DLD) and acquired (e.g., traumatic brain injury; Giola et al., 2002). Whether developmental or acquired, EF deficits

jeopardize future outcomes due to the aforementioned link between EF and academics, behavior, and social-emotional development, though this review focuses on EF deficits of a developmental nature.

Though EF deficits pose a risk to students' success in school, educators can support these students through intervention. Intervention for EF is reported to be most effective for the students with the most significant deficits; repeated, challenging practice in a meaningful context may improve students' EF skills, though transfer effects are generally narrow (Diamond, 2012). Otero and colleagues (2014) conducted a selective review of the literature of school-based EF intervention, and identified five broad categories of intervention that can feasibly be implemented by educators: computerized training, strategy instruction, curricula, mindfulness and physical activities, and games. They noted that computerized training is readily available and easy to implement with fidelity, though they also acknowledged that this approach has been criticized for lacking generalizability and durability. Further, they recognized that computerized training may be financially impractical and time-consuming for some schools. Strategy instruction is a global approach to improving specific learning behaviors, and is traditionally most effective for older children. The curricular approach is designed for a classroom- or school-wide focus on teaching classroom skills such as self-regulation, self-awareness, goal-direct behavior, and others. Otero and colleagues note that the preliminary research of EF curricula offers promising results. Mindfulness and physical activities such as yoga and martial arts have been linked to improved school behaviors and EF skills such as planning, based on various studies with samples ranging from early elementary through college-aged students. Finally, they noted that games such as "Simon Says" and "Mother May I?" may help young children develop WM and inhibitory skills.

Developmental Language Disorder

Developmental Language Disorder (DLD) is the term used to describe a naturally-occurring impairment of one or more language components, including phonology, morphology, syntax, semantics, and pragmatics. It is estimated to occur in about one in 13 children (7.58%; Norbury et al., 2016) and is found in the absence of a causal differentiating condition such as a genetic or neurological etiology (Bishop et al., 2017).[1] However, DLD may co-occur alongside genetic, neurological, or neurodevelopmental disorders such as ADHD (McGregor et al., 2020); indeed, this is not uncommon (Redmond, 2020).

Executive Functions in Speech-Language Pathology

Developmental language disorder is associated with a host of academic outcomes, including reading disabilities, spelling problems, and math difficulties (McGregor, 2020; Young et al., 2002). While the academic risks of DLD have been long-understood, an emerging body of research explores additional risk factors associated with DLD, namely the increased likelihood that individuals with DLD will also present with impaired EF. Much of this research addresses WM in children with DLD, including meta-analyses finding that children with DLD perform, on average, 1.27 standard deviations below their peers for phonological short-term memory (Graf Estes et al., 2007), .63 standard deviations below their peers in visuospatial working memory tasks (Vugs et al., 2013) .56 standard deviations below their peers in tasks of inhibition, and .27 standard deviations below their peers in tasks of cognitive flexibility (Pauls & Archibald, 2016).

[1] Language disorders are described by a wide variety of terms, including Specific Language Impairment (SLI), Primary Language Impairment (PLI), and Developmental Language Disorder (DLD). Of these, DLD is the most inclusive. In accordance with Bishop et al. (2017), this systematic review will use the term "DLD" to broadly describe all language disorders that occur in the absence of a known differentiating condition, though we will note when the original authors used other related terms.

Executive dysfunction is a common characteristic of attention-deficit/hyperactivity disorder (ADHD), and meta-analytic results suggest that groups of individuals with ADHD, on average, exhibit significant impairment in all domains of EF (Willcutt et al., 2005). Perhaps due to the shared characteristics of EF deficits, there is a high rate of comorbidity between DLD and ADHD. ADHD has an estimated co-occurrence rate of 22.3% in children with DLD, and though reports do not indicate that ADHD exacerbates language impairment, this high rate of co-occurrence may impact the way that SLPs conduct assessment and intervention for children in this population (Redmond 2016; 2020).

The growing awareness of EF impairments developing alongside DLD is reflected in the expanding body of research in this area, but much of this research focuses on descriptive information (e.g., Pauls & Archibald, 2016; Redmond, 2020) or assessment practices (e.g., Fahy, 2014). While there is intervention research for children with EF impairments, much of it focuses on interventions for social communication (e.g., Timler et al., 2015) rather than academic outcomes. The prevalence of EF deficits in children with DLD, coupled with the multifaceted risk of added difficulty in domains of organization, planning, and execution, justify the SLP's role in the identification and remediation of EF deficits. However, interventions for this population are underexplored.

There is no doubt that EF is within the scope of speech-language pathology. The American Speech-Language-Hearing Association (ASHA) has made this clear within their list of "The Big Nine" competencies within SLPs' scope of practice (ASHA, n.d.b). This list includes "cognitive aspects of communication," under which EF is explicitly mentioned. The inclusion of EF within the SLPs' scope of practice is logical, given the interactions between EF, language,

and other aspects of communication; however, it highlights the egregious lack of attention to EF in the field's research and practice.

Research Questions

Because there is a dearth of research about interventions to support developmental EF deficits in children with DLD, SLPs are at risk to be insufficiently equipped to serve these children on their caseloads. This paper aims to address this through a systematic review the literature, asking the following two research questions:

1) What are the results of empirical research for interventions for children with co-occurring EF deficits and DLD, primarily those examining the outcomes of language, EF, or broader academic success?
2) What published guidance is presently offered to SLPs providing intervention to children with EF deficits? This includes guidance for accommodations, principles and strategies of intervention, and intervention frameworks.

Method

This systematic review closely adheres to the reporting guidelines and criteria set forth in Preferred Reporting for Systematic Reviews (PRISMA; Page et al., 2021; see PRISMA Flow Diagram in Supplemental Materials). For the purposes of this review, we examined direct and indirect interventions for EF deficits prevalent in school-age children with DLD. Articles of interest include empirical studies evaluating the efficacy of EF interventions for children with DLD, as well as non-empirical papers providing guidance for how SLPs can provide support for children with EF deficits.

Operational Definitions and Search Strategy

In this systematic review, we operationalized EFs based on their description in the Executive Function Mapping Project (Jones et al., 2016), which synthesized the various conceptualizations of EF into a single comprehensive model. This model identified three sub-components of EF: response inhibition, set shifting (i.e., switching between tasks), and WM. Search terms pertaining to EF were drawn from these three sub-components and their related synonyms. Further, because ADHD is a well-known and well-studied disorder of EF, and because much of the literature in the field of speech-language pathology discusses EFs within the context of children with ADHD, the search was also extended to include terms related to ADHD based on the premise that there is meaningful overlap between interventions for ADHD and other EF deficits.

Our search included terms related to DLD and related terms which fall under the umbrella of DLD (e.g., Specific Language Impairment, Primary Language Impairment). We expanded the search terms to include “speech-language pathology” and related terms to ensure the inclusion of literature that is relevant to this population. Interventions were operationalized as direct or indirect services that could be feasibly implemented by a school-based SLP. The initial search was conducted in March 2021, and updated in December 2021.

