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The Education of d/Deaf and Hard of Hearing Children

Edited by
Peter V. Paul

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The Education of d/Deaf and Hard of Hearing Children

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Perspectives on Language and Literacy Development

Special Issue Editor

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About the Special Issue Editor

Peter V. Paul Ph.D. is a Professor in the Department of Educational Studies in the College of Education & Human Ecology at Ohio State University. He has a bilateral, profound hearing loss, but now wears bilateral cochlear implants, and is the father of a son, who has Down syndrome and autism. One of his major professional responsibilities is teacher preparation for the education of d/Deaf and hard of hearing students. His research interests involve areas of English language and literacy, and he has published extensively (over 225 publications), including eight different scholarly texts. Dr. Paul has received the College of Education 2000 Senior Research Award, the Richard and Laura Kretschmer National Leadership Award (Ohio School Speech Pathology Educational Audiology Coalition, October 2010), a Resolution of Recognition from the Ohio House of Representatives November, 2011, and Ohio AER Special Recognition Award, November 2014. Dr. Paul has served on several editorial boards, including those in the general area of reading (Reading Research Quarterly; Balanced Reading Instruction), and is the current editor of the American Annals of the Deaf.

Preface to "The Education of d/Deaf and Hard of Hearing Children"

The main focus of this book is to describe the language and literacy development of children and adolescents who are d/Deaf and hard of hearing (d/Dhh). The development of the English language and literacy has been one of the most long-standing contentious issues in the education of these students. This development has continued to challenge theorists, researchers, and educators because a significant number of d/Dhh students do not read or write as well as their typical literacy peers. Even more distressing, a number of these students may not even reach a level of functional English literacy upon graduation from compulsory education (i.e., high school). The complexity of the acquisition of English has increased in light of the growing number of minorities, including immigrants, in the United States, particularly the growth of d/Dhh students whose home language is not English—that is, English language learners. This has added to the controversy on the manner in which Deaf students whose first language is American Sign Language should be taught.

There has been an ongoing disputatious debate on the interpretation of the role of and research findings associated with the use of assistive hearing technology (e.g., digital hearing aids, cochlear implants) and the development of adequate language and literacy assessments. There has also been a need to address the development of language and literacy in d/Dhh individuals with disabilities or additional disabilities—the so-called "deaf plus" cohort. Another controversial issue has focused on educational placement; that is, whether d/Deaf and hard of hearing children and adolescents should be educated in separate schools or classrooms or whether they should be included in mainstream or inclusive settings along with typical (hearing) peers. The above issues are explored in this book.

Using either a professional review or a meta-analysis format, this book provides a state-of-the-art rendition of the development of language and literacy in d/Dhh children and adolescents. The focus is on research on d/Dhh individuals; however, contributors also found it important and necessary to apply findings from the larger field of language and literacy (i.e., on typical language/literacy learners) due to the dearth of evidence-based research results for d/Dhh individuals. The research findings from these larger content fields have provided pertinent information for differentiating instruction to meet the specific instructional needs of d/Dhh children and adolescents. Finally, this information has deepened our understanding of the relationship between English language proficiency and the development of English literacy skills. The goal of scholarly research, particularly that on language and literacy in this book, is to contribute to the dialog on the most effective manner to improve the educational and social welfare of d/Dhh students.

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Article

Language and Literacy: Issues and Considerations

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Abstract: This article provides background on the major perspectives involving the development of English language and literacy with respect to the evolving demography of d/Deaf and hard-of-hearing children and adolescents. It synthesizes research and controversies on the developmental similarity hypothesis—that is, whether the acquisition of English language and literacy of d/Deaf and hard-of-hearing students is developmentally similar to that of typical language/literacy learners. The outcomes of this discussion have instructional implications and proffer guidelines for teacher preparation programs. The article concludes with directions for further research.

Keywords: language; literacy; deafness; developmental similarity hypothesis

1. Introduction

Guided by the developmental similarity hypothesis or qualitative similarity hypothesis [1–3], this article surveys the most up-to-date research related to language and literacy development of individuals who are d/Deaf or hard of hearing (d/Dhh). The lower case use of "deaf" as an identifier is based on auditory levels; whereas, there is a community composed of members that identify themselves culturally "Deaf", born to Deaf parents and/or use sign language to primarily communicate. In this article, "d/Dhh" represents the deaf, hard of hearing and Deaf communities. Throughout, we concur with Mayer [4] that in order to become competent readers and writers, d/Dhh learners are not different from their hearing counterparts in regard to what skills they need to acquire and master, because the process of learning to read or write is fundamentally the same or similar across populations. The development of a face-to-face form of a language—be it spoken or signed—is essential in learning to read and write, as is phonological awareness and knowledge of the language to be read. The question is not what skills children need to learn to read, but rather HOW individuals who are d/Dhh acquire and master these skills, and at what rate. While maintaining the perspective that developing print literacy requires access to the sublexical components of the language to be read, and is most beneficially acquired during early childhood when the brain is primed for this type of input, we also recognize the value and seek to understand the uniqueness as well as advantages of how some d/Dhh individuals successfully develop language and literacy skills (e.g., [5]).

This article begins with an investigation of the evolving demography of individuals who are d/Dhh. Then, it moves on to discuss the language and literacy (i.e., reading and writing) development of individuals who are d/Dhh using a parallel structure of introducing the development in general first, and then specifically addressing the research and controversies for the d/Dhh population. Reading development is discussed in greater detail, because it currently receives the most attention from the field. The article concludes with implications and suggestions for research and practice. Throughout, it is our intention to *throw a brick to attract jade*—that is, to start a discussion to attract more ideas. Therefore, our review is not exhaustive; for a more comprehensive review on the issues, please refer to other publications within this issue.

2. The Evolving Demography

This section provides a descriptive account of the English language and literacy development of children and adolescents who are d/Dhh over the last two decades. Throughout this period, there have been major shifts in technology, policy, and service provision that have influenced the language and literacy learning trajectories of many of these children, even as some of the demographics of the field have remained fairly stable. It continues that approximately two to three out of every 1000 children in the United States are born with a detectable level of permanent hearing loss in one or both ears, and close to 95% percent of those children are born to hearing parents [6]. Fifteen percent of all American school-age children (aged between 6 and 19) have some degree of permanent or transient hearing loss, and more than half of those children have what is termed *an educationally significant hearing loss* in that it affects how they learn and influences academic achievement [6]. d/Dhh children are ethnically and socioeconomically diverse, although children of low-income families remain at a disproportionate risk for hearing-related disabilities [7]. The population of children with hearing loss has become increasingly diverse in terms of concurrent disabilities, as the number of children born at very early gestational ages are now surviving, but presenting with complex needs in addition to their hearing loss. It is now reported that 40% to 50% of the children who were deaf or hard of hearing have additional disabilities [7,8].

Currently, almost 98% of all babies born in the United States are screened for hearing loss, as opposed to fewer than 3% in the early 1990s [9]. The establishment of universal newborn hearing screening, new screening technologies, as well as procedures for assessing hearing in newborns, has led to a reduction in the average age of hearing loss identification to the age of six months in 2007 from 30 months just two decades ago [9]. This timely identification of hearing loss in infants provides the opportunity for earlier access to visual or spoken language, hearing assistive technology, and early intervention services. Although some challenges in state tracking systems remain, particularly those related to failures to follow up from referrals to audiologic evaluations, over 5000 infants are identified very early in life each year [9].

Along with early identification, techniques for fitting amplification on newborns continue to improve. Digital hearing aids, cochlear implants, and remote microphone systems provide better access to higher quality sound at younger ages than ever before. Infants can be fit with hearing aids during the first weeks of life, and research has evidenced that when children with severe to profound hearing loss begin using hearing assistive technology between six and 18 months of age, listening, language, and speech development improve [10,11]. Early intervention services have also become available for increasing numbers of children between birth and age three. These services, funded through Part C of the Individuals With Disabilities Education Act (IDEA), provide family-centered intervention, which includes counseling, parent education, and services to support early signed and/or spoken communication development [12,13]. Substantial work remains in the area of counseling and reliability associated with early intervention services for caregivers and their d/Dhh children, but the services do much to meet the unique family support that is required. This shift in policy and practice has changed the demographics of the deaf population entering the educational system. Currently, 85% of all d/Dhh students in the United States are educated in public school programs, with 43% spending most of the school day in general education classrooms [14]. Most of these students receive support from an itinerant teacher of d/Dhh and/or an educational interpreter. Others spend part of their school day in the general education classroom, and the remainder in resource room settings receiving instruction from a teacher of d/Dhh.

All of these events have inspired an optimism that d/Dhh students might attain language and literacy levels closer to those of their typical peers, and this has occurred in many instances [15–17], yet many others continue to struggle. In regards to communication options, there continues to be debate around whether deaf children should learn sign language, a sign system, or use listening to learn spoken language [18–20]. Gravel and O'Gara [19] as well as Fitzpatrick et al. [21] stressed in their work that at the current time, there is no solid evidence that one communication option is

optimal for all young children who are d/Dhh, and that regardless of the mode chosen, language development is dependent on regular, consistent, and accessible input. d/Dhh children of deaf parents, with access to a natural sign language from birth, and those who have greater access to spoken language generally demonstrate somewhat better academic outcomes than d/Dhh children without those characteristics. Nevertheless, neither group as a whole achieves at the level of their hearing age peers [22–25]. This situation affects not only language development but also cognitive development, knowledge of the world, and social functioning, all of which influence each other cumulatively over time [26].

3. Language Development

3.1. Language Development in General

The acquisition of language is one of the most remarkable achievements of early childhood, and the literature on child language development has found that the quality and quantity of early language input is associated with children's language performance and later with academic achievement [27]. For any child, the first 12 months of life include decisive experiences for language acquisition. Those with auditory access learn to parse the speech signal, map spoken words to referents, and discover syntactic patterns as they co-construct a communication foundation with their caregivers. Deaf children of signing deaf parents are similarly mapping signs to referents, and by 12 months are producing their first sign or word. By 18 to 24 months, signing and speaking children who have access to a natural language are linking two signs or words to form simple sentences and show early command of the word order patterns of their native language [28]. Later language developmental milestones (from two to four years of age) further evidence a strikingly similar order of progression [29]. By age five, hearing children essentially master the sound system and grammar of their language and acquire a vocabulary of thousands of words. Rinaldi et al. [30] found similar patterns of vocabulary acquisition in the deaf children of deaf signing parents.

3.2. Research and Controversies on Language Development of the d/Dhh

"Being deaf is not the cause of delays in language development; rather, the delays are the direct manifestations of a social world in which language is not fully accessible and thus largely incomprehensible" [31] (p. 77). For the 95% of d/Dhh babies born to hearing parents [32], early critical experiences with language input are initially absent. Currently, a robust amount of research has revealed a significant divide in the language outcomes of children who have full access to language, signed or spoken, during the first 12 months, and those who begin experiencing language later. In general, compared to hearing children, d/Dhh children who are late to language exposure take longer to learn their first 50 words, longer to form combinations [33], and have less vocabulary knowledge [34]. These children also experience delays in the acquisition and use of grammatical structures in spoken language and writing [35,36], have less developed narrative skills [37], and struggle to achieve age-appropriate reading levels [24].

Empirical research on the development of sign language by d/Dhh children with either deaf or hearing parents is limited and varied in focus, and has mostly been used to attempt to explain constructs such as executive function and theory of mind. In a study of signing deaf children's development of executive function, Botting, Jones, and Marshall [38] found that although some deaf children perform within the normal range, particularly those with deaf parents, as a group, deaf children scored below hearing peers on the majority of executive function tasks; they suggested that language delay may be associated with their findings. Kelly et al. [39] found that signing d/Dhh children of non-signing hearing parents were delayed in identifying lies and sincere false statements when matched for chronological age, but that deaf children who experienced early access to conversations with their deaf parents demonstrated no delay in theory of mind activities. Findings suggested that limited access to linguistic exchanges delayed the development of key pragmatic skills. A number of studies [40–42] explored

the development of sign language as a functional tool in children with additional disabilities such as autism, cerebral palsy, and/or developmental delay. Cupples et al. [43] found that d/Dhh children with additional disabilities show specific patterns of development that were influenced by the type, severity, and nature of the secondary disability. They offer that the type of additional disability could be used to understand delays in language development in the population of d/Dhh children with additional disabilities when a formal assessment of cognitive ability was not feasible.

Among the increasing number of children receiving cochlear implants, most research produced from the early 2000s and into the early 2010s noted a high degree of variability in the outcomes of children who are d/Dhh. Although some children did achieve age-appropriate listening and spoken language abilities, many continued to show significant deficits. Geers, Tobey, Moog, and Brenner [24] evaluated the listening and spoken language outcomes of 181 children who were eight to nine years old and who had received a cochlear implant prior to five years of age. They reported that only 30% of the children had developed language comprehension abilities comparable with those of their peers with typical hearing. In addition, Incerti, Ching, and Cowan [44] evaluated the listening and spoken language outcomes of 451 children who were three years old and who were diagnosed with hearing loss and received auditory intervention between birth and age three. Similar to Geers et al. [24], Incerti et al. found that some children with hearing loss achieved language abilities that were similar to those of children with typical hearing. On average, though, these children's expressive and receptive language and speech production were below the level attained by children with normal hearing at three years old. Some studies reported vocabulary outcomes within the normal range of typically hearing children [45–47], while others found the opposite [48,49]. Yet other studies indicated that complicated language components, such as morphosyntax and pragmatic aspects, remained the most difficult to acquire [24,50].

At the moment, a lot of attention is being directed at the information coming out of the Longitudinal Outcomes of Children with Hearing Impairment (LOCHI) study [51] in Australia. The LOCHI study is a population-based longitudinal study that prospectively evaluates the development of a group of Australian children with hearing loss as they progress in age. This study is unique in that it includes all children in Australia whose hearing loss was diagnosed through either Universal Newborn Hearing Screening (UNHS) or standard care (N = 460); all of the children had access to the same post-diagnostic services provided by the national audiological service provider, Australian Hearing. This system provides a nationwide ability to compare results regardless of when and where the children's hearing loss was discovered. The information gathered includes standardized assessments of children's speech and spoken language skills, literacy and numeracy skills, academic achievement, psychosocial development, and cognition. At each test interval, demographic information is collected regarding the child, the child's family, and the intervention that the child receives.

The LOCHI study provides comprehensive data for examining the relationships between different outcomes and predictors, and incorporates randomized controlled trials of hearing aid prescription and cochlear implantation. When assessed at five years of age, the children in the study whose hearing loss was discovered at birth and who received early intervention had better spoken language abilities than those whose hearing loss was discovered later [51]. On average, children fitted with hearing aids before six months of age had higher language scores than those fitted later. For children with severe or profound hearing loss, those who received a cochlear implant before 12 months of age had significantly higher language scores than those who received a cochlear implant at an older age. They also noted that in that same group of later implanted children, many had marked deficits in pre-reading skills compared to their typical hearing peers. Dettman et al. [52] and Geers et al. [24] have reported similar findings.

While there is consensus that early identification and early provision and fitting of assistive listening devices (ALDs) can provide better access to spoken language, a decisive factor in language outcomes for d/Dhh children appears to be related to consistency and the amount of device use. Moeller and Tomblin [53] suggested a dose–response relationship where better language skills are

associated with an increased duration and consistency of use of ALDs. Walker et al. [54] found that for children with mild hearing loss, full-time hearing aid (HA) users (users who wore HAs an average of 8.7 hours per day) demonstrated significantly higher scores on vocabulary and grammar measures compared with part-time users (users who wore HAs between two and 8.7 hours per day) and nonusers. Additionally, Tomblin et al. [55] noted that high devise use (10 hours or more per day) was associated with better language outcomes regardless of severity of hearing loss. Although their research has shown a correlation between ALD use and language progress, Munoz, Preston and Hicken [56] found that parents often didn't understand the importance of consistent use or overestimated their child's hearing devise use time. They offer that more support from audiologists, Early Intervention (EI) providers, and Speech Language Pathologists (SLPs) is needed to help caregivers overcome challenges in effective ADL management for their child.

3.3. Summary

Collectively, the language trajectories of individual children who are d/Dhh vary significantly and are associated with multiple variables. These variables include access to early identification, quality of intervention, hearing assistive device use, and audiological management. d/Dhh children develop language in a similar manner to that of typically hearing children, provided that they are in a language-rich environment, whether signed or spoken. This occurs most readily for d/Dhh children of signing deaf parents, who constitute approximately 5% of the deaf population. For d/Dhh children of hearing parents, language development will depend on the age at which they are exposed to a perceptually accessible first language, as well as the quality of the input of that language. This language diversity or difference contributes to or '*cascades*' into other social, emotional, and cognitive risks as well as all language-related areas of development, most particularly literacy.