Our final search terms were as follows: ("DLD" OR "developmental language disorder*" OR “language disorder” OR “communication disorder” OR “language impairment” OR “language disability” OR “language delay” OR “speech-language patholog*”) AND ("executive function" OR "working memory" OR "attentional control" OR "shifting" OR "inhibitory control deficits" OR “executive function*” OR “cognitive process” OR “cognitive abilit*” OR “cognit*” OR “inhib*” OR “attention” OR “task switching” OR “set shifting” OR “ADHD” OR “attention

deficit" OR "ADD") AND ("intervention" OR "treatment" OR "therapy" OR "accommodation" OR "strateg*" OR "practice").

Inclusion Criteria

The study inclusion criteria were as follows:

1) Original, peer-reviewed journal articles; theses and dissertations. No date restrictions.
2) Included articles must feature intervention for children with EF deficits. This broadly describes direct and indirect therapy, accommodations, and related strategies. Studies focused on descriptive associations or assessment were excluded.
3) Included articles must focus on neurodevelopmental EF deficits, such as those found in Attention Deficit Hyperactivity Disorder. Deficits occurring secondary to acquired brain injuries (ABI), such as strokes or concussions, were not included.
4) Included empirical articles must address the population of school-age children (i.e., K-12) with DLD. Closely-related non-empirical papers (e.g., tutorials for pediatric SLPs) were included on a case-by-case basis dependent upon whether their guidance could be feasibly applied to school-based SLPs' intervention for children with DLD.

Data Extraction

Article Screening

The search and selection process is reported following the PRISMA 2020 standards for reporting systematic reviews (Page et al., 2021). The initial search of the databases PsycInfo, PubMed, CINAHL, ERIC, and ProQuest Dissertations and Theses yielded 6,362 articles that were screened for inclusion. Search results were imported into Rayyan, a free web application published by the Qatar Computing Research Institute (Ouzzani et al., 2016). Following the removal of 1,795 duplicates, 4,567 articles remained. The first author screened each article's title

and abstract to assess eligibility for inclusion, and an undergraduate research assistant screened 1,100 titles and abstracts (approximately 25% of the total). Reliability between the screeners was 98.6%, and the authors reviewed discrepancies to ensure accurate decisions about inclusion.

The initial screening yielded 36 articles for which the full-texts were further reviewed for inclusion. The reference lists of these articles were hand-searched, leading to the identification of two additional articles, and we reviewed special issues of journals to find an additional two articles. After full-text review, four articles were excluded because they did not address EF, four were excluded because they were neither published in a peer-reviewed journal nor were they dissertations or theses, and one was excluded because it did not address intervention. The remaining 27 articles met the inclusion criteria.

Article Coding

For each included publication, we extracted key information necessary to synthesize the overall findings or guidance, and entered into one of two spreadsheets, dependent upon whether the publication was an empirical design or a non-empirical paper offering guidance to SLPs. This information is summarized in Table 1 (empirical studies) and Table 2 (non-empirical papers).

For each included empirical study, we extracted the following information: name of author(s), date of publication, research design, population (e.g, DLD, ADHD, or co-occurring DLD and ADHD), EF construct (e.g., ADHD, working memory), number of participants, interventionist (e.g., SLP, multidisciplinary team), intervention category (i.e., direct [language], direct [EF], or indirect), and outcome variables.

For each non-empirical paper, we extracted the following: name of author(s), date of publication, population, EF construct, DLD focus (coded as “Yes” or “No” depending on the scope of the article), interventionist, intervention category, and the targeted outcome variables.

The first author of this review coded each article, and the third author served as a second coder to demonstrate reliability. We randomly selected eight articles (30%) to double-code; four empirical and four non-empirical papers. Reliability across the empirical studies was 87.5%, and the coders resolved all discrepancies. Reliability across the non-empirical papers failed to meet our standards (78%) due primarily to differences in the level of detail in our descriptions of interventions, so we adjusted our coding scheme for clarity, resolved differences, and selected four new articles to double-code. Our reliability across the second set of non-empirical papers was 96%, and we updated previously-coded articles based on the revised coding scheme.

Results

Our first research question led us to examine the empirical research of interventions for children with co-occurring DLD and EF deficits, and our second research question led us to synthesize the non-empirical articles which contained guidance to SLPs implementing EF interventions. Twenty-seven articles met the criteria for inclusion: ten empirical papers and 17 non-empirical (see Supplemental Materials for the full list of references of included articles). The dates of publication ranged from 1994-2021, and most (n = 21, 78%) were published in peer-reviewed journals of speech-language pathology, communication disorders, or language disorders. See Tables 1 and 2 for more information on included studies.

To answer our first research question, we examined the literature to identify the evidence for interventions in children with co-occurring DLD and EF deficits. The findings pertaining to empirical designs are reported below, containing summaries of quasi-experimental designs, single case designs, and case studies (which, though empirical, are non-experimental in nature). The results pertaining to the second research question (i.e., to explore the current guidance for

SLP intervention into developmental EF deficits) are reported below as guidance. These results contain a variety of tutorials and narrative reviews.

Empirical Designs

Research designs are classified based on the level of evidence they offer, based on the necessary scientific rigor and quality (Robey, 2004). Per the Agency for Healthcare Research and Quality (Shojani et al., 2001), the highest level of evidence is generally regarded to be a meta-analysis of multiple well-designed controlled studies (Level 1A), followed closely by well-designed randomized controlled trials (Level 1). Quasi-experimental designs fall into the next level of evidence (Level 2). Level 3 studies include observational studies with controls, and Level 4 studies include observational studies without controls. Our review identified three studies using quasi-experimental design (Level 2), three studies using single case design (Level 3) and four case studies (Level 4). In order to meet the expectations for each respective level of evidence, studies must adhere to high standards of quality. In our summaries of each study, we analyze the quality based on the quality indicators described by Gersten and colleagues (2005) for quasi-experimental designs, and the quality indicators described by Horner and colleagues (2005) for single subject designs. See Table 3 for detailed information about the quality indicators for each experimental study included in this review.

Quasi-experimental Designs

Gill and colleagues (2013) conducted a quasi-experimental study, the results of which provide some evidence for rehearsal and visualization strategies to improve memory in children with specific language impairment. Thirty children were divided into three groups: ten received traditional speech-language therapy included training in semantic and syntactic structures and practice following directions containing those structure; ten received explicit instruction in the

rehearsal strategy during their therapy time, and ten received instruction in both rehearsal and visualization during therapy. Intervention consisted of ten 30-minute language therapy sessions; two per week for five weeks. Children in the two groups receiving memory instruction performed significantly better than their peers who received traditional speech-language therapy alone, and the effects persisted through a follow-up eight months later. Based on Gersten and colleagues' criteria (2005), this study failed to reach the standards of "acceptable" quality.

Holmes and colleagues (2015) conducted a quasi-experimental study of the computerized working memory training (CWMT) program "Cogmed Working Memory Training RM," which is intended to improve cognitive skills such as verbal short term memory through a series of progressively difficult computer-based tasks (Klingberg, 2001). They compared the intervention outcomes of 12 children with low language ability, ages 8-10, to a comparison group of 15 children with average language ability. Intervention was delivered via Cogmed in 20 45-minute sessions across eight weeks. They found that children with low language ability showed similar benefits from Cogmed as language-typical peers. However, their study did not fully address criticisms that CWMT may not produce generalizable or durable effects (see Gillam et al., 2018; Melby-Lervåg & Hulme, 2013). Nevertheless, the study was designed and implemented in a rigorous manner, meeting Gersten and colleagues' criteria (2005) as "acceptable".

Stanford and colleagues (2019) conducted a similar quasi-experimental study of Magic Memory, another type of CWMT. Their study used an intervention sample of 26 children with DLD and 16 typically-developing children. They also used two age-matched comparison groups receiving a scholastic intervention of online training in subjects such as spelling and history, consisting of 16 typically-developing children and 17 children with DLD, all of whom were French-speaking children aged 5-12 years. The interventions were delivered using electronic

software, across an 8-week training program consisting of three 30-minute sessions per week. They found that WM training resulted in significant improvement to both WM performance and 3rd person accusative clitics (i.e., a morphosyntactic structure referring to the unstressed portion of contractions) in children with DLD. The comparison groups showed no significant changes. This study provides some evidence that WM training may improve not just working memory, but also far-reaching outcomes such as language ability in children with DLD. However, durability and generalizability are still questionable due to the absence of a later follow-up and the narrow scope of linguistic outcomes. Based on Gersten and colleagues' criteria (2005), this study met the standards as "acceptable."

Single Case Designs

Ebert and Kohnert (2009) conducted a multiple-baseline across participants design with two children diagnosed with primary language impairment to determine the efficacy of auditory memory training and visual processing speed training to improve language and cognitive function. Both interventions primarily utilized electronic software interventions, as well as commercially available games selected to place demands on auditory memory and visual processing respectively. Intervention was provided in 16 sessions, four per week, each session 90 minutes in duration. The results lend some support to the notion that cognitive training can improve linguistic outcomes, as both participants improved their performance on rapid naming tasks, and both showed significant improvements in standardized language assessments administered pre- and post-test. However, these findings must be interpreted cautiously due to limitations of internal validity (e.g., limited opportunity to demonstrate experimental effects, the rehearsal effect on standardized assessment, and the absence of a control intervention or task). Finally, the data from the repeated measures tasks cautiously provided only modest for the

efficacy of intervention on linguistic measures, due to high levels of overlap between phases and significant variability within individual phases in both participants. This study met 14 of the 21 quality indicators described by Horner and colleagues (2005).

Ebert (2014) conducted a multiple-baselines across participants design with three children diagnosed with primary language impairment, two of whom had also been diagnosed with ADHD. The purpose was to determine whether conventional language treatment is effective for improving cognitive skills. The intervention consisted of six activities to improve language targets such as vocabulary, morphosyntax, and auditory comprehension; three used electronic software, and three used interactive games and activities. The intervention was delivered across twelve sessions. Ebert concluded that the two participants with ADHD showed mild improvement in WM and processing speed post-intervention, but there was substantial within-child variability both pre- and post-intervention, as well as inter-phase overlap and variability. This study met 17 of the 21 quality indicators described by Horner and colleagues (2005).

Shahmahmood and colleagues (2018) conducted a phased single subject design (A-B-A-C) evaluating the effectiveness of WM training and traditional language therapy on WM and grammar in ten Persian-speaking children with primary language impairment. The WM training consisted of practicing a mix of interactive and computerized activities which taxed WM, such as forward and backward recall. The language intervention consisted of explicit instruction of morphosyntactic structures using imitation, modeling, and focused stimulation. Both interventions took place across 15 hour-long sessions, three per week for five weeks. In contrast to Ebert and Kohnert (2009), this article found that WM training resulted only in improvements to WM tasks, while improvements to language were inconsistent. Dedicated language therapy

resulted in improvements to non-word repetition and sentence completion tasks. This study met 19 of the 21 quality indicators described by Horner and colleagues (2005).

Intervention Case Studies

Clegg and Hartshorne reported two case studies of children with co-occurring speech/language impairment and ADHD (2004). Within these case studies, multidisciplinary educational teams including an SLP implemented a variety of strategies including curricular modifications, reduced distractions, increased structure, visual support, and support in social communication. In the first case study, the authors reported benefits for learning, language, and communication, and the second case study demonstrated the feasibility of coaching teachers to accommodate learners with co-occurring disorders.

Dunaway (2004) contributes a narrative case study describing a school-based SLP's role in supporting a child with ADHD and concurrent language deficits which manifested in "disorganized" oral and written language. This SLP collaborated with educators to implement contextual and instructional modification, as well as direct writing interventions. Through this collaboration, the educators and SLP were able to negotiate mediating opportunities such as service across settings.

In a similar vein, Singer and Bashir (1999) used a case study of a sixteen-year-old boy with language learning disorder to supplement a conceptual description of executive functions and the SLP's role in remediation. The authors emphasize the interaction between cognition and language, noting that speech-language treatment can include metacognitive strategies such as self-talk and thinking maps. The authors note the importance of using dialogic and interactive approaches, teaching the flexible use of strategies, addressing the linguistic underpinnings of

metacognition, and developing the student's self-efficacy and motivation. They encouraged SLPs to provide context for strategies by teaching the student where, when, why, and how to use them.

Datchuk and colleagues (2020) reported a single case study with an A-B design (i.e., a case study) of a specific intervention for a child with co-occurring speech/language impairment and ADHD. In this instance, the interventionist was a special educator using a combined approach of sentence instruction and frequency building to a performance criterion. The intervention targeted the accuracy and speed of sentence writing, and the child demonstrated immediate improvement in both regards following intervention.

Non-empirical papers: Guidance for Intervention

The majority of publications selected for inclusion were non-empirical papers intended to explain the role of SLPs in the treatment of children with EF deficits. The contents of these papers ranged from principles of intervention to intervention categories to explicit descriptions and examples of intervention.

Principles of Intervention

In a tutorial for school-based speech-language pathologists, Drazinski (2014) described the principles of intervention for children with EF deficits, both developmental and acquired. Drazinski encouraged SLPs to select an intervention plan based on the child's individualized strengths and needs, using "repetitive routines with contextualized [and meaningful] activities resulting in positive outcomes" in order to establish a pattern of successful habits. Drazinski also noted that SLPs can use elements of restorative and compensatory approaches within their intervention context.