4. Literacy Development

This section begins by describing the multifaceted nature of reading. It goes on to review the Simple View of Reading as a formula through which we can understand the various components of successful reading as well as how they interact. Finally, we define and differentiate the notions of constrained and unconstrained skills and contextualize their significance within the Simple View of Reading.

4.1. Reading Development in General

As one of the most researched areas in education, reading is also heatedly debated. Recognizing the danger of deconstructing reading into isolated components, we echo the perspectives of the RAND Reading Study Group [57] and Snow [58] in which decoding, fluency, vocabulary, motivation, prior knowledge, self-regulation, and interest all interact in nonlinear, unequal ways during the complex process of reading [59]. Therefore, reading is a process involving at least four elements: reader (e.g., prior knowledge, motivations), text (e.g., complexity, familiarity), activity or task (e.g., locate details, evaluate arguments), and situation or context (e.g., during high-stakes testing, working in cooperative groups, reading for pleasure). Reading comprehension emerges from the interaction of an individual (reader) engaged with linguistic materials (text) for a given or self-generated purpose (activity) in a specific time and place (situation) [60].

Admitting that the Simple View of Reading [61] does not fully explain all the factors mentioned (e.g., text and task), we use it as a window into the factors contributing the most to reading. The Simple View states that proficient reading consists of two key components: word recognition and language comprehension. The word recognition component includes efficient decoding, precise sight-word identification, fluent word reading, and access to semantic information in the reader's mental lexicon. In this way, efficient word recognition allows the reader to quickly *pronounce* words while also triggering the recognition of words acquired through language experiences. Linguistic comprehension encompasses knowledge of facts and concepts, vocabulary, language and text structures, verbal

reasoning structures, and strategies. The interaction of these two components results in reading comprehension. Successful reading is an act of recognizing words that are written and having the ability to comprehend the meaning behind what was read. Word recognition or decoding has an interdependent relationship with language comprehension. One cannot "read" without the other.

For developmental considerations in reading assessment, the Simple View is often translated into the differentiation between constrained and unconstrained reading skills. For novice readers, *constrained skills* (e.g., print concepts, letter knowledge, phonemic awareness, phonics) involve learning a finite set of items, which while requiring practice, can be mastered within a relatively short period of time. These skills are critical as novice readers begin to negotiate text, but alone are not sufficient for comprehension. *Unconstrained skills* (e.g., vocabulary and language comprehension) develop more slowly over a reader's lifetime through experience and as one engages with more complex reading [62–64]. As unconstrained skills grow and expand, they have more and more influence on reading comprehension. Different understandings/perspectives on the roles of constrained and unconstrained skills in reading often leads to the controversies in the reading research for individuals who are d/Dhh.

4.2. Research and Controversies on Reading Development of the d/Dhh

This section describes the role of phonology in word recognition, which is the first component of the Simple View of Reading. It cites research exploring the potential role of phonological processing for d/Dhh readers as well as some alternative word recognition strategies for d/Dhh readers who use sign language as a primary mode of communication. Next, it explores the second area of the Simple View: language comprehension in reading. A brief review of affective factors as well as the potential effect of hearing assistive technology follows. Finally, we include a summary of the section as a whole.

4.2.1. Phonological Processing in Word Recognition

Most hearing readers encode print by sounding words out phonetically. This encoding allows a reader to hold chunks of text in short-term memory long enough for higher-level processors to assign meaning to it for overall comprehension. Since phonological processing plays a fundamental role in reading acquisition for hearing readers, researchers have investigated whether and how deaf readers are able to activate phonological representations when reading, and there has been considerable variability within the literature. In a meta-analysis, Mayberry, Del Giudice, and Lieberman [65] analyzed 57 studies exploring this question, and reported that about half of them provided evidence in favor of phonological coding and awareness skills in severely and profoundly deaf participants. They concluded that phonological coding and awareness skills were a low to moderate predictor of reading achievement for deaf individuals, while overall language ability played a more significant role on reading development.

Harris and Moreno [66], as well as Luetke-Stahlman and Nielsen [67], found that more proficient deaf readers used more phonology than less proficient deaf readers. Kyle and Harris [17,68,69] in three different studies also showed that some deaf readers access phonological processing, although usually to a lesser degree than hearing readers. Spencer and Tomblin [70] reported phonological awareness to be predicative of reading abilities in cochlear implant users. In a longitudinal study of children in Australia who used cochlear implants and digital hearing aids, Ching, Day, and Cupples [71], as well as Cupples et al. [72], found that phonological awareness was a significant predictor of reading at age five, after controlling for receptive vocabulary and nonverbal cognitive ability. A number of more recent studies [73,74] have also suggested phonological skills as the key to reading for young children who are d/Dhh. As testament to the primacy of the role of phonology in learning to read, various interventions have been designed to facilitate the auditory access to English phonology through visual means for d/Dhh students. These include cued speech (see the review in [75]), visual phonics (see the review in [76]), and speechreading (see the review in [17,69]).

Eye movement studies on foveal and parafoveal word processing in reading are also contributing to our understanding of the reading process in deaf readers. These studies show that when a word in a text is fixated, identities of letters and their corresponding phonemes are activated early during the fixation. Blythe et al. [77] reported on two experiments in which participants' eye movements were recorded as they silently read sentences containing correctly spelled words (e.g., church), pseudohomophones (e.g., cherch), and spelling controls (e.g., charch). Three groups were tested: teenagers with permanent childhood hearing loss (PCHL), chronological age-matched controls, and reading age-matched controls. These researchers found that the teenagers with PCHL showed a pseudohomophone advantage from both directly fixated words and parafoveal preview, which was similar to their hearing peers. They suggest that this data provides strong evidence for phonological recoding during silent reading in teenagers with PCHL.

Alternately, other studies have not shown clear use of phonological processing in deaf readers [78–81]. As a result, some researchers believe phonology might be bypassed by focusing on morphemes in the orthography of text. According to Gaustad [82], orthographic processing, or the visual processing of whole words or parts of words, may be a viable approach to decoding for deaf readers. The proposed morphographic approach to word identification with its emphasis on morphographic elements replaces an emphasis on phonemic elements as the focal element for analyzing print. This has implications for classroom practice; however, Gaustad noted that morphographic processing has not been extensively researched, particularly in relation to deaf participants.

Furthermore, McQuarrie and Parrila [83] suggested that bilingual d/Dhh readers had a different approach to cracking the orthographic code for reading. The authors believed that focusing on a sign language phonological system would support the development of reading acquisition. Rather than concentrating on how signed languages can be directly mapped to print, this shift in thinking or approach to research could then explore how dual languages interact/work in bilingual minds cognitively. The authors recognized that while there were universal fundamental reading skills that needed to be developed for all readers, the HOW question might mean a qualitatively different development for d/Dhh readers.

Meanwhile, Allen et al. [84] agreed with the validity of the qualitative similarity hypothesis regarding the role of phonology in reading. However, they suggested a visual sign phonology instead of a sound-based English phonology as consequential for d/Dhh readers. In a review of research on the impact of early visual language exposure on a variety of developmental outcomes, including literacy, cognition, and social adjustment, they came to the conclusion that young deaf children of signing parents were able to recognize language patterns in segmented sign streams, which is a skill that is critical for early reading acquisition. They hypothesized that this skill would allow the brain and its memory processes to retain more words and facilitate the reading process. By having a visual sign phonology foundation, d/Dhh children would be able to map the sign phonological unit to print, especially during early emergent literacy (e.g., ABC letter writing or letter shape recognition). Allen et al. also found that American Sign Language (ASL) exposure had an independent effect on the participants' letter knowledge and print concepts. An analysis of a parent rating scale given to over 100 children in this study showed that d/Dhh children from d/Dhh signing parents were more likely to demonstrate language and reading skills, whereas the results for d/Dhh children from hearing parents varied based on signing ability. Collectively, the authors supported the qualitative similarity hypothesis only if it was modality independent. Other studies [85,86] have also proposed using ASL phonology to teach reading, although the impact of ASL phonology knowledge on English reading is still questionable [87].

4.2.2. Language Comprehension in Reading

Language comprehension is a top–down, higher-level process that extracts explicit and implicit information from text and integrates text-based information with prior/world knowledge and knowledge of the structure of English (e.g., morphology, syntax, semantics, and pragmatics) [88].

Unfortunately, the research on improving language outcomes for school-age children who are d/Dhh is limited, and offers little advice to education practitioners. For instance, in a review of literature on classroom language interventions with children who are d/Dhh, Easterbrooks, Cannon, and Trussell [89] reviewed various interventions available to teachers of d/Dhh children, but found none with strong evidence of success for an individual language structure. They suggested that a more wide ranging research agenda was necessary.

Another salient language-related factor is *metacognition*, that is, thinking about thinking, which refers to being aware of one's reading comprehension and ways to improve it. Readers must use metacognitive strategies to monitor levels of text difficulty, evaluate the relevance of background knowledge, identify problems in comprehension, process meaningful text, and set/reach reading goals [90]. The National Reading Panel [91] found that explicit comprehension strategy instruction was as effective as vocabulary and text comprehension instruction, with success rates of 85% to 90% measured by outcomes among experimental groups. For students who are d/Dhh, very few studies have examined their metacognitive skills, and the available data often suggest difficulties in this area [92,93]. However, research on skilled deaf readers suggested that they were able to use metacognitive strategies as proficiently as their hearing peers, and that the competent use of metacognitive strategies distinguished skilled deaf readers from non-skilled deaf readers [5,94,95].

Meanwhile, what is often overlooked in reading research for the d/Dhh is affective elements such as interest, engagement, or self-efficacy. Dewey [96] argued that interest-based learning was naturally superior to effort-based learning. While motivation, generally speaking, is a reader factor, interest is typically situated within a specific context. Springer, Dole, and Hacker [97] stated: "affective elements impact individuals' willingness to focus attention or to use cognitive reading strategies, and individuals' use of these strategies impacts their enjoyment of the task. These affective and cognitive factors, in turn, influence text comprehension" (pp. 529–530). Research on the affective factors in reading for students who are d/Dhh is limited. In an interview study with 29 prelingually deaf adolescents, Strassman [98] found that very few participants defined reading as meaningful, while most referred to grades instead of comprehension as indicators of good reading skills. In her review of literature, Strassman [99] suggested that many deaf readers took a passive approach to reading because they were not taught or encouraged to become independent readers. Poor reading comprehension leads to low interest or motivation to read, which results in less reading practice and further decrease in reading comprehension. Without instructional intervention or motivational encouragement, the circle goes on.

4.2.3. Additional Consideration: Hearing Assistive Technology

As hearing assistive technology has become more sophisticated, some researchers [100–102] believe that comprehending the auditory phonological structure of words is a key component that is necessary in deaf children's early literacy education. This has led to numerous investigations of children with cochlear implants. A long-term study by Geers et al. [24] found that phonological coding ability and linguistic competence were both predictive skills for reading in elementary school. However, in a follow-up study of those same participants in high school, age-appropriate reading achievement had not been maintained for the majority of students. The authors suggested that the gap between deaf children and hearing peers widens with age. Marschark, Rhoten, and Fabich [103] also found deaf children with cochlear implants to be reading at or near grade level during the elementary school years, but high school and college implant users were no longer associated with better reading achievement.

In a longitudinal study to explore whether outcomes had improved in line with earlier diagnosis and better hearing aid technology, Harris, Terlektsi, and Kyle [104] found that recently evaluated d/Dhh elementary school children had an average English vocabulary age that was two years higher than that of children assessed 10 years ago; however, the commensurate improvements did not occur in either phonological awareness or reading ability. They concluded that the advent of better hearing aid technology has not yet enabled d/Dhh children to read at an age-appropriate level.

In a more recent study, Mayer and Trezek [105] examined the available peer-reviewed research regarding literacy achievement in deaf children with cochlear implants. They looked at 21 studies published between 1996–2016 that collectively reported literacy outcomes for over 1000 children who used cochlear implants. They noted that in terms of reading comprehension, even though there was a wide range of variability, a majority of the participants achieved scores in the average range. Variables that influenced achievement were related to age at implantation and consistency of device use, with earlier implanted children who wore their implants for most of their waking hours scoring better. Another variable was the presence of additional disabilities, where children without additional disabilities had higher scores. The authors note that the sparseness of research in this area is problematic to the field, and they call for more studies that measure the literacy growth of deaf children who use cochlear implants, particularly studies that track development over time.

4.2.4. Summary of Research and Controversies on Reading Development of the d/Dhh

Although there is consensus regarding the skills that are necessary for hearing children's attainment of literacy, there remains considerable debate regarding what skills are important for children who are d/Dhh, and especially for those whose hearing loss is in the severe to profound range, except for the importance of consistent and high-quality early language, whether signed or spoken. It is important to recognize here that as a population, d/Dhh children are a heterogeneous group, and determining the components of reading success for various subgroups is complex. d/Dhh children vary, among other things, regarding degree of hearing loss, age of diagnosis, age of provision and use of hearing aid technology, mode of communication, educational setting, and the hearing status of their parents. All of these variables have an impact on literacy [106,107]. Another aspect of heterogeneity that must be acknowledged here is the general ability level of d/Dhh children with additional needs, such as visual, attention, motor, and learning disabilities. See Edwards [108] for a review of the research on outcomes and grouping studies relative to the nature of the additional disabilities and specific etiologies of deafness. Meanwhile, the advance of assistive hearing technology has brought attention to the field; however, its long-term effect on the reading development of children who are d/Dhh is still evolving.

4.3. Writing Development in General

Historically, reading and writing were thought to be separate entities within the literacy spectrum, and were taught accordingly [109]. Reading was believed to be a receptive skill that one had to develop in order to understand the author's message, while writing was an expressive and productive skill motivated by the intention of communicating a message to others [110,111]. However, this perspective evolved throughout the 1980s and 1990s as the field began to think more about the writing process than the product. Several studies [112,113] proposed a more interdependent relationship between reading and writing in terms of meta-knowledge (awareness of one's own knowledge) and cognition. More recently, neuroimaging studies have shown that reading and writing activate overlapping brain regions [114], and furthermore, interventions that have focused on a transfer of skills show that reading instruction has a positive effect on writing [115] and writing instruction on reading [116,117].

A conceptual model of writing systems in the brain promoted by Niedo et al. [118] includes four language systems (auditory language perception, visual language perception, oral language production, and manual language production), each of which is multi-leveled (subword, word, multi-word syntax and idioms, and text). These language systems are said to interact with each other and with sensory/motor, cognitive, and attention/executive function systems in the brain. The way the systems interact with each other depends on the developmental level of the writer and the specific language or writing task. As in reading, young children move through a series of stages as they are learning to write. The stages reflect their growing knowledge of the conventions of literacy, letters, sounds, words, and composition. These stages typically begin with drawing and scribbling and the production of mock letters. Letters and letter strings appear next, and then progress into stages where

invented spelling, phonetic spelling, and conventional spelling successively become more apparent as children move into increasingly more complex composing tasks.

4.4. Research on Writing Development of the d/Dhh

Research on the writing of d/Dhh students has consistently shown that these individuals demonstrate considerable delays when compared with typically hearing peers [119–121]. Earlier investigations of the writing skills of pre-lingual, severe to profoundly deaf children mainly focused on their limited auditory access to spoken language to note difficulties at the lexical level [122] as well the grammatical level [123]. A later study [124] found much of the same difficulties in hard-of-hearing children who attended school in general education settings. For both groups, noted causes include the lack of or limited exposure to a natural language from birth, the difficulty in accessing and learning English syntactical and morphological structures, either auditorily or visually, and struggles with reading, resulting in limited experience with good writing models. Quality of writing instruction has also been implicated. Maxwell and Falick [125] and Yoshinaga-Itano, Snyder, and Mayberry [126] found that teachers of the d/Dhh often focused on teaching basic sentence patterns, which resulted in the production of stilted and overly formulaic writing. More recently, Williams and Mayer [127] in a review of the literature on writing development, instruction, and assessment, for d/Dhh three to eight-year-olds published between 1990–2012 found that studies mostly investigated spelling and writing at the word level, and that there was very little information on assessment of writing.

In terms of writing interventions, Strassman and Schirmer's review [121] of the literature of writing interventions for d/Dhh students examined 16 studies, with the participants ranging from elementary school students to college students. Only a few writing interventions were considered to have a strong evidence base for practice. This was due to a lack of replication studies and weak methodological designs, which were similar to the issues identified in Trezek and Wang's meta-analysis [76] on reading interventions for students who are d/Dhh. Yet, Strassman and Schirmer [121] did identify a few approaches that seemed promising. One was the collaborative writing approach called Strategic and Interactive Writing Instruction (SIWI), which was described by Wolbers et al. [128–130]. SIWI is an approach to teaching writing that includes explicit and interactive instruction of the writing process and incorporates the learners' knowledge of and linguistic competence from their face-to-face language, which may be ASL or a sign system. Many of its practices are drawn from first and second language acquisition theory.

Schirmer, Bailey, and Fitgerald [131] explored whether a writing assessment rubric could be used as an effective teaching strategy for d/Dhh students who used ASL. In this year-long study, fifth and seventh-grade students were taught to use a rubric that included writing elements such as sequence, story development, organization, word choice, details, sentence structures, and mechanics. Quantitative analysis of compositions written earlier and later in the year showed that the use of the rubric as a teaching strategy significantly improved four traits of writing (topic, content, story development, and organization) for both the fifth and seventh graders. However, the strategy did not improve their performance on text structure, voice/audience, word choice, sentence structures, or mechanics. Easterbrooks and Stoner [132] used a single-subject design to evaluate the use of a visual tool to increase adjective use in the writing of d/Dhh adolescents. Students described action pictures using a graphic organizer with guidance from the teachers that faded over time. They found that while adjective use increased the number of action words, story grammar elements decreased.

Berent et al. [133] implemented a visually based *focus-on-form* approach to writing instruction in which learners were made aware of the grammatical form of language features that they were already able to use communicatively. Experimental groups in this study demonstrated significantly greater improvement in English grammatical knowledge relative to the control group after a 10-week remedial grammar course. In another study, Berent et al. [134] explored the concept of *enhanced input* in supporting the writing of college age d/Dhh students. Input enhancement (IE) is a model that originated in second language acquisition theory. IE includes techniques used by instructors to make

salient selected features of a language for students such as word order or parts of words that express tense, agreement, and number. These techniques aim to draw attention to aspects of a language that previously appeared to have made insufficient impact on the learner. Berent et al. found significant improvement immediately after a 10-week instructional intervention, along with retention of skills five months after instruction concluded.

As previously noted, newborn hearing screening programs, early access to language, and advanced hearing assistive technology, including digital hearing aides and cochlear implants, have changed the landscape of deaf education. The literature documents sizable gains in the speech perception and receptive and expressive spoken language, and it was anticipated that improvements in spoken language would also lead to improvements in other language skills such as writing. However, gains in this area have been less remarkable, and reading and writing continue today to be a major challenge for children with cochlear implants. Overall, very few studies have been conducted on deaf children with cochlear implants and their writing development. The following studies review the limited literature available.

Spencer and Marschark [135] evaluated the writing skills of 16 pediatric cochlear implant users and 16 age-matched, normal-hearing children, who were all educated in mainstream classes. Performance measures for the writing analyses included productivity, complexity, and grammaticality measures. On this written language measure, children with cochlear implants performed within one standard deviation of their typical-hearing, age-matched peers on writing accuracy. In addition, children with cochlear implants performed significantly poorer than children with normal hearing on the expressive "Sentence Formulation" subtest. The cochlear implant users also produced fewer words on the written narrative task than did the normal-hearing children, although there was not a significant difference between groups with respect to total words per clause. Furthermore, there was a strong correlation between language performance and total words produced on the written performance measure for children using cochlear implants.

Mayer [136] assessed the writing skills of 33 nine to 16-year-old cochlear implant users, most of whom were educated in mainstream schools and used oral communication in school. Free writing samples showed that 25% were performing at the expected level for their age, 19% were performing above average, and 56% were performing below average. Influences on outcomes included age at implantation, bilateral implantation, and age at testing. Writing outcomes were not as strong as in reading, but did show the use of non-standard English that was typical of d/Dhh children in the past, and the writing samples showed writing strategies such as invented spelling, which is common in hearing children.

Hayes, Kessler, and Treiman [137] also indicated in their study that the spelling skills of the implanted children between six and 12 years of age were comparable to those with typical hearing who were matched for reading abilities. However, when compared to the age-matched children, a significant difference was found between the two groups of children. Children who were cochlear implants users demonstrated lower performance on formulating sentences than their hearing peers, and they were reported to produce fewer words in their expository writing, although no significant difference was noted in terms of total words per clause.

4.5. Summary

Learning to write is a complex activity involving spelling, punctuation, and increasingly complex grammar, syntax, and vocabulary. d/Dhh children often face the additional challenge of not having a firm foundation in the language or an underdeveloped understanding of the language of the text as they are expected to write it. It would be important to understand more regarding (1) how to develop the language foundation that is needed for learning to write in children who use spoken and/or signed language, including those who are bilingual learners, and (2) the role played by continuing advances in hearing technologies such as digital hearing aids and cochlear implants.

5. Recommendations for Future Research

Regarding recommendations for future research, we advocate for (1) larger descriptive, longitudinal, and correlational studies to examine the interaction of various factors in maximizing the language and literacy development of individuals who are d/Dhh; (2) qualitative designs to compliment information gleaned from student achievement measures; and (3) replication research and intervention studies.

The LOCHI studies mentioned previously in this paper provide an interesting longitudinal research model. In Australia, all the children with hearing loss are followed by Australian Hearing. Australian Hearing is a statutory authority constituted under the Australian Hearing Services Act 1991, which reports to the Minister for Human Services. Australian Hearing provides hearing rehabilitation services and hearing technology to children and adults with hearing loss at no cost to families and conducts hearing-related research via its research division, the National Acoustic Laboratories. All the children receive evidence-based audiology and habilitative services and are monitored carefully over time. Audiology evaluations are consistent and in depth. Hearing aids are fit using prescriptive targets and are monitored to ensure that they are meeting prescribed targets. All the children have regular and complete language, literacy, and social skills evaluations in addition to audiological evaluations. As all the children throughout the country are monitored by the same agency, it is possible to evaluate many aspects of their development, and every child, regardless of communication mode or the presence of additional disabilities is monitored, evaluated, and included in the studies; thus, there is no selection bias in research. The data produced through the LOCHI study is currently being used to explore the impact of newborn hearing screening and early intervention on outcomes of children with hearing loss, as well as the factors that influence these outcomes and possible predictors of these later outcomes.

In the United States (U.S.), the Listening and Spoken Language Data Repository (LSL-DR) [138] was established in 2010 at the Vanderbilt University Medical Center by OPTION Schools, which is an international, non-profit organization comprised of listening and spoken language programs and schools for children who are deaf or hard of hearing in Canada, South America, and the U.S. LSL-DR addresses a critical need for a long-term system-wide outcome data-monitoring program in member schools and programs highlighted in Goal 3b of the 2007 Joint Committee on Infant Hearing position statement supplement [139]. The LSL-DR functions as a multicenter, international data repository for recording and tracking the demographic information and longitudinal outcomes of children with hearing loss who are enrolled in private, specialized programs that focused on supporting listening and spoken language development. Since 2010, annual speech–language–hearing outcomes have been prospectively obtained from 48 programs in four countries for over 5000 children. The design and overview of the project was recently described in a recent American Speech Hearing Association publication [138], and population characteristics and preliminary outcome data have been reported. As the LSL-DR grows, studies will explore the variables that have the greatest impact on enhancing outcomes for children with hearing loss. Residential schools for the d/Deaf might consider a similar type of data collection following the performance of individual students as well as groups of students across schools and programs over time. As with the LSL-DR, this could provide an opportunity for the greater mining of data and possibly contribute to more robust analyses of individual school variables, including curriculum programs.

A major longitudinal effort designed to provide trend data could be complemented by qualitative measures that are designed to capture information on critical transitions experienced by d/Dhh students as they proceed through the stages of language and literacy development. The power of using longitudinal data in conjunction with holistic inquiry that is context-specific and acknowledges the uniqueness of individuals and settings can be valuable to improving literacy outcomes for d/Dhh students. Qualitative research continues to be of relatively lower visibility in areas of language and literacy education, particularly in deaf education research [140]. Both quantitative and qualitative research models can be important and necessary as we look to develop the fullest understanding of instructional approaches that are most effective for d/Dhh students.

In regards to replication research, a recent study published in *Educational Researcher* (*ER*), a peer-reviewed journal of the American Educational Research Association (AERA), reported that although replicating is essential for helping education research improve its usefulness to policymakers and practitioners, less than 1% of the articles published in the top education research journals are replication studies [141]. The authors note that despite increasing methodological rigor in education research, the field has focused far more on experimental design and far less on replicating important results. The study analyzed the complete publication history of the current 100 education journals with the highest five-year "impact factor" (an indicator of how often a given journal's articles are cited in other scholarly work), finding that only 0.13% of published articles were replications. More troubling, the study went on to note that of the very small percentage of replication studies in education, replications were significantly less likely to be successful when there was no overlap in authorship between the original and replicating articles. The results emphasize the importance of third-party, direct replications in helping education research improve its ability to shape education policy and practice. While this study did not include the journals where most deaf education research is published, we guess that the results would be similar if these were considered.

Getting research-based instructional practices into the hands of professionals who teach d/Dhh students has been a significant challenge. While encouraging results sometimes emerge in individual intervention studies [76], it has been difficult to successfully bring them to scale and sustain them over an extended period of time in different deaf education settings and under differing conditions. One difficult issue in intervention research is related to the size and heterogeneity of groups in the randomized trials. Groups have to be large enough to detect a significant difference in treatment outcomes when it occurs. In most settings in the field of deaf education, small sample sizes typically render it more difficult to show a statistically significant effect. A meta-analysis conducted by Luckner et al. [101] reviewing 20 literacy intervention studies found that no two studies examined the same dimension of literacy (e.g., vocabulary, reading comprehension, word recognition, writing), and no replications of previous studies had been undertaken. While we acknowledge the difficulties described above, we call for more intervention research in deaf education.

6. Conclusions

"Most educators and investigators familiar with the literature in deaf education recognize they can find at least one published study to support almost any methodology or perspective" [32] (p. 518). One of the reasons behind this seeming proliferation of methodologies or perspectives in deaf education is that individuals who are d/Dhh are a heterogeneous group with diverse cultural values, family communication choices, learning styles, and child/family needs [142], which leads to a garden variety of practice or viewpoint that might fit one case, but is hard to apply to another. Diversity issues should always be considered when working with individuals who are d/Dhh, and a *one-size-fits-all* practice is impractical or unrealistic for this population. The idea that students will bring a variety of identities, languages, cultures, and abilities to their learning is a given, and not something educators can control. However, what educators are able to control is their own knowledge base, the implementation of their craft, and their belief system on learning and learners.

Although teachers are considered consumers of research, Kucan, Hapgood, and Palincsar [143] found that 85% of teachers had no theoretical framework for guiding their teaching of reading or writing. Teacher preparation programs have been slow to close the gap between their pre-service curricula and what the research says regarding teaching reading. Teachers can't teach what they don't know. Teacher preparation programs need to make sure their early childhood and elementary teacher candidates understand how children learn to read, as well as how to help students who struggle with early literacy skills. One big takeaway from the mountains of research that have accumulated over the years is that reading is not a natural act. We are not wired to read from birth [144]. Children become skilled readers by learning that written text is a code for speech sounds, and the primary task for a beginning reader is to crack the code. Even skilled readers rely on decoding.

Stanislaus Duhaene, a cognitive neuroscientist whose research uses brain imaging to explore the neural basis of reading, has made some claims that from our view support the qualitative similarity hypothesis. From the brain's point of view, he noted that learning to read consists of first recognizing letters and how they combine into written words, and then secondly, connecting them to the brain systems for the coding of speech sounds and meaning. He offered that reading starts in the general visual areas of the occipital pole of the brain, but then very quickly moves into an area that concerns the recognition of the written word. He described the next step as an explosion of activity into at least two brain networks: one that concerns the meaning of the words, and another that concerns the pronunciation and the articulation of the words [145]. Duheane did not study d/Dhh readers, but noted that the work of a beginning reader is to build an interface between the vision and spoken language areas of the brain. He claimed that the brains of all readers are universally structured with the same brain mechanisms, and that reading always requires specialization of the visual system for the shape of letters and connecting them to speech sounds, regardless of the language being read [145].

The premise of the qualitative similarity hypothesis is that all learners, deaf and hearing, learn similarly through similar strategies, but perhaps at different stages or ages, depending on their circumstances and that the acquisition of English by any individual as a first or second language will be developmentally similar, whether they are d/Deaf, hard-of-hearing, or hearing, to others in similar first or second language learning circumstances. Teaching the correspondences between sounds and letters is essential, and is the most efficient way to acquire reading comprehension [2].

Numerous national reports [57,91] have suggested the usefulness of systematic, explicit phonics instruction based on word structure along with wide reading of quality literature for supporting development in early reading instruction. However, other studies have indicated that many in-service teachers are not knowledgeable in the basic concepts of the English language or how to address the basic building blocks of language and reading. One of the reasons for this situation is that many teacher preparation programs that are responsible for training future elementary teachers are not providing sufficient coursework regarding the concepts of literacy pedagogy.

Planning language and literacy instruction and supplemental intervention for d/Dhh students whether in a general education classroom, a resource room, or in bilingual education programs begins by assessing the students' current performance, strengths, and needs. Additionally, current functioning must be interpreted in relation to past performance and the nature and quality of instruction that the students have received over time. Another area of need in teacher preparation programs relates to a deeper understanding of and facility with varieties of assessment and assessment tools. Ideally, a framework for documenting students' educational histories, native language and English development, and academic achievement *longitudinally* would exist allowing teachers, clinicians, and child study teams to differentiate instruction and inform practice. This individualized assessment is particularly relevant in a field where almost half the population experiences one or more additional disabilities.

Accordingly, the curricula in teacher preparation programs in deaf education should include (1) the diversity of individuals who are d/Dhh, including those with multiple disabilities; (2) understanding of an individual's type and degree of bilingualism or multilingualism; (3) language and literacy development theories, as well as assessment frameworks for consistent progress monitoring; and (4) evidence-based practice in facilitating the language and literacy development of individuals who are d/Dhh, particularly the strategies in providing rich and varied language experience. Meanwhile, the discussion of language and literacy development for d/Dhh continues as more research data is collected and instructional practice evolves.

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Article

Language Development and Deaf/Hard of Hearing Children

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Abstract: This article explores the available research literature on language development and language interventions among deaf and hard of hearing (d/hh) children. This literature is divided into two broad categories: Research on natural languages (specifically American Sign Language and spoken English) and research on communication systems (specifically iterations of signed English and cued speech). These bodies of literature are summarized, with special attention paid to intervention research and research exploring the impacts of language skills on literacy development. Findings indicate that there is generally a stronger research base on natural languages as compared to communication systems, though more studies in both categories are necessary. Additionally, there are very few intervention studies and even fewer that aim to intervene upon language with the explicit goal of impacting literacy; therefore, there is little known about whether and how interventions that aim to support language development may have direct or indirect impacts on literacy within this population. Further research on this topic, as well as replication studies and research with larger sample sizes, is strongly recommended.

Keywords: deaf; hard of hearing; language development; language and literacy; American Sign Language; listening and spoken language; signing systems; cued speech

1. Introduction

The question of language(s) used with and by deaf and hard of hearing (d/hh) children is long studied and complex. While strides have been made in our understanding of the modalities of language that d/hh children may use and the ways language can develop within this population, there is still a great deal about d/hh children and language that is unknown. Lingering questions regarding how to best support language development and provide intervention for those children who are showing signs of language delay and/or deprivation is of significance because of the life-long effects that language acquisition and proficiency can have on the eventual acquisition of literacy [1–4]. This has important implications for the ability to succeed in postsecondary education and/or the workplace. The vast majority of d/hh children are born into homes with hearing parents [5], and regardless of eventual dominant modality, they are likely to have limited access to language during the earliest period of their lives. This is true whether it is the result of time between birth and access to spoken language through the use of amplification (such as cochlear implants or hearing aids) [6] or the result of the absence of fluent American Sign Language (ASL) models in the home and community [7,8].

Researchers have long made the connection between language development and outcomes related to literacy (Literacy can be defined both broadly (encompassing methods of communication and understanding outside of print literacy) and more narrowly (focused specifically on reading and writing). Though there are many benefits to the broader definition, for the purposes of this review, we explore specifically the narrow conceptualization of literacy through print.). It has been identified as an

essential predictor of the reading skills of both hearing [1] and deaf students [2–4]. For children who are developing bilingually, there is evidence that development of their native language is an important tool for learning both language and literacy skills in their additional language(s) [9]. In addition, early language abilities have been linked to later academic outcomes beyond basic reading ability [10]. Due to the likelihood of delayed exposure to an accessible language among many d/hh children (regardless of modality), the importance of language for eventual academic success makes it an essential area for high quality research that has the potential to impact the education and lives of d/hh children.