R. Gillam (1997) provided a summary of principles for incorporating memory into language intervention. Based on the premise that success in language intervention depends

heavily on memory processes, Gillam states the importance of promoting attention through salient intervention targets and limiting distractions, providing emphasis and speaking clearly and slowly, promoting phonological coding to enhance listening skills, planning activities around familiar content, helping learners organizer new knowledge, and teaching retention cues. Gillam described these principles to address both working and long-term memory, suitable for children and adults. Gillam acknowledged that the evidence behind some of these principles was sparse, singling out phonological coding as "promising" if not yet empirically validated.

S. Gillam and colleagues (2018b) echo many of the same principles espoused by R. Gillam in 1997: the value of an organizational framework and the importance of developing phonological awareness. This article also discusses self-esteem as a correlate of performance in WM tasks (Autin & Croizet, 2012). Though DLD did not seem to be a consideration in Autin and Croizet's article, Gillam and colleagues noted that this research has meaningful implications for individuals with DLD, many of whom experience lower self-esteem than their typically-developing peers (Durkin et al., 2017). Despite this article's support for different principles and types of interventions to support children with WM deficits, one overarching message is a caution against WM training intended to improve WM capacity. Citing a number of meta-analyses (Au et al., 2015; Karbach & Verhaeghen, 2014; Melby-Lervåg & Hulme, 2013; Melby-Lervåg et al., 2016; Randall & Tyldesley, 2016; Sala & Gobet, 2017; Schwaighofer et al., 2015), Gillam and colleagues noted from their review of the literature that WM training rarely produces far transfer effects into skills such as language and reading, and cautioned against their use in therapy.

Interventions for Children with DLD

Montgomery (2006) and Montgomery et al. (2010) promote the use of phonological awareness training alongside verbal rehearsal and paraphrasing as viable WM interventions for children with DLD. Montgomery (2006) refers to this as a "dual language-memory approach," intended to resolve the co-occurring deficits attributed to a bidirectional association between language and memory. Montgomery and colleagues (2010) also suggest working memory capacity training as an intervention option, in contrast to later work by Gillam et al. (2018), along with a program called Fast ForWord, intended to improve processing speed.

Fahy and Browning (2021) also provided a functional guide for intervention supported by numerous ready-to-implement examples of activities. Their article addresses adolescent therapy for children with co-occurring DLD and EF deficits, and their intervention approach suggests that the adolescents work in teams to create and follow linguistically-complex instructions. This activity is intended to exercise participants' expressive and receptive language, as well as their planning and reasoning skills in a meaningful and engaging context.

Meltzer and colleagues (2021) published a clinical tutorial describing how SLPs can provide direct intervention to teach explicit strategy use to improve various EFs. The authors noted that these skills are valuable for all children, but especially for children with language deficits. They emphasized the importance of helping students recognize their own strengths and weaknesses, and teaching strategies that the students themselves can implement and self-monitor. They also introduced their "SMARTS program," which they described as a research-based program to support executive function across various educational settings.

Singer and Bashir (2018) summarized and synthesized the existing literature describing verbal WM limitations in children served by SLPs, which they used to provide a clinical framework to guide WM interventions. As a narrative review, many of the principles in this

article echo those of other authors included in this systematic review. Singer and Bashir cautioned against WM training due to the lack of evidence to improve far outcomes. Instead, they advised SLPs to improve language efficiency and automaticity. Their rationale is that improving children's language will reduce linguistic demands on WM, allowing them to repurpose their cognitive capacity towards the content of the message. They also advise the use of visual anchors, including rehearsal, visualization, advance organizers, and graphic organizers, which may complement the child's efforts to store a verbal message in their memory. Likewise, the authors noted that WM demands can be supported through heightened linguistic structure and reduced demands, which include various internal and external factors. Finally, they stated the need for SLPs to collaborate with other professionals to help address students' needs across contexts.

Gillam and colleagues (2019) and Montgomery and colleagues (2021) bridged the gap between practitioner-focused intervention articles and empirical research in these research summaries. They reported previous results from a large-scale study of children with DLD and their propensity-matched typically-developing peers (Evans et al., 2018), and provided insight into the implications for assessment and treatment based on their findings. Their study found that WM mediated the association between other cognitive functions (i.e., fluid reasoning, controlled attention, and long-term memory for language knowledge) and sentence comprehension. In the former article, Gillam and colleagues (2019) suggested a functional approach to language intervention which promotes "strategic organization of information," similar to the recommendations for organizational framework discussed in Gillam (1997) and Gillam et al. (2018). They promoted a narrative-based approach called "Supporting Knowledge in Language and Literacy" (SKILL: Gillam et al., 2018a) to target language in children with co-occurring

cognitive and language deficits. In a follow-up article (Montgomery et al., 2021), the authors encouraged interventionists to address underlying language skills of syntax and sentence comprehension directly, rather than attempting to improve WM through training. They suggested methods for implicit and explicit interventions, to reduce WM demands and improve language respectively.

Interventions for Children with ADHD

Several articles (incl. Damico et al., 1999; Damico & Armstrong, 1996) provided intervention strategies for SLPs to use with children with ADHD. Aligned with the prevailing literature of ADHD interventions (Barkley, 2018, DuPaul & Stoner, 2014), the intervention strategies described within these publications were categorized as pharmacological, behavior management, cognitive-behavioral therapy, direct communication intervention, or classroom academic management strategies. These broad categories of ADHD intervention align with the strategies and interventions presented in other papers included in this review.

Dunaway (2004) builds on the literature of strategies for SLPs to use with children with ADHD. This article provided insight into the classroom academic management strategies introduced by Damico and colleagues, including contextual and instructional modifications. Dunaway encouraged SLPs to collaborate with other educators and explore services across setting and service delivery models.

Similarly, Jansen and colleagues (2010) shared strategies materials that SLPs can use with children with ADHD. The authors promoted sensory strategies to improve students' motivation and academic performance, particularly those utilizing "stimulating, novel, active, meaningful, and interesting" stimuli; examples of tactile, visual, and auditory strategies are provided, as are examples of strategies to optimize peer interaction and meaningful intervention.

This article is a functional resource for clinicians, and includes sample activities to address pragmatics, WM, and reading comprehension.

Westby and Cutler (1994) authored a review of language ability in children with ADHD, noting the prevalence of language disorder in children with ADHD, as well as the associations with pragmatic and metacognitive deficits. They advised clinicians to develop children's planning skills and social-emotional cognition in order to ameliorate these deficits. Specifically, they propose cognitive-behavioral intervention consisting of cognitive modeling and verbal mediation to ensure that children with ADHD can understand and describe the strategies they are asked to implement. They also encouraged explicit instruction in problem-solving techniques, particularly those consisting of a self-questioning script. These three strategies meet children with ADHD at the intersection of language and cognition, allowing the clinician to address both domains, but Westby and Cutler note that the linguistic limitations of many children with co-occurring ADHD and language disorders presents a barrier to effective strategy use.