In this article, we examine the available literature on language development, instruction, and intervention for d/hh children across modalities, with a special emphasis on the potential impacts of interventions in each area on later literacy development. As is true with all domains of research, each of the research strands included in this article has strengths, as well as areas that require further study. We conclude with recommendations for future research in the area of language development and intervention for d/hh learners. We begin, however, with an overview of language, language deprivation, and literacy outcomes among d/hh children.

2. Language Delay and Deprivation and Literacy

Historically, researchers frequently cited the hearing level of the d/hh child as the sole culprit for performance, or lack of performance, in a variety of areas, including literacy, theory of mind, and language development [11–15]. In recent years, however, some have posited that deprivation of language at early ages may be responsible for difficulties with later achievement in these areas rather than hearing loss itself [12,16]. This perspective allows for a broader consideration of languages and modalities and a wider array of strategies for meeting the needs of d/hh children and places special emphasis on the importance of language access at early ages.

Although the literature on language deprivation and its effects on academic outcomes such as literacy is in its early stages, researchers have examined the differences between d/hh students who had early versus late exposure to language for a number of years. Mayberry [17] and Mayberry and Lock [18], for instance, documented differences in language development and language outcomes for children who were exposed to ASL early in life as compared to those exposed to ASL later. However, such differences are not only present in those who go on to use ASL: there is also potential for children with even a mild to moderate hearing loss and who use primarily or only spoken language to experience the effects of language delay [19]. Other researchers have found a strong relationship between language proficiency (regardless of modality) and literacy among older d/hh learners [3,4,20–22]. Together, these bodies of literature suggest a strong need for accessible exposure to language from birth.

The important research documenting the effects of language delay or deprivation on literacy development is of paramount importance to the field. However, the research base is still limited in terms of our knowledge of language and communication interventions that may be most effective for those children who do not receive the ideal early language exposure. Below, we explore the development of and instruction in the most common modes of communication for d/hh children. We have broken these into two major areas: the use of natural languages, such as ASL and spoken English are explored first. These are grouped together because they are both languages that can be naturally acquired and are full and independent languages. Then, we examine what is known about systems that involve both spoken language and visual supports, specifically signed versions of English and cued speech. These are grouped together because they are systems of communication that have been created to support the learning of a natural language (English) among d/hh children. Neither of these are a language in their own right, but are tools that have the goal of making English more accessible and visual. Natural languages and visual systems differ in how they develop, but users of both have the goal of providing d/hh children with educational experiences that will support their development of both language and literacy skills.

3. Language Development

There are two main ways that d/hh children may be exposed to means of communication. The first is through natural languages, and the second is through communication systems. For d/hh children, natural languages may be signed (such as American Sign Language (ASL) or other signed languages that have developed naturally within deaf communities around the world), or spoken (such as English or other spoken languages that have developed naturally within broader communities around the world). Natural languages are created through communities of language users and can be considered as fundamentally different from systems of communication that were systematically created by a single person or group (such as the invented spoken language Esperanto) because of how they develop and are used. Below, we explore two natural languages that are commonly used with d/hh children: American Sign Language and spoken English.

3.1. American Sign Language and Spoken English

3.1.1. American Sign Language Development and Instruction

In this section, we summarize existing studies on the development of ASL skills among d/hh students and what is known about how this visual modality language may be related to literacy in an auditory modality language, English. Because our knowledge of and discourse around ASL has changed dramatically in recent years, this review focuses only on the research published on this topic within the last 20 years. The research in this area covers a wide range of methodologies, including qualitative studies [23] and single case design research [24,25], as well as larger quantitative group studies [3,26–29] and quasi-experimental studies [30,31]. Currently, there are no instances of direct replication or extension of studies in this area, which limits the ability to create more generalizable research-based conclusions about the role of ASL in literacy development and acquisition.

In the last 30 years, increasing attention has been paid to ASL, including how ASL tends to develop among children with early access to this visual language, and its impact on literacy and other academic outcomes [3,4,17]. According to the Gallaudet Research Institute, in 2010, 27.4% of d/hh were educated in classrooms that used sign language only, although 14.5% of classrooms reported using ASL regularly [32]. There has also been research on promising instructional interventions that may support language development in ASL among d/hh learners who do not have this early exposure to language [24,33]. There is evidence that the presence of a proficient ASL language model in the home is related to overall ASL proficiency because these models provide children with exposure to fluent use of the language in a naturalistic setting [27]. For both deaf and hearing children who have deaf parents, there is evidence that ASL develops naturally, as any language would [34]. Unlike spoken language, ASL proficiency does not seem to be related to socioeconomic status (SES) [28]. This is likely because ASL proficiency is related to having a fluent ASL model, and deaf adults and native ASL language models can be found at all SES levels, so this leaves limited room for SES to mediate this relationship.

Ultimately, higher levels of ASL proficiency have been linked with greater proficiency for isolated word reading skills [26], reading comprehension [3,4,28,35,36], features of academic writing [37], and vocabulary usage during writing [38]. Given the relationship between ASL proficiency among signing d/hh children and these vital skills, it is important to understand what is known about how to teach and foster the development of ASL among d/hh children who use this language. This is especially important since most d/hh children are born into homes with hearing parents who may not be proficient signers [8].

Few studies have examined the effectiveness of interventions aimed at improving ASL proficiency among d/hh learners (as opposed to teaching ASL to hearing second language learners). These include studies of learner characteristics, as well as studies examining instructional approaches for ASL development. For example, there is some evidence that child-level characteristics, such as flexibility in the use of cognitive and affective strategies for learning, is associated with greater improvement in ASL proficiency following intervention [39]. However, this is the only study that examines this type of

characteristic for language learning in ASL, and both replication of this finding and exploration of other child-level factors that may be relevant for ASL learning among d/hh children are necessary.

Other researchers have focused their attention on the use of ASL modeling as a tool for intervening on ASL proficiency, including both using ASL narratives and modeling features of ASL during instruction. These studies have found that opportunities to engage in repeated viewings of ASL narratives has potential to supply d/hh students who sign with ASL language models [33] and that this in turn may support the development and increased use of more advanced ASL linguistic structures [24]. These studies suggest that access to ASL linguistic models may be supportive of linguistic development. This is an important finding considering that most d/hh children have hearing families [5] and may require access to language models other than their parents.

The use of ASL during intervention also appears to have the potential to not only support ASL development, but also literacy development. For instance, repeated viewings of ASL videos that include explicit instruction in literacy seemed to support improvement in early literacy skills among preschool-age d/hh children [23]. Similarly, when d/hh children were engaged in a shared book reading intervention implemented in ASL, researchers found a positive effect on both ASL proficiency, as well as emergent literacy skills [31]. In a small single case study of an older elementary student, the use of a dialogic reading approach in ASL appeared promising to support reading comprehension in informational texts, suggesting that interactive experiences about texts in ASL have the ability to improve understanding of these texts [25]. Similarly, the Strategic and Interactive Writing Intervention (SIWI) initiative, the only writing intervention specifically designed for d/hh learners, found that explicit focus on language development in the context of writing improved writing outcomes for d/hh learners [29,30,40], as well as reduced the use of ASL grammar in English writing [41,42].

Overall, these studies indicate that among d/hh children who communicate through ASL, greater levels of proficiency with the language are related to literacy outcomes. Although, there are few studies that intervene on ASL, though there is promise in the practice of having strong ASL models (both in person and virtually) to support ASL linguistic development. Finally, intervention studies suggest that supporting student access to text through the use of ASL in explicit and purposeful ways during literacy activities may support the development of more proficient reading and writing abilities among d/hh students who sign.

3.1.2. Spoken Language Development and Instruction

In this section, we summarize existing studies on the development of listening and spoken language (LSL) skills among d/hh students, beginning with predictors of proficiency and continuing with a summary of studies that explore the impact of various amplification strategies. We then consider potential influences on listening and spoken language development over time, and its relationship to literacy and language proficiency in general.

According to the Gallaudet Research Institute, in 2010, the majority of d/hh children in the United States were educated using spoken English only (53%) [32]. Because our knowledge of and discourse around how spoken language develops among d/hh children and the availability of technologies that may support access to speech have both changed dramatically in recent years, this review focuses only on the research published on this topic within the last 20 years. Among studies of language acquisition after cochlear implantation, study designs and salient participant demographics vary widely from longitudinal case studies of a single child [43], to short-term investigations with multiple children [44]. Some studies focus on participant language development from as early as seven months old [45], while others investigate the period immediately after implantation or several years after implantation up to ages 10–15 [20]. Other researchers focus on exposure to early intervention rather than age or time relative to implantation [46], and thus, include a range of ages and language histories within their samples. These differences in participant age, language history, age of implantation, and time after implantation are sensitive to differences in the exposure to language and language training among participants. Because of the diversity of language and implantation histories among children

with cochlear implants (CI), there are no instances of replication or direct extensions of previous studies, which makes it difficult to compare or accumulate findings in efforts to generate cohesive, research-based conclusions about the nature of language development in this diverse population.

However, there are some patterns related to language proficiency, the impact of CI and LSL on language acquisition, and the development of phonological awareness through spoken language and its impact on later reading. Findings from recent research suggest that purposeful interactions and early language exposure and learning are important for d/hh students to develop spoken language proficiency. Purposeful interactions with educators and family members impact the overall language outcomes of d/hh children regardless of when they were identified as having a hearing loss [46–48]. However, children who are identified with hearing loss earlier and provided with early intervention services at a younger age demonstrate more robust vocabulary knowledge compared to infants and toddlers identified and enrolled in intervention services later [46–49]. Likewise, in a study by Miller, Lederberg, and Easterbrooks (2013) of five emergent d/hh readers, the researchers demonstrated the effectiveness of explicit instruction in syllable and onset-rime awareness [50]. This suggests that purposeful interactions and early language exposure are important throughout development and that earlier exposure to these interactions is supportive of early language development. A higher volume of purposeful interactions and language exposure also supports the development of executive function skills. For example, Figueras and colleagues [51] (p. 374) argued that "the behavioral manifestations of EF [executive function] difficulties observable in deaf children are unlikely to be a consequence of deafness per se but rather result from the language delays that are a consequence of the deafness." This is similar to the language deprivation argument put forth by Hall and colleagues [12]. Therefore, the literature suggests that exposure and interactional experiences are key factors in early language and social development, regardless of how this exposure or experience is achieved or the modality in which it is delivered.

There is great variability regarding the impact of cochlear implants on d/hh children's proficiency and rate of spoken language acquisition; however, the patterns of interactions and language exposure identified above are relevant to CI users, as well. Early identification and access to language impact language acquisition for CI users as they do for the general LSL population. For example, in a study by Figueras and colleagues [51], researchers found strong correlations between executive functioning and spoken language, but no difference between children who used CIs and those that did not. Similarly, Jones and colleagues [52] found that there was no difference in narrative performance between deaf children using hearing aids and those with CI. Further, they found that there was also not a difference based on hearing levels. However, it is documented that the volume of exposure to accessible auditory input produces great variability in results related to children's language acquisition [46,52]. Taken together, these findings again point to language access and interactions using meaningful language as the salient variables, not merely access to sound. This complex relationship between language, speech, and audition requires nuanced research into how this is related to literacy development.

The relationship between language proficiency and literacy outcomes is well documented [53]. Therefore, students with complex language histories often demonstrate difficulty when developing literacy. However, there are some areas of literacy where d/hh students demonstrate proficiency on par with hearing peers, such as written expression discourse and phonological awareness among young LSL users [22,54]. Many studies of literacy achievement examine subtest scores for isolated areas of literacy in order to better understand composite skills of literacy (e.g., phonological awareness, word recognition, vocabulary). For example, Goldberg and Lederberg (2015) found that d/hh preschool children who used amplification and had better phonemic awareness recalled more letter names and letter sounds than their peers with less developed phonemic awareness and that the preschoolers learned letter sounds partly through the use of phonological information contained in letter names [55]. However, Jones and colleagues [52] (p. 268) found that "deaf children showed equivalent performance to their hearing peers at the macro-level; however, performance on micro-level narrative skills was poorer, and less relevant and detailed answers were provided to the inferencing probe questions

than hearing peers." This suggests that relative weaknesses on some literacy-related subskills may not entirely be indicative of overall literacy proficiency among d/hh students using LSL because of differences in how language is perceived and processed. However, Nelson and Crumpton [22] (p. 342) demonstrated that "vocabulary awareness was the major predictor of d/hh students' [using LSL] listening comprehension, reading comprehension, and nonword spelling skills … [and] phonemic awareness skills significantly contributed to their reading decoding.".

Overall, the evidence suggests that regardless of modality, language development has profound implications for the literacy development of d/hh children. Interventions that systematically use ASL to support reading (among signing d/hh students) seem to show promise, though more and rigorous research is needed to fully understand this complex relationship between languages and modalities. In general, earlier exposure to an accessible language seems to be key for supporting language development and later literacy skills. In the section that follows, we turn our attention to visual systems that have been invented with the purpose of supporting the English language development of d/hh children, specifically the research available on signed forms of English and on cued speech.

3.2. Systems Combining Spoken Language with Visual Codes

The second popular method for exposing d/hh children to a means of communication is through the use of invented communication systems that seek to represent English visually in order to make it more accessible to this population. There are two more frequently-used communication systems used with d/hh children. The first is the use of signed representations of English, which to greater and lesser extents use invented signs to express morphemes and words from English that did not have natural sign language equivalents. These systems also use signs borrowed from ASL, but which are presented in English word order. The second is cued speech, which is an invented system of hand positions placed systematically around the face to disambiguate phonemes in English to assist with speech reading.

3.2.1. Sign Systems' Development and Intervention

In this section, we explore the literature available on signing systems that were created and intended to be representations of English expressed via the visual modality. Unlike the research with ASL and spoken English, there has not been as much new research on sign systems in recent years. As a result, we included all available research on sign systems, how they develop, and interventions to support their use here. Sign systems are artificially-derived forms of English expressed using signs, some borrowed from ASL and some invented to differentiate between similar English words or to express words in English that did not previously have a sign equivalent [56,57]. There are a number of different sign systems, such as Signing Exact English, Seeing Essential English, Manually-Coded English, and Pidgin Sign English [56,57]. Though each of these systems has features that make it distinct from the others, they are all representations of English conveyed through the signing modality; therefore, we review the research available on each of them together. According to the Gallaudet Research Institute, in 2010, 12.1% of d/hh students were educated in classrooms that used sign-supported spoken language [32]. Though this statistic may under-represent the number of students who are taught using signed English, it is the nearest approximation available. The data-driven research available across all of these systems is somewhat dated, but includes single case intervention studies [58], small-scale pilot studies [59,60], larger group designs [61–63], surveys [64,65], and one quasi-experimental study [66]. While some researchers have completed studies with the intention of testing what type of communication is more accessible or preferable for use with d/hh children (signing systems, ASL, or written English), because the purpose of this article is to explore outcomes related to language development or impacts on literacy based on signing system usage, we do not include articles of this type in this review.

The purpose of sign systems was to support the development of English language skills among d/hh students [67]. The reasoning behind this was that because d/hh children did not have auditory access to English, providing a pathway to English that relied on the eyes instead of the ears may provide the accessible input necessary for language acquisition [56]. Some researchers specifically felt that the use of signing systems held particular promise for conveying English morphemes [57]. This resulted in a great deal of debate among researchers and others, starting in earnest regarding whether the potential exists to learn an auditory language through visual channels [66–70].

Some have argued that a contact version of a signed English system may be useful in codeswitching between ASL and print English or for teaching English grammar [64,69], or as a tool to support communication among children with cochlear implants [64]. However, others have posited that signed English systems used in classrooms are frequently ungrammatical in both English and in ASL, thus sending a confusing linguistic message to children [65,71]. In fact, in a study of preschool-age children, researchers found that d/hh students interacted more during a storytelling activity that was in ASL or contained ASL-like signing as compared to storytelling activities using strict signed English [72]. There is also evidence that teachers using signed English tended to use fewer complex grammatical structures as compared to teachers who were just speaking in English [73]. This could be due to the cognitive strain of attempting to use multiple modalities of expression simultaneously. Critically, evidence has shown that even among teachers who had high levels of proficiency in signed English, at best, they were found to be only 86% accurate in their representation of English using this system [67]. Like all languages and communication systems, there is an issue of complete and accessible opportunities for exposure among d/hh children for signed English.

Overall, there have been a limited number of studies that systematically examined the relationship between signing systems and English knowledge or reading comprehension. Studies investigating the impact of using signing systems on literacy achievement have produced mixed results. For instance, one study found a correlation between signed English proficiency and reading comprehension [57]. However, other studies suggested that poor achievement in English syntactical knowledge among d/hh children who were educated using a signed English system meant that signed English was ineffective at supporting the development of English syntactic understanding [60]. Others have found that students raised in signed English environments showed typical development in terms of lexical and syntactic skills, but a significant deficit in morphological knowledge, an important facet of language development [58]. Longitudinally, time in a signed English program was not predictive of English skill among a group of d/hh students, suggesting that exposure over time to signed English may not support the development of English grammatical understanding [59].

More recently, researchers found significant variability in the overall language and literacy abilities of d/hh learners who use signed English, ranging from two standard deviations below the mean to at or above the mean [61]. Problematically, in this line of research, assessments of language development (i.e., the Clinical Evaluation of Language Fundamentals [CELF]) administered using simultaneous communication were found to be predictive of reading scores, but these findings cannot distinguish between the effects of mastery of signed English versus general mastery of English [62]. Therefore, it is difficult to ascertain whether signing systems specifically are related to these scores.

In perhaps the only study explicitly examining the effects of an intervention using signed English, Bennett and colleagues [56] found using single case research that four children were able to correctly articulate signed English sentences following English grammar after an intervention that explicitly taught English grammatical structures via simultaneous communication. Unfortunately, this study did not include a measure of comprehension, meaning that participants could have learned to copy the pattern without necessarily acquiring a deeper understanding of the syntax. Similarly, incorporating signed English pictures into written texts appeared to increase d/hh students' comprehension; however, it is unclear whether it was the presence of the signs at all compared to the signs specifically being signed English that provided the scaffolding students needed to access the texts.

The research exploring signed English systems is limited in that, although colloquially, many in the field use the term signed English as a "catch-all" for all signing systems, these studies explored different manifestations of signed English systems that may be more or less comparable to one another. In general, the findings do not tell a generalizable story: some found higher achievement in some areas after instruction in signed English, while others found lower achievement or areas of significant difficulty. In many cases, it is difficult to tease apart the effect of the presence of signs in general versus the specific use of signed English as the causal factor contributing to children's development of English knowledge.

3.2.2. Cued Speech Development and Interventions

Cued speech is a combination of speech reading and hand placements around the face and mouth that was designed to facilitate communication through speech for d/hh children. Unlike the research with ASL and spoken English, there has not been as much new research on cued speech in recent years. As a result, we included all available research on cued speech, how it develops, and interventions to support its use. According to the Gallaudet Research Institute, as of 2010, only 5% of d/hh children in the United States received cued speech services in K–12 schooling [32]. This system specifically strives to disambiguate between sounds that cannot be differentiated through speech reading alone (i.e., /p/ and /b/). Although cued speech has been a tool used with d/hh children since the 1960s, there is presently not enough research on how the ability to use cued speech develops or what impact the use of cued speech may have on the language and literacy outcomes for individuals who use it. The studies available are case studies [74–76], neuroscientific [77], small or pilot studies [78], and group designs [79–82].

Researchers have attempted to understand the way that cued speech is processed in the brains of users. In perhaps the only study of its kind, Aparicio and colleagues [76] found through fMRI imaging that cued speech appeared to be processed in pathways that are classically associated with speech processing and also makes use of pathways that are related to visual and motion processing. Research has found that d/hh adults who use cued speech have better speech reading skills than d/hh adults who used spoken language only [80], which is unsurprising, but important, as it is the goal of cued speech to improve access to spoken language for d/hh individuals. However, others have found that, even though cued speech seemed to support speech reading, the intelligibility of a cued speech-interpreted message was still lower than the intelligibility of a hearing person listening to a spoken message [77]. As far as the authors are aware, there has been no attempt to compare the intelligibility of messages across multiple languages, modalities, and/or communication systems.

One recent study attempted to disambiguate the effects of early versus late exposure to cued speech combined with early versus late cochlear implantation and how each combination (i.e., early cued speech + early cochlear implantation; early cued speech + late cochlear implantation; late cued speech + early cochlear implantation; or late cued speech + late cochlear implantation) affected literacy. In this study, the effects of early exposure to cued speech were noted only in spelling ability, and these effects seemed to disappear over time [81]. It may be important to note that despite characterizations of d/hh learners in the study as having early or late exposure to cued speech, none of the participants in this study were exposed to cueing before age two, and many had inconsistent exposure to cued speech that was not comparable across or even within participants (for instance, with heavy use at age two, less use after one year, and increased use again at school entry), making it difficult to understand the effects of what could truly be considered early and consistent exposure to cued speech.

One study compared literacy subskills with d/hh learners who used cued speech with those who used ASL or communicated orally and found that those who used spoken language or cued speech had better ability to detect phonemes than users of ASL [82]. Others have found that early exposure to cued speech was related to the ability to read pseudo-words [79] and that when producing rhymes, d/hh young adults who used cued speech seemed to rely more on phonology for rhyme generation, while those who did not use cued speech seemed to rely more on orthography [82].

Additionally, there have been some studies that investigate the global abilities of cued speech users. Several studies found users of cued speech to perform at or above average on assessments of literacy [75,76,78]. However, these studies included only a small number of cued speech users (between one and eight) and did not include comparison groups of d/hh children who used other types of communication methods. A case study following one young child with a cochlear implant who used cued speech found that although her development of phonemic awareness and vocabulary was similar to hearing children of the same age, she had difficulty with grammatical development [73].

Overall, it seems to be true that cued speech can provide support to spoken language phonemes, and thus assist in phonemic awareness, spelling, and decoding. However, there are no longitudinal studies the authors are aware of that expressly look at the longitudinal relationships between these skills. There is no evidence that cued speech supports English grammatical development and even some evidence of difficulty with English grammar associated with its use [74].

4. Recommendations for Future Research

Though the available research documenting the development of language proficiency among d/hh children and the importance of language for the development of later skills has grown, there are still numerous areas that require further study. Across all languages, modalities, and systems, the number of intervention studies is extremely limited. More studies, larger sample sizes, and replication studies are necessary across all domains. We also argue that there is a need for studies that cut across modalities. Especially in terms of interventions, there can be value in understanding not only whether, but for which subgroups of d/hh children are particular interventions most effective.

Overall, we know that the majority of d/hh children are not born into homes with deaf parents who can serve as fluent ASL language models [8]. Similarly, contrived signing systems and the use of cued speech will require direct instruction for children, parents, and teachers. d/hh children who ultimately use spoken language will also require training in the optimal use of amplification devices and speech therapy to expand their ability to produce and understand speech. For these reasons, increased intervention research is needed for all potential approaches to communication with d/hh learners.

One of the biggest challenges in reviewing this literature was a lack of research that intervened upon language with the intent of impacting literacy skills (rather than research that happened to use a specific language for communication during a literacy intervention). In the authors' opinion, an additional broad area in need of research moving forward is research that studies the longitudinal effects of intervening upon language (this is especially important for d/hh children who, as noted in the Introduction, are likely to be in environments where they may have delayed or incomplete access to the language being dominantly used in their homes and classrooms) and whether the effects of such intervention can be seen in terms of later literacy (and other academic) skills. This may be especially important in ASL, as currently, many schools do not provide d/hh children with systematic instruction in ASL (akin to how both hearing and d/hh children are taught English) despite the availability of standards for ASL teaching. Even among those schools that do, there is no current systematic research on what this instruction looks like or what its impacts might be.

There are also specific areas within languages and modalities that would benefit from further research. For instance, our understanding of the natural development of ASL does not explore the ways in which more advanced features develop, as well as the timeline for their development. Purposeful sampling of d/hh children with deaf parents and longitudinally following their linguistic development could provide researchers and teachers with invaluable information regarding the natural progression of more advanced features of ASL proficiency. Similarly, previous research related to spoken language development with d/hh children investigated speech production abilities and the development of certain speech skills. Future research in this area could extend this work by investigating language development, as speech and language are not synonymous.

Additionally, much of the intervention research on both ASL and spoken English can be considered piecemeal: there are few interventions that aim to develop overall language proficiency. Instead, the

tendency is toward interventions that are highly specialized on small subskills that are related to one language or the other. Though these are valuable, future research might endeavor to combine interventions to create an approach that develops language proficiency on a more global scale. Additionally, these interventions frequently are not evaluated for whether and how they improve a child's overall ability to produce and understand language, though this is the ultimate goal of language development interventions. Instead, they again focus on the development of linguistic subskills, which may contribute to overall language proficiency, but research is needed to ascertain whether these interventions are having a measurable effect on overall language skills in addition to these smaller skills. Perhaps a more holistic intervention on language development could also result in an intervention that has the potential to support measurable gains in overall language development especially among d/hh learners who have hearing parents (who do not use or are not proficient in ASL), but are being educated primarily in ASL. This may be a valuable area for future research.

There is little available research documenting signed English systems, how they can be developed, and what their impact is on broader outcomes. Some suggest a potential relationship between signing systems and components of literacy (for instance, phonological awareness, [81]); however, there is a need for more high-quality research on whether sign systems have the potential to support overall literacy ability. It has been argued, for instance, that the incorporation of signed English visuals or the use of signed English during instruction supported literacy achievement [56,62]. However, due to the designs of many of the studies, it is not clear whether the change in scores noted was due to signed English per se or due to the addition of sign language as a broader construct into instruction. Additionally, a great deal of the research that currently explores signed English is dated, and given the rate of change found in the populations of children in schools who are d/hh, past findings may no longer be relevant for the students who are currently being taught. Future research that more rigorously teases apart the effects of signs writ large versus signed versions of English specifically is necessary.

Finally, cued speech is also a practice that is still used with d/hh learners, but requires more research. The most robust research indicates that there is a relationship between the use of cued speech and phonology, which can be thought to support related literacy skills such as decoding and encoding [79,82]. However, there is no evidence that directly connects the use of cued speech per se to stronger literacy outcomes more generally; future research should endeavor to include children who use cued speech alongside those with other communication modalities or languages and to follow their development over time to not only understand how those who use cued speech develop in their literacy skills, but also to understand their development in context with other d/hh learners.

5. Conclusions

Language and communication are pressing issues for the education of d/hh students and have historically been among the most studied areas in deaf education research. Despite the attention these areas have received, there is an abundance of lingering questions regarding language development, the potential role of communication systems, and the best mechanisms for improving the overall language and literacy skills of d/hh learners. It is absolutely essential for the field to continue to disentangle the effects of various language and communication backgrounds while being mindful of the competing effects of home lives, educational settings, and opportunities (or lack thereof) for engaging with language and experiences that may also influence academic outcomes. Only through this type of thoughtful and thorough engagement with research can we truly understand the language and literacy needs of d/hh students and how to meet those needs effectively in the classroom.

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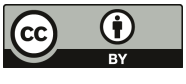

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Review

Reading and Deafness: State of the Evidence and Implications for Research and Practice

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Abstract: Over the years, persistently low achievement levels have led scholars to question whether reading skill development is different for deaf readers. Research findings suggest that in order for deaf students to become proficient readers, they must master the same fundamental abilities that are well established for hearing learners, regardless of the degree of hearing loss or communication modality used (e.g., spoken or signed). The simple view of reading (SVR), which hypothesizes the critical role both language abilities and phonological skills play in development of reading comprehension, provides a model for understanding the reading process for a wide range of students and has the potential to shed light on the challenges deaf students have historically experienced in achieving age-appropriate outcomes. Therefore, the purpose of this paper is to review the components of the SVR and use this conceptual model as the basis for exploring and discussing both historical and current research evidence in reading and deafness, with a particular focus on phonological skills. Recommendations for future research and practice based on the existing body of literature will also be provided.

Keywords: deaf; reading development; simple view of reading; reading instruction; reading interventions

1. Introduction

Deaf learners have historically faced challenges in achieving reading outcomes commensurate with their hearing peers. Specifically, outcome data have consistently indicated significant delays in achievement among this population of students, with a reported median fourth-grade reading level for high school graduates [1]. Over the years, these persistently low achievement levels have led scholars to question whether reading skill development is different for deaf readers (see [2,3] for discussions). In a seminal discussion of this topic, Hanson [4] directly explored the question, "Is reading different for deaf individuals?" (p. 85). Based on the evidence available at the time, rather than a yes or no answer, a dual response to this question was offered. Hanson suggested that even though deaf learners often bring a different set of language experiences to the task of reading, the fundamental task of reading remains the same. Like their hearing peers, they need to rely on an understanding and application of both English language and phonology when reading (see also [5]).

A contemporary interpretation of Hanson's [4] dual response is reflected in the qualitative similarity hypothesis (QSH) proffered by Paul and colleagues [6–10]. According to the QSH, deaf children follow a qualitatively similar developmental learning trajectory to that of hearing students, even though the development of skills may be quantitatively delayed. Furthermore, becoming a proficient reader depends upon mastering the same fundamental abilities that are well established for hearing learners, regardless of the degree of hearing loss or communication modality used (e.g., spoken or signed). In discussing conventional literacy skills specifically, Paul, Wang, and Williams [10] recognized the importance of the ability "to decode and encode written language to attain or construct meaning"

(p. 90) as well as apply strategies to both comprehend and create text. While the authors acknowledged a number of current literacy theories (e.g., constructivism, cognitivism, cognitive-processing, social learning), and the influence each may have on interpreting the nature of skill development, the specific abilities explicated when describing the QSH (e.g., word recognition, orthographic processing, vocabulary development, fluency, reading comprehension instruction, phonology, and phonological processing) were not directly tied to a specific framework or theory.

Considering the aforementioned skills, [10] we see this perspective closely aligned with the Simple View of Reading (SVR) [11], which establishes the critical role that both language and phonological skills play in the development of reading comprehension abilities. While it has been suggested that the SVR "is neither a full theory of reading nor a blueprint for instruction" [12] (p. 75), it has become a widely accepted framework for understanding the abilities required for developing reading competencies, explaining reading challenges and disabilities, assessing prerequisite skills and reading outcomes, and selecting appropriate instructional interventions to meet students' identified needs. Given the strong theoretical and empirical base for the SVR, coupled with the insights garnered regarding students with reading disabilities as part of its development, we contend that the SVR provides a model for understanding the reading process among a wide-range of students, including those who are deaf, and serves as an appropriate framework for explaining development within the context of the QSH.

The benefit of explicitly interpreting the QSH [10] in light of the SVR [11] is that it provides the opportunity to draw upon the research findings associated with this model, relate them to the existing literature in reading and deafness, and identify areas of future research that can be enhanced by employing similar research methodologies used to evaluate the SVR. As such, we will begin by providing a review of the components of the SVR, a brief overview of the research evidence supporting it, and a discussion of current interpretations of this framework in the field of literacy more broadly. Drawing upon both historical and current research in reading and deafness, we will summarize findings, discuss them within the context of the SVR framework, and offer implications for future research and practice based on the available evidence.

2. Simple View of Reading (SVR)

More than 30 years ago, Gough and Tunmer [11] proposed the SVR to describe the components and process involved in the development of reading. According to this model, reading comprehension relies on two, interdependent processes—decoding and language comprehension. Broadly defined, reading comprehension is the ability to construct meaning from language represented in print, whereas language comprehension involves the ability to derive an understanding of linguistic information presented through oral language. Decoding involves the ability to recognize words in print with sufficient automaticity to provide access to the proper meaning within the learner's mental lexicon [11,13].

It is noteworthy that the SVR was conceptualized during the height of the 'reading wars' when opinions regarding the development of reading and instructional strategies to support achievement were extremely polarized, with proponents of decoding (phonics) on one side and advocates for comprehension (whole language) on the other [14,15]. Because of this, some consider the creation of the SVR an attempt to bring about balance in the field by developing a model that recognized the contributions of both decoding and comprehension in the reading process (see [12] for discussion). Given the contentious debates surrounding reading at that time, and the on-going debates in the field of reading and deafness, it is important to further explore the terminology used in describing the key components of the SVR, particularly the term decoding.

2.1. Decoding

For some, the word decoding is synonymous with applying the alphabetic principle, or the understanding that there is a systematic and predictable relationship between letters and sounds, to read individual words ('sounding out'), whereas others equate decoding with context-free word recognition. In clarifying their definition, Gough and Tunmer [11] suggested that decoding in an

alphabetic language such as English relies heavily on the "orthographic cipher" (p. 7), or knowledge of grapheme-phoneme relations, to read words quickly, accurately, and silently. This definition of decoding highlights the role of automaticity in the process of applying the alphabetic principle to word reading (quickly and silently) and the importance of activating meanings from the mental lexicon (accurately).

Despite a strong emphasis on the application of alphabetic coding or phonics, the fact that knowledge of the cipher alone would be insufficient to support the ability to recognize phonetically irregular (e.g., said, was) or orthographically ambiguous (e.g., meat, leather) words was recognized, albeit with the caveat that developing alphabetic decoding skills would enable beginning readers to access a large number of English words [11]. As such, it has been suggested that the term 'decoding' was selected over 'word recognition' to emphasize the importance of alphabetic coding as the foundation for word reading, as phonics was at the center of the debates at the time the SVR was proposed [13].