Nelson and Hawley (2004) provided SLPs with a guide to address inner control in children with ADHD. This article advocated for literacy interventions as a way to develop inner control following the premise that reading relies on inner control to focus on the text, to interpret the orthography, to employ comprehension strategies, and ultimately to find meaning. Citing Cambourne (1988), the authors outlined key principles to literacy intervention: immersion into a literacy-rich environment, sufficient demonstrations, mediated opportunities to participate, significant opportunities to practice independently, and opportunities to "perform" their reading for others. This progression allows readers to develop independence.

Interventions for Children with General and Specific EF Deficits

While the publications above provided SLP with intervention approaches for the broad deficits associated with ADHD, Boudreau and Constanza-Smith (2010) focused more narrowly on WM. They suggested that SLPs may implement computerized WM training to improve discrete skills, but also provide strategies leading to more generalizable academic success. The latter strategies include working with teachers to reduce WM demands, and working with students to improve skills and teach strategies that will result in improved performance on tasks that require WM.

Gathercole and Alloway's tutorial and narrative review (2006) addressed a broader audience of practitioners treating children with neurodevelopmental disorders. It was selected for inclusion due to its explicit mentions of specific language impairment as a neurodevelopmental disorder associated with WM deficits. The strategies within this article focused on improving the outcomes of children with WM deficits, but are not differentiated between children with specific language impairment or other neurodevelopmental disorders such as Autism Spectrum Disorder or ADHD. The authors described strategies to accommodate poor verbal short-term memory and WM.

Discussion

The purpose of this systematic review was to review the current state of evidence for EF interventions for children with co-occurring DLD and EF deficits, and to synthesize the guidance pertaining to the speech-language pathologist's role and capacity to support students with deficits of EF. The results of this review support the notion that SLPs are able to support children with EF deficits in educational settings. Based on our results, we present three central findings from this review. First, in response to our first research question, there appears to be little empirical research exploring interventions at intersection of DLD and EF deficits, and the findings of these

studies fail to provide overwhelming evidence in support of the interventions' efficacy in improving cross-domain or functional outcomes. In response to our second research question, we found that despite the lack of empirical support in favor of interventions, the present guidance encourages SLPs to draw from literature outside the realm of communication disorders research to provide direct intervention addressing the functional deficits of children with EF impairments. Third, based on trends we identified in empirical and non-empirical articles, we conclude that SLPs can be valuable team members by collaborating with other educators to ensure that children with co-occurring deficits can access their academic curriculum. The following discussion will elaborate on each of these central findings, describe the limitations of this systematic review with consideration of the article selection and scope of this research, and explore the implications of these findings for SLPs and researchers.

Evidence for EF Interventions in Children with DLD

The primary aim of this review was to identify studies of EF interventions for children with DLD. To the authors' best knowledge, few such studies exist; this review identified only three quasi-experimental studies, three single case design studies, and four case studies. Of these, quasi-experimental studies provide the strongest level of evidence, but this highlights the lack of randomized controlled studies which would provide even stronger evidence still than that. This guidance should be considered when evaluating the research behind executive function interventions. While the efficacy of interventions may have been evaluated at a high level in other populations (e.g., ADHD trials without controlling for language ability, or studies of individuals with acquired brain injury), clinicians should be cautious about assuming that interventions have been validated in the populations of children they serve.

Despite small sample sizes, single-case research designs have a strong potential for experimental control, allowing them to provide valuable insight into intervention efficacy (Horner et al., 2005). This is particularly valuable for researchers of children with disabilities (Ledford et al., 2019), and can be adapted by clinicians to carefully monitor (via detailed data collection) the effects of their intervention, while using strategies such as comparison treatments or multiple baselines to demonstrate that any effects are indeed attributed to their intervention efforts. Within our review, Ebert's (2014) multiple baselines study of three children with DLD examined whether conventional language therapy (including relational vocabulary, morphosyntax, and auditory comprehension of directions) can improve task-based measures of WM, sustained attention, and processing speed. Since many aspects of EF are tied to linguistic ability (e.g., using self-talk scripts to make plans and follow through, or using verbal rehearsal to improve WM), it is important to conduct research such as Ebert's, to determine whether speech-language therapy alone can improve the EF of children with co-occurring language and EF deficits. The findings of this study were not particularly strong, but it sets the stage for future research. One possible direction for future research would be to use parent- and teacher-reported behavior scales to identify functional changes to children's EF skills. Task-based measures of EF, like those used by Ebert, are sometimes considered flawed due to poor generalizability to meaningful tasks (see the discussion of CWMT), and often have only a weak correlation with stakeholders' reports of EF performance (Snyder et al., 2021), which may be better equipped to identify meaningful changes to everyday performance.

A primary finding of this review is that the field has barely begun to explore the efficacy of EF interventions in children with DLD, and this remains a vital area of research for future study. Language and EF are deeply intertwined, so it should not be a surprise that so many of the

EF interventions directed toward SLPs and other educators are structured around linguistic ability. Some of the approaches to EF intervention appear to circumvent language deficits (e.g., visual supports, external memory aids) while other approaches appear dependent upon language ability (e.g., self-talk, rehearsal, organizational frameworks). The function of language in the efficacy of these interventions is unclear. Does language ability moderate the child's success with EF interventions which are heavily rooted in language? If so, then children with DLD may not receive the same benefits as their language-typical peers. Alternatively, perhaps explicit instruction in language-based interventions such as self-talk will yield more substantial results as children's language improves alongside their executive skills. SLPs must consider the interdependency between language and EF, and tailor their intervention accordingly.

Guidance for Direct Intervention

Though the evidence for intervention in children with co-occurring EF deficits and DLD is sparse, this review found an abundance of articles which encourage and inform SLPs in the provision of direct intervention to teach the skills necessary for academic success. The articles in this review used research from related fields (e.g., ADHD research in developmental psychology), and claimed that direct intervention may take a narrow approach by addressing discrete linguistic skills necessary to perform tasks, or a broader approach by equipping the student with strategies that can be applied to various situations. Examples of the narrow approach include teaching relevant knowledge and skills to build automaticity, thus reducing cognitive demand; teaching relational vocabulary and morphosyntax to better understand complex instructions and retain them in memory; and teaching memory-assisting techniques such as rehearsal and visualization (Boudreau & Costanza-Smith, 2010; Gathercole & Alloway, 2006; Gill et al., 2003; Gillam et al., 2019). The broader approach can include strategies that

empower the student, such as emphasizing the meaning and relevance of curricular content and teaching interactional strategies (Damico & Armstrong, 1996), teaching self-talk and problem-solving strategies (Dunaway, 2004), and teaching children how to implement organizational frameworks such as visual organizers and concept maps (Gillam et al., 2018). SLPs may consider a careful selection of intervention focus (narrow, broad, or a combination) based on the child's individualized needs.