2.2. Language Comprehension

Within the original iteration of the SVR model, the term comprehension was used to refer to linguistic comprehension, or the process used to interpret words, sentences, and connected discourse [11]. However, in more recent descriptions of the SVR, the term language comprehension has been used to denote these abilities [13]. Some researchers have argued that the processes involved in reading differ from those required for language. However, Gough and Tunmer [11] suggested that these activities are parallel processes, although it was acknowledged that additional skills such as eye movements are involved in reading. In other words, once words have been accurately decoded, an individual engages the same processes to understand what is read as those that would be used to comprehend oral language.

2.3. Application of the SVR Components

Within the SVR model, reading comprehension (R) is considered the product of decoding (D) and language comprehension (C). Using the simple equation $R = D \times C$, Gough and Tunmer [11] explained that each variable could range from 0 (nullity) to 1 (perfection). The formula was then used to illustrate the notion that both decoding and language comprehension are necessary components, but alone are not sufficient, for reading comprehension to occur. In other words, without the skills to decode ($R = D \times C$ with $D = 0$), no amount of language comprehension can compensate for a lack of decoding ability ($R = 0$). Similarly, if an individual is able to decode words but is unable to comprehend ($R = D \times C$ with $C = 0$), then reading is not taking place ($R = 0$).

Using a range of measures to assess skills in the domains of decoding (e.g., letter knowledge, print knowledge, phonological awareness, rapid automatized naming or RAN, word identification, word attack) and language comprehension (e.g., expressive and receptive vocabulary, vocabulary depth, expressive and receptive syntax), findings of studies have consistently demonstrated the contributions of the two components to reading comprehension (see [13] for discussion). While the research has also demonstrated the differential contributions of decoding and language comprehension to reading comprehension at specific points within the developmental process, the SVR does not predict that as one relation becomes stronger (e.g., relation between language comprehension and reading comprehension) the other becomes weaker (e.g., relation between decoding and reading comprehension). Rather, it has been suggested that if skill in one component reaches perfection, the level of skill in the other will likely determine the level of reading comprehension ability [13]. This explanation may account for the demonstrated increase in the role of language comprehension in reading comprehension over time, as decoding is considered a constrained skill that is typically mastered by the age of eight [16], whereas language continues to grow throughout the school years and arguably across the life span [13,15].

When developing the SVR, Gough and Tunmer [11] acknowledged the relation between process and instruction but were primarily interested in creating a model to explain the extent to which decoding skills were implicated in the development of reading. More specifically, the goal was to

explicate three types of reading disabilities that were the result of challenges stemming from: (1) Decoding (i.e., dyslexia), (2) comprehension (i.e., hyperlexia), or (3) a combination of decoding and comprehension (i.e., garden-variety reading disability). The theoretical foundation for the SVR is further bolstered by Chall's [15] reading scheme that was developed during the same era. Within this model, it was hypothesized that an interaction between bottom-up, code-related skills (decoding) and top-down, language-related abilities (language comprehension) is required in order for readers to comprehend texts. While the SVR and Chall's schema share a similar conceptual base, Chall also took into account readers' interactions with their environment and the specific instructional strategies to support skill development across six, hierarchical stages from preschool through college. In other words, in Chall's cognitive information-processing model, reading is viewed as a process involving the text, reader, and context.

2.4. Recent Evaluations and Discussions of the SVR

Several recently conducted large-scale, empirical studies provide further evidence for the efficacy of the SVR. Specifically, these investigations have explored the predictive ability of prekindergarten skills to third grade reading comprehension [17], the individual and joint contributions of decoding and language comprehension to reading comprehension among third through fifth grade students, the developmental shift in relative importance of the two components across the grade levels [18], and the impact of text variation and the role of fluency among typically developing and struggling middle school readers [19]. Findings of these studies have also offered scholars the opportunity to reflect on the SVR more than 30 years after its inception and comment on the educational implications of the model [13], the impact of type of assessments used to measure comprehension [20], and the contributions of the model to advances in the field [21]. In commenting on its history, Snow [20] suggested, "Few hypotheses in the field of literacy have proven as robust as the Simple View of Reading" (p. 313).

As a result of recent research findings, more nuanced descriptions of the components of the SVR have emerged. We found Kirby's and Savage's [12] review of the empirical evidence associated with the SVR, and their commentary regarding the ability to explain the complexities of reading using this model, as well as Hoover's and Tunmer's [13] discussions of recent research findings, particularly salient to these discussions. In the area of decoding specifically, information from the dual route model of reading (e.g., [22]), in which both lexical (e.g., memory for previously seen written words) and non-lexical (e.g., grapheme-phoneme correspondences) routes contribute to word reading abilities, has influenced understandings of the skills readers employ to read both phonetically regular and irregular words. Similarly, research findings indicating the strong association between phonological sensitivity (i.e., phonological and phonemic awareness) and subsequent decoding skills have provided valuable insights into precursor phonological abilities associated with early decoding skills (e.g., [23–26]).

Research has also highlighted the importance of additional cognitive activities and prerequisite skills associated with the decoding domain such as RAN, or the ability to name objects represented by pictures, colors, letters, or digits presented in random order. Phonological memory, which is the ability to remember spoken information for a short period of time, has also been associated with decoding and other early literacy abilities. Finally, alphabet knowledge, or the understanding of the names and sounds associated with printed letters, is considered a precursor skill that is correlated with later measures of literacy development (e.g., [12,27]).

In addition to the aforementioned skills, the reciprocity between the development of alphabet knowledge and phonological abilities has been discussed (e.g., [28,29]). Specifically, it has been hypothesized that alphabet knowledge furthers children's understandings of how spoken language is represented in print [30] and illustrates that words are comprised of smaller units [31]. Because phonological information is included in all letters except the consonant *w* and the short vowel sounds (e.g., the letter name b contains the /b/ sound as in /b/ /ē/, the letter name m contains the /m/ sound as

in /ĕ/ /m/), it has been suggested that print and alphabet experiences contribute to the development of the phonological skills that support later decoding abilities (e.g., [32,33]).

A recent critique of the SVR is that it focuses primarily on reader-based variables and does not take into account variability associated with text ([19] see also [20,21]). Furthermore, it has been suggested that the SVR is more a conceptual model of reading rather than a developmental or statistical one. To address these limitations, a Complete View of Reading (CVR*i*) has been proposed, whereby oral reading fluency serves as a proxy for reading comprehension. It has been suggested that the CVR*i* expands on the foundation of the SVR and offers a more comprehensive model of reading by considering the impact of text features (e.g., complexity, genre) on comprehension abilities [19]. It is interesting to note that the CVR*i* more closely aligns with Chall's [15] schema, as well as the findings of the National Reading Panel (NRP) [34], which recognize the key role reading fluency plays in serving as a bridge between decoding and reading comprehension abilities.

While potential limitations to the SVR have been noted, and adjustments to the framework have been offered to clarify and expand its components, findings of research investigations have consistently illustrated that the core principles of the model (i.e., decoding, language comprehension) represent a robust hypothesis for understanding the development of reading comprehension abilities. In fact, we would suggest that the components of the SVR are echoed in both existing (e.g., Chall [15]) and emerging (e.g., CVR*i* [19]) models of reading development, as well as the findings of large-scale research analyses (e.g., NELP [27], NRP [34],), thereby lending further support for the importance of both skills in the reading process.

3. Historical Research Evidence in Reading and Deafness

Large-scale data collection on the academic achievement of deaf students in the United States began approximately 50 years ago, with the *Stanford Achievement Test* (SAT) used as an outcome measure. At the time, the typical administration procedures of this assessment required students to take the test corresponding to their current grade placement. For example, a student enrolled in fourth grade would be required to take the fourth-grade test. However, given the history of achievement challenges experienced by deaf learners, a special version of the assessment was developed in 1974, the *Stanford Achievement Test for Hearing Impaired* (SAT-HI). While the test questions and format of the SAT-HI remained consistent with the original SAT measure, a screening assessment was created so that test levels could be matched to students' current level of performance rather than grade level. For example, a student enrolled in fourth grade who was achieving below grade level expectations could take a lower-level test, such as the one intended for second-grade students [1].

Beginning in 1974 and continuing through 2003, five large-scale studies were conducted using the SAT-HI, with normative data regarding student performance developed as a result of each investigation. Data from nearly 7000 students ages 8 through 18 comprised the special norming sample in 1974, whereas the normative data from 2003 represented approximately 3500 students. Considering the data for the reading comprehension subtest across 11 cohorts of students over time (i.e., students age 8 through 18 from 1974 to 2003), performance levels were shown to increase slightly as a function of age. However, the median grade equivalent never exceeded the fourth grade level for any given cohort. These findings led Qi and Mitchell [1] to conclude, "there has been little or no change in the central tendency of academic achievement among the deaf and hearing student population over the last three decades" (p. 7).

In addition to the results for the reading comprehension subtest, Traxler [35] also reported data for the reading vocabulary subtest from the SAT-HI norming study conducted in 1996. In this investigation, four performance levels (i.e., below basic, basic, proficient, advanced) were used to interpret the findings for deaf learners relative to hearing students. For the reading comprehension subtest, the median score (50th percentile) for the entire group of deaf students ages 8 through 18 fell within the below basic level, whereas data for those students achieving at the 80th percentile revealed

performance within the basic level. Findings of the reading vocabulary subtest indicated a similar pattern of performance.

Historical Research Evidence and the SVR

One of the challenges in interpreting the historical achievement data in the context of the SVR is that the SAT-HI only included data on the product of reading (i.e., comprehension, reading vocabulary) and not the components skills of decoding and language comprehension. While these findings do demonstrate a significant achievement gap between deaf and hearing readers, the underlying cause of reading difficulties—decoding, language comprehension, or a combination thereof—remained a question. Within the field of deafness, discussions of reading frequently become an either-or debate, with phonological decoding skills pitted against language abilities in determining which is critical to the overall developmental process and/or responsible for achievement outcomes (e.g., [2,36,37] see also [5] for discussion). In many ways, these debates parallel those that began in the field of reading more than a half-century ago [14], and those that were prominent during the time the SVR was proposed.

In response to these debates, supporters of the QSH have asserted that phonological skills are a necessary component of reading for deaf individuals but have also recognized these skills alone are not sufficient for reading comprehension to occur [3]. These assertions clearly align with the premise of the SVR. In fact, several research teams have explicitly referenced the SVR or similar cognitive models when discussing phonological skills as essential components of both early and conventional reading for deaf learners (e.g., [38–40]). The alternative view, in which phonological skills are not considered a necessary element (e.g., [37]), has been critiqued because it has not been contextualized within an extant model of reading, and an alternative hypothesis of development has not been empirically demonstrated [3].

When applying the SVR equation $R = D \times C$, it can be argued that in order for reading comprehension to occur, readers must first be able to access the text through the decoding process. Although not explicitly discussed as a feature of the SVR, it is also true that individuals must possess a threshold of language comprehension abilities before decoding even becomes a goal. In fact, it is widely accepted that knowledge of syntax, words, and the nature of words (e.g., rhyme, alliteration) are pre-reading abilities that form the foundation for, and have a substantial influence on, early decoding skills (e.g., [15,27,34]. We would suggest that this prerequisite level of communicative competence in the language to be read (e.g., English) is assumed in a conceptual model of reading, particularly when applied to hearing readers. Gough's and Tunmer's [11] discussion of the ability of readers to activate accurate meanings within the mental lexicon as part of the decoding process further supports this assumption.

However, we recognize that some deaf children may not possess the essential language foundations at the onset of formal decoding instruction, which typically begins in kindergarten. This includes deaf children whose first language is not English, but rather a natural signed language (e.g., American Sign Language) or another spoken language (see [39] for discussion). From the perspective of the SVR, it is likely that this subgroup of deaf learners would evidence performance similar to the students described as having a "garden variety reading disability" [11] (p. 8), in which barriers to reading comprehension result from challenges with both decoding and language comprehension.

While the language delays and deficits of deaf learners have been widely accepted and are well documented in the literature (e.g., [41]), the role of phonological decoding in reading for deaf learners is one of the most fiercely debated topics in the field (see [2,3,5]). In fact, criticisms of the QSH have focused "mostly on the role of phonology in the development of reading, particularly in the learning to read period" ([10] p. 17). From the perspective of the SVR, "reading comprehension increases linearly with increases in either decoding or linguistic comprehension except where skill in one component is nil." [13] (p. 308). The notion that an absence of skill in the decoding domain, or a lack of instructional focus on this component, largely contributes to the difficulties deaf learners experience in attaining

age-appropriate reading outcomes has been the focus of many discussions in reading and deafness in recent years (see [5,39,40] for discussions). Therefore, our discussion of current research evidence will focus primarily on the phonological aspects of reading development and instruction. While not to diminish the critical role of language as a pre-reading ability and a necessary component for reading comprehension, the rationale for this decision is guided by our interpretation of the SVR equation, whereby automatic and accurate word decoding precedes the activation of language comprehension abilities in the process of reading comprehension.

4. Current Research Evidence

When considering the current research evidence regarding the phonological aspects of reading development and instruction, we relied on the studies identified and findings summarized within three recent reviews of the literature published in the last five years. This includes a qualitative meta-analysis [42], a standards-based examination of intervention research [43], and a review of reading comprehension and phonics studies employing correlational analyses [44]. Because our primary goal was to comment on existing evidence in reading and deafness within the context of the SVR framework, we did not consider it necessary to conduct our own meta-analysis of the research. In fact, we chose to rely on the aforementioned reviews because they examined recently published works, employed rigorous standards in terms of search procedures and reporting of findings, and represented a range of research methodologies. Collectively, we would suggest that these publications represent the current state of the evidence on this topic.

4.1. Qualitative Meta-Analysis

Even though several scholars in the field have contextualized their intervention research within a conceptual model of development (e.g., [38–40]), the findings of the NRP [34] are more frequently referenced as a foundation for this work. This situation may not differ substantially from the field of reading more broadly, as it has been suggested that curricular standards tend to drive instruction more frequently than cognitive models [13]. Schirmer and McGough [45] are credited as the first in the field to explore the applicability of the findings from the NRP, including phonemic awareness, phonics, fluency, vocabulary, and comprehension, to reading development and instruction for deaf learners. In their review of 67 studies conducted between 1970 and 2001, they identified only one study that examined phonologically based instruction. However, due to inadequate descriptions of the methodology and results, this investigation was characterized by Schirmer and McGough [45] as one "with serious flaws" (p. 89).

A series of four meta-analyses by Luckner and colleagues were also conducted that explored the areas recommended by the NRP [34]. These included an examination of reading research across all five areas of instruction in general [46], as well as in the components of reading fluency [47], vocabulary [48], and reading comprehension [49] specifically. A meta-analysis of 57 studies in reading and deafness, 25 of which measured the relationship between participants' phonological coding and awareness skills and reading abilities, was also completed [36].

The findings of the six aforementioned publications were among the 11 qualitative and 39 quantitative meta-analyses of reading research systematically reviewed across three groups of learners: (1) Monolingual hearing students, (2) special education students and English language learners (ELL), and (3) deaf students. In their conclusion regarding the category of alphabetics (i.e., phonemic awareness and phonics), Wang and Williams [42] suggested that the research with monolingual, special education, and ELL hearing students provided support for phonemic awareness and phonics as part of reading instruction, particularly in prekindergarten through first grade. However, they also acknowledged that the research conducted with deaf learners, "was too limited or too methodologically weak to permit conclusions to be drawn" (p. 342). In discussing the implications for this finding, a call for an increased number of quality studies was made, especially those employing designs in which causality can be determined.

4.2. Standards-Based Examination of Intervention Research

The evidence-based standards published by the Council for Exceptional Children (CEC, [50]) were recently applied to the body of intervention research conducted in reading and deafness between 2000 and 2016 [43]. The CEC standards include a set of quality indicators to evaluate studies using group comparison (e.g., experimental, quasi-experimental, regression discontinuity) and single-subject designs. The eight quality indicators of these CEC standards are applied to an investigation to determine the thorough reporting of key study elements (e.g., context, participant, intervention agent, description of practice, implementation fidelity) and to examine the study's methodological rigor (e.g., internal validity, outcome measures, data analysis). In accordance with the CEC procedures, studies are grouped for analysis based on target outcomes and are classified in one of five categories (i.e., evidence-based, potentially evidence-based practice, mixed evidence, insufficient evidence, or negative effects) based on factors such as the number of studies, type of study design, number of participants, and study effects.

In this analysis, the categories associated with decoding interventions included explicit phonological/phonemic awareness and phonics instruction, and one titled 'comprehensive', which was used to capture studies of specific reading approaches or curricula that addressed and measured more than one area of instruction (e.g., decoding and vocabulary). Because several of the explicit phonological/phonemic awareness and phonics studies used the Visual Phonics instructional tool as part of intervention, the category was divided in two to account for those that used the tool and those that did not [43]. Visual Phonics is a multisensory system designed to provide visual, tactile, and kinesthetic information regarding the production of individual phonemes. The Visual Phonics system is comprised of 46 hand gestures and associated written symbols and is frequently used to supplement phonologically-based reading instruction for deaf learners, particularly for those students with limited auditory access and/or the ability to differentiate phonemes produced in a similar manner (e.g., phonemes /t/ and /d/) (see [39,40] for discussions).

Of the 30 total intervention studies identified for the standards-based examination, six investigations of phonological skills employed either a group comparison or single-subject design. Three of these studies, one group comparison [51] and two single-subject [52,53], were identified in the category of phonological instruction supplemented by Visual Phonics. Based on the positive effects obtained in each of these studies, coupled with the study design and number of participants, this category of instruction was identified as potentially evidence-based. Two of the studies, both using single-subject design [54,55], comprised the phonological instruction without Visual Phonics category. Due to the number of studies and the fact that mixed results were obtained in one investigation, the CEC [50] mixed evidence classification was assigned to this practice. Finally, a phonologically focused reading curriculum included in the comprehensive category, *Foundations for Literacy*, was evaluated by one study [38] and identified as a potentially evidence-based practice as a result of the CEC evidence-based practices analysis [43].

4.3. Correlational Research

In a recent review of correlational research, Luft [44] summarized the findings of 28 studies of reading comprehension and phonics. Research supporting the role of phonologically related abilities across alphabetic languages, as well as the relatively few studies available in the low incidence disability category of deafness, was provided as the rationale for including studies within the review that examined languages other than English. Specifically, studies that examined the correlation between constrained reading skills (e.g., orthographic awareness, phonemic awareness, phonological skills), and the unconstrained area of reading comprehension, were examined. Because it was unclear whether phonemic awareness (PA) was measured without the use of print in some of the reviewed studies, this ability was combined with measures of phonological skills involving print (PS) in order to create one category (PA/PS) to discuss findings across investigations.

In discussing the findings of studies examining PA/PS and orthographic awareness (OA) skills, Luft [44] was particularly interested in exploring the type of measures used and the administration timing of these measures across the body of correlational studies. Findings suggested that a wide range of assessments were used to assess PA/PS and OA skills including those measuring phonological and phonemic awareness abilities (e.g., rhyme decision and generation, syllabic similarity, phoneme detection, blending and matching), the alphabetic principle (e.g., phoneme-grapheme correspondences), decoding (e.g., reading words, non-words, and word chains), and encoding (e.g., spelling). Additional measures assessing cognitive tasks (e.g., RAN of letters and numbers) were also included in some studies. Similarly, measures used to assess reading comprehension varied across word (e.g., word identification, pseudoword reading, word chains), sentence (e.g., cloze), and passage (e.g., cloze, reading selections followed by questions) level assessments.

When examining studies, Luft [44] considered the age at which PA/PS and OA skills are typically the primary focus of development and instruction, between six- to eight-years-old, and defined this as the target age range for participants in studies. Across the 28 studies, she identified only three investigations examining the development of skills among participants within this age range exclusively [56–58]. The remaining studies involved participants outside of the age range entirely (n = 11) or a combination of participants both within and outside the target age range (n = 14). In considering the results for PA/PS skills across all investigations, 17 studies reported significant correlations with reading comprehension. Another five studies included in the review reported significant correlations between OA and reading comprehension.

Issues regarding both type and timing of measures across areas of reading that were identified as a result of this review undoubtedly contributed to the mixed findings obtained across studies. In fact, this led Luft [44] to conclude, " ... that the varying measures likely obscured patterns as well as differences among the reading constructs and PA/PS and OA subskills. This was further complicated by participant age effects on variability across early, constrained and later, unconstrained skills." (p. 159).

4.4. Current Research Evidence and the SVR

While the recently published reviews examining the phonological aspects of reading development and instruction for deaf learners revealed some mixed findings, it could be argued that the research to date points to the fact that successful deaf readers have control of phonological skills, and that there is no compelling empirical evidence to suggest that deaf learners can become proficient readers without them (see [3,5,42] for discussions). Given the long-standing and on-going debates in the field, we find the increased research attention in this area encouraging. A particular strength of the current body of evidence is that a variety of research methodologies have been employed to examine issues of phonological skill development, and efforts have been made to implement instructional interventions with deaf learners that target these skills. However, despite these developments, we also acknowledge that more rigorous investigations of this topic are needed in order to provide further support for the role of phonological skills in reading for deaf learners.

One of the on-going challenges in interpreting the findings of phonologically based studies in the field of deafness relates to the terminology used to describe these skills and to categorize assessments used to measures them, as it does not necessarily reflect those used in the general field of reading. For example, the term phonological awareness is typically used to describe a broad skill that involves manipulating elements of oral language (e.g., rhyming, syllable blending and segmenting), whereas phonemic awareness refers to the specific ability to manipulate individual sounds within words. In regards to skills that involve print, the alphabetic principle refers to the understanding of the systematic and predictable relationship between letters and sounds, and phonics is used to describe the ability to use this knowledge to read (decode) and spell (encode) words. As previously indicated, it has been suggested that combining these abilities across categories of skills may conflate or obfuscate the findings obtained (see [5,44] for discussions).

In the general field of reading, latent variable models are frequently used to evaluate the adequacy of the SVR. In investigations of this type, multiple measures of each construct are employed to determine the influences of decoding and language comprehension on reading comprehension. For example, in a recent investigation exploring the ability to predict third grade reading comprehension abilities from prekindergarten skills, 11 measures assessing language abilities (e.g., vocabulary, grammar, and discourse-level language) and four measures of code-related skills (e.g., letter knowledge, phonological awareness, RAN) were used to assess the skills of the prekindergarten participants [17]. In order to confirm the applicability of the SVR to reading for deaf learners and draw firm conclusions regarding the QSH [10], studies that employ similar study designs and measures would need to be conducted. In this way, we agree with Luft's [44] comment that sophisticated causal modeling may serve to overcome the current limitations of correlational research.

Of the 30 intervention studies Trezek and Wang [43] identified for their analysis, 12 (40%) examined the area of decoding and eight included the Visual Phonics supplement as a component of the intervention. The inclusion of the Visual Phonics instructional tool suggests that researchers recognize that this type of instruction has the potential to benefit a wide range of deaf learners, including those who may require differentiated access to the phonology of English. However, only half of these studies represented group comparison and single-subject design studies in which causality could be inferred. In addition, the majority of these studies drew conclusions based on researcher-developed measures of decoding and word-level skills and none of them examined the impact of these skills on reading comprehension outcomes. Furthermore, at the time the review was conducted, only one study was identified that focused exclusively on the development of phonological or phonemic awareness abilities among deaf learners [55]. This stands in contrast to the significant number of studies in both general and special education examining these skills in addition to those associated with decoding.

5. Discussion and Recommendations

The SVR [11] provides a robust hypothesis for explaining the reading development of a wide range of learners and has the potential to inform our understandings of the QSH [10] for deaf learners. Supporters of the SVR framework acknowledge that both decoding and language comprehension are essential elements of reading comprehension and recognize the differential and relative contributions of these skills across grade levels. As such, reading is not viewed as an either-or debate between decoding skills and language comprehension abilities. Rather, reading comprehension is seen as a product of the two components, in which neither decoding or language comprehension alone is sufficient [3].

For all readers, language forms the foundation for reading [15]. This fact may be particularly salient for deaf readers who have historically experienced challenges in acquiring competence in the face-to-face form of the language that is required for reading. Furthermore, it can be argued that several abilities often associated with the decoding domain that involve understanding of the nature of words, such as phonological and phonemic awareness, may actually be more closely associated with language comprehension abilities. These skills, along with general language abilities that involve the understanding of English words and syntax, are seen as critical elements for both early and conventional reading abilities (see [39] for discussion of deaf learners).

The findings of this review of the current evidence offer several implications for research and practice. To foster a research-to-practice orientation that recognizes the connection between the two in the process of identifying evidence-based practices, the implications for future directions will be discussed collectively. In light of the information presented and discussed, the following recommendations for future research and practice in reading and deafness are offered:

- Researchers should employ structural equation modeling to test various hypotheses of reading development to examine the applicability of the SVR to reading and deafness. As part of a recent investigation, Chui [17] offered several hypotheses to explain the relations between language comprehension abilities and decoding skills that may serve to inform hypotheses to be tested with deaf learners.

- Studies with deaf learners should be conducted within the appropriate target age range for the constructs under investigation and include a longitudinal component in order to examine participants' progress over time (e.g., preschool through third grade). Within these and all investigations, the demographic characteristics (e.g., degree of hearing loss, use of hearing technologies, educational placement, communication modality) of study participants should be thoroughly described in order to ensure the generalizability of findings.
- Given the availability of standardized measures of decoding, language comprehension, and reading comprehension, assessments of this type should be employed in the research whenever possible. This will allow researchers to compare reading outcomes to normative data as well as across investigations. Using these assessments will also permit researchers to replicate studies, thereby increasing the number of participants assessed under similar conditions. This would be particularly useful in terms of conducting research with a low incidence population of students such as deaf learners, since achieving adequate sample sizes presents an on-going challenge in conducting research in the field. In relation to phonological abilities specifically, the use of standardized assessments may also foster the use of appropriate terminology to characterize skills, describe assessments, and report findings.
- Future studies of phonics interventions should examine not only the immediate effects of instruction on word-level reading skills but also the longitudinal impact on reading comprehension outcomes.
- It is recommended that future intervention research studies examine the implementation of phonological and phonemic awareness instruction, particularly among deaf children at the prekindergarten level. It is further suggested that existing curricula or readily available interventions (e.g., commercially available) be used in order to permit study replications.

6. Conclusions

The present review examining the state of evidence in reading and deafness provides interesting insights that can inform both research and practice. Given the historical reading outcomes documented for deaf learners, coupled with a relatively weak methodologically research base, future investigations should focus on identifying and empirically evaluating conceptual models of development and instruction for this population of students. We would suggest that the SVR [11] provides an appropriate framework for exploring the individual and joint contributions of decoding skills and language comprehension abilities to reading comprehension for this population of students and complements Hanson's [4] work examining the influences of language and phonology on the reading abilities of deaf individuals. Testing various hypotheses within the framework of the SVR would also allow researchers to evaluate the QSH [10] and identify similarities as well as potential differences in the reading development of deaf learners.

From a research-to-practice orientation, intervention research should focus on areas identified as a result of evaluating conceptual models such as the SVR [11]. Given the reciprocity between research and practice, the findings of these investigations can serve to further inform these models, thereby offering a robust framework for future research and practice in the field. This work would be particularly timely, as current large-scale data documenting the reading outcomes for deaf learners were collected more than 20 years ago [35]. As such, these data do not represent the impact of two major advances in the field—the introduction of universal newborn hearing screening and improved hearing technologies, including cochlear implantation. Recent findings suggest that both early and conventional literacy outcomes have improved as a result of these advances, with a significant number of deaf students reading at age-appropriate levels [59,60]. However, findings of the present review of the evidence suggest that additional investigations, particularly those that employ robust methodologies, examine precursor abilities such as phonological and phonemic awareness, and track children's achievement over time, are clearly warranted.

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Notes on Terminology

deaf	We use the term deaf to refer to any individual identified with a hearing loss, from mild to profound, irrespective of the use of amplification. For instance, individuals with cochlear implants are regarded as deaf. We are also not making a distinction between deaf and Deaf, as we do not consider this difference germane to our view of the development of reading.
oral language	When the term 'oral language' is used, it is done so to reflect the terminology employed in the original source (e.g., National Early Literacy Panel, a published study, etc.). This term is often used synonymously with 'spoken language' in the broader literature in the field of literacy. It is only in the field of deafness in which the distinction between oral and spoken language merits attention.

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Review

Writing and Deafness: State of the Evidence and Implications for Research and Practice

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Abstract: Although reading and writing play equally important roles in the literacy development of deaf individuals, far more attention has been paid to reading than to writing in both research and practice. This is concerning as outcomes in writing have remained poor despite changes in communication philosophies (e.g., spoken and/or signed) and pedagogical approaches. Although there are indications of a positive shift as the context for deaf education has been transformed with advances in hearing technologies, challenges are ongoing. In order to better understand why deaf learners struggle to achieve age-appropriate outcomes in written language, the goal of this paper will be to take stock of the available research evidence in writing and deafness, and interpret it in light of both the Simple View of Writing (SVW), in which ideation or text generation is linked to oral language, and current models of the composing process. Based on this overview and analysis, implications and directions for future research and practice will be discussed.

Keywords: deaf; writing development; simple view of writing; writing interventions; writing instruction

1. Introduction

Although reading and writing are regarded as the two sides of the literacy coin, it would be fair to say that much more attention has been paid to reading than to writing, with respect to both research and practice, for both hearing [1] and deaf learners [2]. It is well documented that not enough classroom time has been devoted to writing, the teaching of writing, and to using writing as a tool for learning [3]. In addition, teachers often report that they feel underprepared to effectively teach writing and incorporate it into learning across the curriculum.

Given the power of writing as a communicative and cognitive tool, this lack of attention could be seen as surprising, since it is one of the necessary abilities students must master to ensure success in schooling, in the workplace, and in life [4]. Particularly in the current climate of texting, emailing, blogging, Facebook posting, and tweeting, writing plays an increasingly vital role in social interaction. For deaf individuals, writing affords access to easier, more effective communication with a wider community than ever before [5].

It is equally surprising that writing receives less consideration than reading, given the substantial body of literature that focuses on the ways in which the two are interrelated both in terms of their development (i.e., they depend on common knowledge sources that inform each other) [6,7], and how they are taught—that writing can support the development of reading [8], and reading can support the development of writing [4].

Lastly, it is puzzling that more emphasis is not placed on writing and the teaching of writing when the outcomes for pupils in this area have not been strong, with many high school graduates falling short of skilled performance. For example, only 27% of 12th grade students in the United States

were reported to be at a proficient level or above in writing (http://www.nationsreportcard.gov). It is also worth noting that, although achievement in writing tends to be weaker than reading, assessments of writing are not regularly included in national or international assessments of literacy. For example, the Programme for International Student Assessment (PISA), a triennial international survey aimed at evaluating education systems worldwide by assessing the skills and knowledge of 15-year-old students nearing the end of compulsory education, includes a measure of reading but not of writing (http://www.oecd.org/pisa/aboutpisa/). Similarly, the writing component is the only optional aspect of the ACT (American College Testing) assessment, and even if it is completed, this result is not included in the composite score (http://www.act.org/content/act/en/products-and-services/the-act/test-preparation/writing-test-prep.html).

This situation may be reflective of the challenges encountered in assessing writing more broadly. Despite the fact that the act of writing produces a tangible product that can be reviewed and analyzed, assessments of these products can be challenging, and do not typically generate scores and grade equivalents in as a tidy a fashion as do tests of reading. This often leads to questions as to how to accurately document performance in ways that can inform both research and practice.

Despite these assessment challenges, the concerns with respect to the writing achievement of deaf learners are well recognized and ongoing. Outcomes have remained poor for the better part of the past century despite changes in communication philosophies and pedagogical approaches [2]. However, there are indications of a positive shift as the context for deaf education has been transformed with the introduction of cochlear implants and other advances in hearing technologies [9]. To move the conversation forward, the goal of this paper will be to take stock of the available research evidence with respect to the writing performance of deaf students, interpret it in light of what is understood about writing development and the process of writing more broadly, and consider implications and directions for research and practice.

2. Writing Development

2.1. The Simple View of Writing

As was noted above, there is an intimate and reciprocal relationship between reading and writing, and it is this relationship that speaks to the core of what is required for a child to develop as a writer. As Shanahan so aptly put it in describing this relationship, reading and writing are "two buckets drawing water from the same well or two buildings built on a common foundation" [7] (p. 195). In thinking about what constitutes these foundational requisites, it is useful to refer to the Simple View of Writing (SVW) [10,11]—a framework that parallels the notion of a Simple View of Reading (SVR) [12] in which it is proposed that reading comprehension is the product of decoding and language comprehension. While there has been much written with respect to the SVR, and the extent to which it accurately represents what is required in learning to read, there has been less discussion as to how the SVW can be used to characterize what is important to develop as a writer.

Based upon this view, writing is conceptualized as the product of two necessary skills—transcription and ideation (text generation). Transcription is the act of getting the language down on paper; that is, the physical act and process of representing the sounds of the spoken language in print (i.e., spelling, handwriting). A level of automaticity and accuracy is required in these transcription skills in order to write fluently, so as not to interfere with the process of generating the text.