Computerized Interventions

While the research and literature supports the use of strategy instruction and cognitive and cognitive-behavioral interventions, the findings of this review suggest approaching computerized interventions with caution. Though the findings of Gathercole and Alloway (2006) support the use of CWMT, these findings must be considered within the context of Gillam and colleagues' (2018) rebuttal, and meta-analytic findings (e.g., Melby-Lervåg & Hulme, 2013; Melby-Lervåg et al., 2016). These articles concluded that the benefits of CWMT show limited evidence of durability (i.e., sustained improvement at later follow-up) or generalizability (i.e., providing benefits in functional or related contexts outside of discrete tasks). Likewise, while Montgomery and colleagues (2010) promoted the use of a computerized training called Fast ForWord to improve processing speed, subsequent research disputes the efficacy of this program (Strong et al., 2011). When providing services to children with EF deficits, school-based SLPs would do well to select interventions that offer meaningful improvement to functional tasks, rather than narrow benefits to discrete tasks identified by studies of CWMT.

Guidance for Collaboration and Accommodations

A recurring theme throughout the included articles posited that interventions for EF provide notable benefits when they are meaningful and contextualized, thus suggesting the need

for SLPs to ensure that students receive educational support in the classroom. To accomplish this, SLPs are encouraged to work with teachers across several fronts: implementing contextual modifications, adjusting instructional practices, and balancing curricular demands. Such collaboration may yield benefits for teachers and SLPs alike, resulting in improved services for students (Wallace et al., 2021).

This review identified contextual accommodations recommended to improve the learning outcomes of children with EF deficits, including tangible supports such as visual aids. Visual aids may be used to supplement learning (e.g., graphic organizers, concept maps, organizational frameworks) and executive processes (e.g., visual activity schedules, timers, calendars, planners, checklists). While visual aids are reported to be effective for children with EF deficits, educators may implement verbal modifications to accomplish many of the same goals. Examples include verbally redundant instruction, mental imagery, advanced notice of transitions, etc. (Dunaway et al., 2004; Gillam et al, 2018).

The literature within this review emphasized the importance of ensuring that children with EF deficits can access their academic curriculum, particularly when their EF deficits are accompanied by language disorder. SLPs should consider working with educators to promote supportive discourse strategies (e.g., repetition, examples, reduced rate of instruction, allowing time for processing, emphasizing key words, pairing auditory cues with visuals), and to pre-teach key concepts and topical language. Likewise, educators may break tasks and instruction into smaller chunks to reduce cognitive demands, and may deliver short and specific instructions (Boudreau & Costanza-Smith, 2010; Jansen et al., 2010).

A recurring theme of articles within this review suggested that balancing curricular demands against executive demands is essential for children’s classroom success. Academically

challenging tasks should be paired with higher levels of support for EF deficits in order to allow students to focus on learning material, and tasks with higher levels of executive requirements should be paired with less-demanding academic material, so that children may devote more of their cognitive efforts to the planning, organization, and completion of the assignment (Gathercole & Alloway, 2006). Boudreau and Constanza-Smith (2010) cited previous research of working memory demands in the classroom (Gathercole et al., 2006) to encourage SLPs to remain aware of linguistic and cognitive demands in discourse and text, and to collaborate with teachers to strike a balance between competing demands between content and EF. They note that while executive demands are not exclusive to linguistic contexts (i.e., discourse and text), SLPs are particularly well-suited to address these domains.

Limitations

This systematic literature review aimed to compile and synthesize the research and guidance for speech-language pathologists' EF interventions, particularly for children with DLD. However, the methodology presents a number of limitations, mostly centered around the vulnerability to errors of omission. First, the search criteria and abstract screening were crafted to include EF interventions that reported results for children with DLD, but this review may have inadvertently omitted relevant articles that failed to mention language measures in their abstracts. For instance, in a study of interventions for children with ADHD or other impairments of EF, language scores or DLD diagnosis may have been collected as covariates even if language ability was not central to the study's aims or research questions. Further, the search was limited to peer-reviewed scholarly publications, dissertations, and theses, thus excluding relevant articles published in non-peer reviewed journals such as the ASHA Leader (e.g., Prath, 2019).

Second, this review sought to compile articles offering guidance directed to SLPs based on the premise that this guidance would be relevant to children on the SLP's caseload. To that end, the author included publications that did not include specific mentions of DLD, so long as the publications discussed developmental EF deficits that might be expected in children with DLD. While this advances the understanding of an SLP's role in EF interventions, the review may have overidentified articles offering guidance for children with typical language ability. Conversely, this review does not include articles containing general research and guidance for children with EF deficits unless they contained a direct mention of speech-language pathologists or language disorders, so readers should be aware that this review is not an exhaustive compilation of EF interventions that an SLP may choose to implement.

Third, the scope of this review is limited to interventions with outcomes related to academic achievement, EF, or language ability. A growing body of research documents the role of an SLP in addressing social communication deficits in children with ADHD (see Brien et al., 2021; Timler & White, 2015), but these studies fall outside the scope of this review. Nevertheless, SLPs must remain aware of the prevalence of social communication deficits in this population to ensure that their students receive the services they need.

To mitigate the risks associated with article inclusions and exclusions, this review implemented a second screener to establish reliability, and reviewed the references of included studies to search for relevant articles not included within the initial abstract screening. The limitations above are worth noting, but they do not devalue this review's effort to inform practitioners and researchers of the present state of the literature.

Implications for Practice

Executive functions, categorized as a cognitive aspect of communication, appear on the "Big Nine" list of domains served by speech-language pathologists across the lifespan (American Speech-Language-Hearing Association, n.d.b). Their inclusion on this list signals the need for SLPs to be proficient in the treatment of children with EF deficits, and the findings of this systematic literature review hold meaningful implications for practitioners and researchers alike.

Practicing SLPs should mindfully consider their role in both direct and indirect services for children with EF deficits. Based on previous meta-analyses of EF performance in children with DLD (see Graf Estes et al., 2007; Pauls & Archibald, 2016; Vugs et al., 2013), it is reasonable to assume that most children with DLD will also present with deficits in at least one component of EF. Therefore, SLPs may do well to incorporate contextual modifications and modified instructional practices into their therapy. Depending on the child's educational needs, an SLP may target EF deficits directly through their intervention goals. Functional approaches, such as teaching and rehearsing graphic organizers or self-talk scripts, appear to be particularly favorable approaches for intervention in this population. Interventions should be selected to provide meaningful, functional, and contextualized benefits for children.

SLPs must also be mindful of the need to provide indirect services as necessary to support the child's ability to access their classroom curriculum. To that end, they may collaborate with classroom teachers to ensure the implementation of appropriate modifications, whether contextual or instructional. Classroom observation, or therapy provided within the inclusive classroom setting, offer the SLP the opportunity to take note of the child's instructional needs, and to identify systemic barriers to their learning. The classroom teacher may benefit from an SLP's perspective and coaching, while the SLP may benefit from the opportunity to further individualize their services by using classroom content and tailoring services accordingly.

Due to the general lack of evidence to validate specific interventions for children with co-occurring DLD and EF deficits, clinicians must consider other facets of evidence-based practice. ASHA espouses the "Evidence-based Practice triangle," which shows the integration of client perspectives, clinical expertise, and external and internal evidence (ASHA, n.d.a). Client perspectives are particularly important for EF interventions, since it is essential to find a strategy that students will remain motivated to implement. Clinical expertise and internal evidence can be derived through careful evaluation of the implementation of interventions; SLPs need to determine which interventions work, and for which students they are effective. Motivated clinicians may consider partnering with researchers to optimize their "research design," and they may disseminate their findings through presentations or publications in order to expand our understanding of this under-researched topic.

Implications for Future Research

The findings of this systematic review suggest that the evidence base for EF interventions for children with DLD is underwhelming. Randomized control trials, which are the gold standard of experimental research, were conspicuously absent. The majority of the included publications were not experimental; they offered guidance for practitioners, but their claims were often supported by research on samples for which DLD was not a requisite (e.g., samples of children with ADHD, whose language abilities likely varied between average and below-average). Whereas research using DLD samples likely accounts for the below-average EF performance common among this population, the reverse is not necessarily true; EF interventions are not necessarily validated for children with DLD. Language ability may play a mediating role in the efficacy of EF interventions, particularly those centered around self-talk and rehearsal. Further research may aim to replicate interventions in a sample of children with co-occurring DLD and

EF deficits, as well as assess the efficacy of SLP-implemented interventions such as Ward and Jacobsen's "Get Ready*Do*Done" model (2014).

Further research may be necessary to evaluate the SLP's comfort and competence in the remediation of developmental EF deficits. Salis et al. (2018) conducted similar research of the assessment of memory deficits in clients with Aphasia, finding that SLPs often used unreliable evaluation instruments, and that their attitudes about memory varied. Surveys of acute care SLPs indicate a lack of confidence and preparation in the treatment of clients with cognitive-communication disorders (Morrow et al., 2021), so it is not unreasonable to suspect that school-based SLPs are similarly under-equipped to deal with cognitive deficits (namely, EF) in children on their caseload. Despite growing awareness of the prevalence of EF deficits in children with DLD, and of language disorders co-occurring in children with ADHD, EFs remain on the fringe of pediatric speech-language pathology, especially when compared to speech sound disorders, language disorders, and fluency disorders. At this time, the author is unaware of studies which explore pediatric SLPs' perspectives and experiences remediating developmental EF deficits with (or without) co-occurring DLD, nor any studies which explore their confidence and competency in this area.

Contribution and Conclusion

To the authors' best knowledge, this review is the first to systematically explore the evidence for interventions for children with co-occurring DLD and EF deficits, and to synthesize guidance for SLPs implementing interventions for that population. As such, this review can serve as a resource for practicing clinicians seeking to learn about EF interventions and evidence-based practices that they can use in their therapy. Likewise, this review can be used as a map for researchers to establish what has and has not been explored. While other professions have

charged ahead in pursuit of effective EF interventions, we must cautiously ensure that children with co-occurring DLD also benefit from these approaches. If not, we must balance children's linguistic and cognitive demands to facilitate their academic success. Finally, we must bridge the research-to-practice gap by determining clinicians' readiness and willingness to remediate EF deficits, and by identifying opportunities to improve SLPs' clinical skills in this domain.

Data Availability Statement

Most of the pertinent data can be found within the text of this article, the tables, and/or the Supplemental Materials. Additional requests may be directed to the corresponding author.

Table 1

Description of Included Empirical Studies: Case Studies, Single Case Designs, Quasi-experimental Designs

Author(s)	Date	Research Design	Population	EF Construct	*N*	Interventionist	Intervention	Outcome Variable
Clegg & Hartshorne	2004	Case studies	SpLI + ADHD	ADHD/ Hyperactivity	2	School-based multidisciplinary (incl. SLP)	Indirect	Learning, language & communication
Datchuk et al.	2020	Single baseline design (Case study)	SpLI + ADHD (hyper-activity and impulsivity)	ADHD	1	Researcher	Direct (language)	Correct writing sequences
Dunaway	2004	Narrative case study	ADHD	ADHD	1	SLP	Indirect	Not specified
Ebert	2014	Multiple-baselines design	PLI (2/3 w/ co-occurring ADHD)	WM, processing speed, sustained selective attention	3	SLP	Direct (language)	Task-based EF measures
Ebert & Kohnert	2009	Multiple-baselines design	PLI	Auditory memory	2	Not specified	Direct (EF)	Language and cognitive tasks
Gill et al.	2003	Quasi-experimental	SLI	Memory (following verbal instructions)	30	SLP	Direct (EF, language)	Oral Directions subtest score
Holmes et al.	2015	Quasi-experimental	LLA	Verbal memory	179	Cogmed trainer	Direct (EF)	Cognitive skills (e.g. verbal STM)
Shahmah-mood et al.	2018	Phased SCD	PLI	WM	10	SLP	Direct (EF, language)	WM, grammar

Singer & Bashir	1999	Case study	LLD	EF, SR	1	SLP	Direct (EF, language)	Academic achievement, communication
Stanford et al.	2019	Quasi-experimental	DLD	WM	42	Not specified	Direct (EF)	WM, language

DLD = Developmental Language Disorder, EF = Executive function, LLA = Low language ability, LLD = Language-learning disorder, PLI = Primary Language Impairment, SCD = Single Case Design, SLI = Specific Language Impairment, SLP = Speech-language pathologist, SpLI = Speech and Language Impairments SR = Self-regulation, STM = Short-term memory, WM = Working memory

Table 2

Description of Included Non-empirical Papers: Tutorials, Narrative Reviews, Research Summaries

Author(s)	Date	Population	EF Construct	Focus on Language Disorder	Interventionist	Intervention	Outcome Variables
Boudreau & Costanza-Smith	2010	WM-impaired	WM	No	SLP	Direct (EF, language) and indirect	WM in the classroom
Damico et al.	1999	ADHD	ADHD/ Hyper-activity	No	SLP	Direct (EF, language) and indirect	Not specified
Damico & Armstrong	1996	ADHD	ADHD/ Hyper-activity	No	SLP	Direct (unspecified) and indirect	Not specified
Drazinski	2014	EF-impaired	Develop-mental EF deficits, TBI	No	SLP	Principles of intervention	Not specified
Fahy & Browning	2021	DLD + EF	Reasoning, planning	Yes	SLP	Direct (EF, language)	Planning, reasoning
Gathercole & Alloway	2006	Neuro-developmental disorders (incl. SLI, ADHD)	WM	No	Not specified	Direct (EF) and indirect	WM
Gillam	1997	DLD	Memory	Yes	SLP	Principles of	Not specified

						intervention	
Gillam et al.	2018	DLD, WM-impaired	Long-term memory retrieval	Yes	SLP	Direct (EF)	WM
Gillam et al.	2019	DLD	Cognitive processing	Yes	SLP	Direct (language)	Language
Jansen et al.	2010	ADHD	ADHD	No	SLPs and educators	Direct (EF, language)	Language and learning
Meltzer et al.	2021	EF	Various EFs	No	SLP	Direct (EF)	Student success
Montgomery	2003	SLI	WM	Yes	Clinician	Direct (EF, language)	Language and learning
Montgomery et al.	2010	SLI	WM	Yes	Not specified	Direct (EF)	WM, cognitive processes
Montgomery et al.	2021	DLD	WM	Yes	Not specified	Direct (language)	Learning and Language
Nelson & Hawley	2004	ADHD	Inner control	No	SLP	Direct (language)	Inner control
Singer & Bashir	2018	Low WM	Verbal WM	Yes	SLP	Principles of intervention	Not specified
Westby & Cutler	1994	ADHD	ADHD	No	Not specified	Direct (EF)	Academics, social interactions, self-regulation

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795 CWMT = Computerized working memory training, DLD = Developmental Language Disorder, EF = Executive function, SLI =
796 Specific Language Impairment, SLP = Speech-language pathologist, WM = Working memory
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Table 3

Quality Indicators for Included Experimental Studies

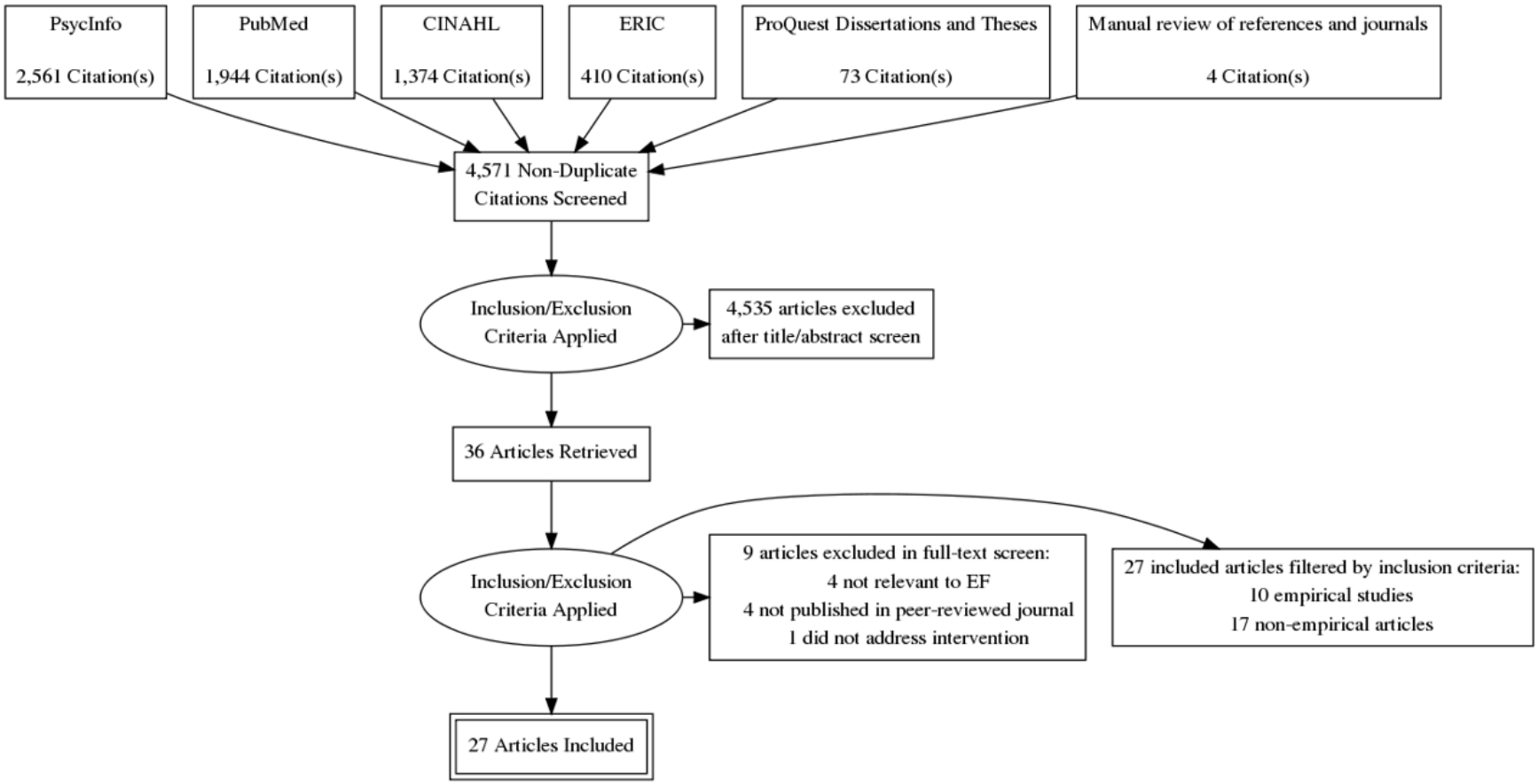
Author(s)	Date	Design	Criteria Applied	# Quality Indicators Met	Descriptive Rating	Key Missing Information
Ebert & Kohnert	2009	Multiple-baselines SCD	Horner et al. (2005)	14/21 indicators	n/a	• Descriptions of participant selection and setting • Measure of intervention fidelity • Sufficient number of demonstrations of experimental control • Control against threats to internal validity • Social validity
Ebert	2014	Multiple-baselines SCD	Horner et al. (2005)	17/21 indicators	n/a	• Description of setting • Measure of inter-observer agreement • Results were weak, inconsistent
Gill et al.	2013	Quasi-experimental	Gersten et al. (2005)	7/9 essential indicators	Not acceptable	• Description and assessment of intervention fidelity • Additional outcome measures to assess generalization
Holmes et al.	2015	Quasi-experimental	Gersten et al. (2005)	8/9 essential indicators	Acceptable	• Additional outcome measures to assess generalization
Shahmahmood et al.	2018	Phased SCD (A-B-A-C)	Horner et al. (2005)	19/21 indicators	n/a	• Intervention fidelity • Social validity (due to intensive time requirements)
Stanford et al.	2019	Quasi-experimental	Gersten et al. (2005)	8/9 essential indicators	Acceptable	• Additional outcome measures to assess generalization

SCD = Single case design

Note. Gersten and colleagues' criteria is based on nine essential and eight desirable quality indicators; acceptable studies must meet eight of the nine essential indicators and at least one desirable indicator, and high quality studies must meet eight essential and four desirable indicators. Horner and colleagues' criteria is based on 21 quality indicators, though their scale does not correspond to descriptive ratings.

Figure 1

PRISMA Flow Diagram



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