Ideation, or text generation, refers to the production of what the writer wants to communicate. Of necessity, this process rests on oral language representations, since thoughts and ideas must first be encoded in oral language before they can be transcribed in print [13,14]. Teachers operationalize this by directing beginning writers to write down what they say. "As [children] are discovering the power and role of written text in their stories, they must come to work among symbolic worlds, and talk is a tool they use to help them with this task" [15] (p. 42). For the great majority of deaf children in the current context, this ability to encode in oral language is a consequence of having auditory access

to spoken language via hearing technologies. For some deaf children, this auditory access may be supported visually (e.g., signed forms of the spoken language, Cued Speech, speechreading), but it is critical to note that this support is secondary to the access that is provided via the hearing technology.

Building on the SVW, the not-so-simple view of writing was subsequently proposed [16,17], whereby the model was broadened to include executive function and self-regulatory processes (e.g., reviewing, goal setting) along with the existing elements of transcription and ideation. It was further posited that working memory was central to all three of these components (i.e., transcription, text generation, and self-regulation).

In a recent study, Kim and Schatschneider [18] investigated the extent to which the component skills included in both views were implicated in learning to write among a cohort of 193 children in first grade. One of the central findings was that "discourse-level oral language and transcription skills (spelling and handwriting fluency) had direct relations to writing. In contrast, all the other language and cognitive component skills were indirectly related to writing via discourse-level oral language and transcription skills" [18] (p. 12). They also reported that discourse-level oral language skills are the primary mediator not only of higher-order cognitive skills, but also of the relationships of foundational oral language skills (such as vocabulary and grammatical knowledge) to writing.

Keeping this in mind while returning to a notion of reading and writing relationships as described by Shanahan [7], it seems clear that oral language is foundational to the "well" that children draw from in learning to read and write. It is also interesting to consider how language is fore-fronted to a greater extent in writing than in reading. While both activities require code-related, transcription skills (decoding and encoding) and oral language abilities, when children write, the encoding happens only after the language has been generated (i.e., talk precedes text). In other words, children would not attempt to write a word that was not already in their language repertoire.

In contrast, when a child reads, the text is already available; therefore, decoding precedes the talk (i.e., the reading aloud), and is a necessary first step to comprehension. The challenge facing deaf children in learning to write often rests on the fact that they do not have the requisite language "well" to draw upon. In the absence of the discourse-level oral language abilities that are fundamental to the process, it becomes impossible to generate text. It has been demonstrated that this is the case for hearing children, and there is no reason to suspect that this explanation would not apply to deaf children as well. Such a view is in line with the Qualitative-Similarity Hypothesis (QSH) (e.g., [19]), in which it has been argued that becoming a proficient reader and writer depends upon mastering the same fundamental skills and abilities that are well recognized for hearing learners.

2.2. The Composing Process

Beyond thinking about the foundational requisites needed for learning to write and develop as a writer as conceptualized in the SVW, it is also useful to consider the nature of the composing process itself and the ways in which these requisites play a role. A widely accepted model of the composing process is that of Bereiter and Scardamalia, who propose a "dual model space problem of written composition" [20] (p. 303), that captures the essence of what effective writers do in generating a text. They describe two problem spaces in the writing process—the content space and the rhetorical space.

The content space is concerned with meaning and what the writer wants to say. This content knowledge is realized intra-mentally in the language of everyday discourse [21,22]. The rhetorical space is tied up with how to move these ideas from the content space to the written form so that writers can effectively convey what they mean. The challenge for all writers is to rearticulate their intra-mental meanings (i.e., what they want to say) in the language of the text. As Collins and Gentner describe it,

"It is important to separate idea production from text production, as the processes involved in producing text (the rhetorical space, whether they operate on the word level, the sentence level, the paragraph level or the text level, must produce linear sequence that satisfies certain grammatical rules. In contrast, the result of idea production (the content space) is a set of ideas with many internal connections, only a few of which fit the linear model desirable for text." [23] (p. 53).

In addition, all of this takes place as the writer is dealing with the added constraints that are a feature of using written as opposed to oral language (i.e., communicating with an absent interlocutor without benefit of the auditory and visual cues inherent in face-to-face communication). Clear communication in writing requires greater precision in the use of language, and more expansion and elaboration of thought than is needed when speaking or signing to make the intended meaning as clear as possible [24–27].

A fundamental requisite for reformulating meaning from the content space in the rhetorical space is facility in the language to be written. Within the SVW, this has been described as oral language representations, and by Kim and Schatschneider [18] as "discourse level oral language." Although meaning in the content space can be represented intra-mentally in any language or modality (i.e., spoken or signed, English or Spanish), realizing this meaning in written form requires that it be represented via the language of the text [28]. Oral language competence is central to this process, as it provides the foundation for the morphosyntactic and semantic understandings, and the development of the phonological awareness and other code-related abilities needed for making meaning in print ([29]; but see also [30] for a review). Singer and Bashir [31] refer to this as being able to depend on intuitive language knowledge (i.e., that has already been acquired) to encode implicitly in the process of text generation.

Beginning writers use this oral language as the foundation to compose as they speak (i.e., talk their way into text) while simultaneously dealing with the transcription challenges of spelling and handwriting. In essence, as they write young children are dictating to themselves. More practiced writers have typically gained control of the transcription level skills, but the fundamental challenges of composition (i.e., clearing representing meaning in print) are ongoing. To achieve clarity of meaning requires the writer to engage in the writing process as a recursive activity in which the text is understood to be a malleable artifact that requires rereading and revision in order to make the meaning as clear as possible to the intended audience.

Bereiter and Scardamalia [20] referred to this as writers reflecting on a text as they are creating it; making the trip from the content space to the rhetorical space and back again, often multiple times, to ensure that what has been written is what is meant (i.e., writing as a recursive process). In order to accomplish this, the writer must at minimum have competence in both transcription skills and oral language abilities. This notion is consistent with the SVW. However, while these discourse level oral language abilities are a necessary foundation, becoming a more proficient writer requires knowledge and control of the lower frequency vocabulary, the greater morphosyntactic complexity, and textual coherence that is a feature of more mature writing—aspects that are grounded in, but go beyond control of the language of everyday discourse.

In bilingual contexts, when writers are composing in their second language (L2), the same principles apply. Irrespective of the level of competence in oral language in L1, it is not possible to compose in L2 in the absence of oral language abilities in L2 (i.e., to readily move ideas from the content space to the rhetorical space so that they are represented in L2 text). It is also possible to be a skilled writer in L1, and struggle in writing in L2 in the absence of the implicit knowledge of oral language in L2. Cumming [32] suggests that some of the confusion in L2 writing research often stems from the fact that an adequate distinction has not been made between what constitutes writing expertise and what constitutes L2 language proficiency.

This is not to say that L1 proficiency cannot be supportive in the writing process [33]. However, given the complex nature of linguistic interdependence or cross-linguistic transfer, the relationships between languages are not clear-cut. While interdependence can afford benefits, it can also yield deficits (i.e., interference), or it may be neutral in its impact [34]. Simply put, L1 oral language cannot just "stand in" for L2 oral language in the process of writing and learning to write in the L2. Harkening back to the SVW, oral language competence *in the language to be written* is a necessary foundational requisite, and there is no evidence to suggest that this does not hold true even in the bilingual context of spoken and a signed language (see [21,35–37] for discussions).

3. The Evidence Base

The aim in the following sections is to present an overview of the state of the available research evidence with respect to deaf individuals, and to frame the discussion of this research in light of the theoretical models described above. The focus of this overview will be limited to an examination of studies that report outcomes in writing and will not include papers that describe interventions or programs for teaching writing unless they also include information on achievement. As well, studies in which outcomes were confined to examinations of transcription skills (e.g., spelling, handwriting) have not been included.

3.1. Historical Perspectives

Although the historical evidence base on the writing performance of deaf learners may be relatively limited in volume and scope, the findings across the available research are remarkably consistent. In a word, deaf writers have rarely evidenced outcomes that were age-appropriate and commensurate with their hearing age peers. Further to this, it was often the case that the writing evidenced features that were idiosyncratic to deaf students, with features not typically seen in the writing of hearing learners.

In considering the literature from the early 20th century onward, it becomes evident that deaf individuals struggle with almost all aspects of writing and learning to write, encountering difficulties with text production that include phonology, morphology, lexicon, grammar, syntax, conceptual coherence, and text and discourse structures (e.g., [38–41]), and with the composing process itself (e.g., [28,42,43]). Consistent with the fourth grade levels reported for reading, typical 17- to 18-year-old deaf students were said to be writing at levels comparable to that of an 8- to 10-year-old hearing children [44,45], "failing to master elements of English morphology, grammar structures, and transformational grammar rules, even by age 21" [41] (p. 10).

The bulk of this early writing research concentrated on lexical and grammatical aspects (e.g., [46–51], with researchers concluding that deaf writers generally used a greater number of nouns, verbs, and determiners, with less frequent use of adverbs, auxiliaries, and conjunctions. The writing was characterized by shorter, simpler sentences with a reliance on subject-verb-completion constructions, less flexible word order, numerous grammatical errors, and non-standard usages of English (see Yoshinaga-ltano [52] for a discussion). The examples below are illustrative of the quality of writing from this period.

> Boy walk see to cat say "Meow" he pet to cat. Boy walk to but balloon said help me boy hear to balloon boy climb he got to balloon. (8-year-old deaf student)

> How are you? I'm fine. Yes I want try other cheezes on the break. What you buy cheezes other on the break? What you undecided no or yes to me? (13-year-old deaf student)

Moving into the latter part of the 20th and early 21st century, written products continued to evidence problems with regard to lexicon, morphology, and syntax [38–40,53–56]. However, research attention was expanded to take into account not only lexical and grammatical features, but also the organization of the written discourse (e.g., conceptual coherence, text, and discourse structure). Findings indicated that deaf writers faced challenges with these aspects of text generation as well [41,52,57–64]. Yoshinaga-Itano and Downey [62] concluded that while hearing children evidence adult structures in their written narratives by age 6, most deaf students did not employ even minimal story components by age 18.

Some researchers suggested that although deaf writers demonstrated challenges with form (e.g., morphology, syntax), they were still able to convey content, even as well as their hearing peers [41,65,66]. Arfe and Boscolo [67] reported that while deaf writers in their study made use of causal coherence in narrative writing, it was less coherent than their hearing counterparts. Marschark, Mouradian, and Halas [65] contended that deaf writers are able to appropriately apply discourse rules in narrative production, but that this performance is "obscured by disfluencies in writing,"

with disfluencies being characterized as a lack of literary and syntactic means (p. 89). This gives rise to questions as to how, and the extent to which, deficits (disfluencies) at the lexical, morphological, and syntactic level impact the ability to organize content coherently in order to convey intended meanings in a text.

What becomes apparent in reviewing this research in light of the views of writing proposed above is that the challenges for deaf writers may rest less in the content space than in the rhetorical space—or as Bereiter and Scardamalia [20] describe it, sorting out how to say what you mean in written language as you move ideas from the mind to the page. Put another way, it seems that although deaf writers often have something to say, they are not able to construct these meanings in the language of the text in order to say it. According to the SVW, a foundational requisite for being able to accomplish this is having implicit control of the oral language that is represented in the text. This is at the heart of text generation as writers represent their intra-mental talk in text. Evidence from deaf writers provides a fruitful vantage point from which to consider the robustness of this claim.

Among all groups of students coming to the task of writing, it could be argued that, at least historically, deaf learners have been at a great disadvantage. The challenges they have faced in developing age-appropriate levels of oral language (i.e., oral language in English to read and write in English), irrespective of modality, are well documented (see [37] for a discussion). In the absence of this requisite oral language ability, writing becomes a daunting task. As Webster explains, it is necessary to "rehearse before and after writing. Rehearsal of material in one's head and then on paper would be impossible without some inner language code" [60] (p. 194). In terms of the SVW it could be argued that this inner code needs to be in the language of the text. Since deaf writers have consistently evidenced poor oral language outcomes and relatively poor outcomes in writing, an argument could be made that this provides support for the SVW and the critical role played by oral language.

It would be worth noting that deaf students are not alone in this regard. Students with language-learning disabilities who exhibit oral language deficits also "struggle with planning, organizing, and revising their writing. Their texts are short and poorly structured. Their use of language is problematic in terms of syntax, vocabulary diversity, and cohesion, and they make frequent errors in spelling and writing mechanics" [31] (p. 559). It appears that the activity of writing requires the same set of requisite skills and abilities irrespective of the nature of the learner, lending credence to a notion that the development of literacy is qualitatively similar for deaf and hearing students.

3.2. Current Evidence

Where the technology is available, most profoundly deaf children now receive cochlear implants, bilaterally and at increasingly younger ages, even in the presence of additional needs. In addition to cochlear implants, there has been rapid growth in the development of other hearing technologies (e.g., the digitization and miniaturization of hearing aids, other forms of implantable devices such as bone anchored hearing aids). As Archbold [9] suggested, these advances have effectively made audiological categorizations (e.g., mild, moderate, severe, profound) rather arbitrary when taking into account the impact a hearing loss may have on a child's development, learning, and educational placement. It is now the case that many students with profound hearing losses function audiologically as well as, or even better than those who are "less deaf," with indications that the groups with moderate to severe losses are the ones who may face more significant challenges in developing language and literacy [68].

One of the most significant consequences of the improved auditory access afforded by these hearing technologies is the enhanced opportunity and possibility for the development of age-appropriate spoken language for the majority of deaf children. Reported outcomes in this regard do indicate significant gains in language development for many deaf children that outstrip those evidenced historically. In characterizing the results of their study in which almost half of a large cohort of deaf children with cochlear implants demonstrated spoken language standard scores within the average

range for hearing age-mates, Geers et al. remarked that "this result represents a remarkable achievement for children with this degree of hearing loss and is not unique to this particular sample" [69] (p. 383). It is important not to lose sight of the import of this and other similar findings as they represent a major shift in the field that has implications for the development of literacy [70]. It equally important to keep in mind that there continues to be considerable variability in these outcomes depending on child factors (e.g., presence of additional disabilities), technology factors (e.g., consistency of device use, age of implantation), and demographic factors (e.g., parental involvement, home language) [9]. Not all children achieve the same level of success with the technology.

Recent evidence on the writing achievement of deaf students reflects the impact of the advances made in hearing technologies. In a 2018 review of the literacy outcomes of deaf students with cochlear implants, Mayer and Trezek [71] identified only three studies that included a measure of written expression in addition to those reported for reading. There were no studies that investigated writing performance only. Spencer, Gantz, and Knutson [72] utilized a standardized measure (i.e., Written Samples subtest of the WJ-III) and reported a mean standard score of 125 (SD = 29) indicating that as a group they were performing better in writing as compared to reading. Using the National Curriculum Assessments of England Key Stage levels, Mayer et al [73] found that 44% of their student participants (n = 33) were writing at or above grade level. In her study of 10 children, Watson [74] reported that six demonstrated an average level of achievement based upon grade level exemplars from the English National Curriculum.

Two of the studies [72,73] included written language samples as well, and it is in looking at these examples that the differences from the outcomes reported historically are most apparent. The writing [73] (see below) did not exhibit the lexical, grammatical, and syntactical weaknesses of the writing reported in previous studies, even when the writing was assessed as below grade level.

> My name is Harvey and when I went to the bach and my ~~b~~ dad hung me upsid bane and I lost my in plandt so I did not hear. ~~Of anuker yare year~~ when ~~im~~ go swiming I ware ear bags so I can hir in the pool. I have somme colus. I neely war them evry day (9-year-old deaf student with cochlear implants, below average achievement)

> My cochlear implants give me a connection to the world and help me hear sounds, voices, the world in general. They also give me a conversation starter and give me more people to make friends with. For example, there are lots of people who I wouldn't have a friendship with, if it wasn't for my implants: one has a deaf brother, one is deaf and one has two deaf twin sisters. I wouldn't knew these people if it wasn't for my implants. They do, occassionly, bring up questions but I am more than happy to answer them. (13-year-old deaf student with cochlear implants, average achievement)

The positive shift seen in writing performance could reasonably be attributed to the stronger oral language foundation that these students have as a consequence of their access to audition via their cochlear implants. In terms of the SVW, this aligns with the notion that a writer needs to have control of the language represented in the text in order to generate meaning in print (i.e., ideation).

With respect to thinking further about the need for this language foundation, it can be informative to consider the writing performance of students in bilingual settings whose first language is American Sign Language (ASL). Singleton and her colleagues [75] compared the written productions of five groups—hearing monolinguals and hearing English as a Second Language learners, and deaf students with low, moderate and high proficiency in ASL. All students were asked to produce a written retell of the classic fable, *The Tortoise and the Hare*. The primary goal of the study was to consider vocabulary use and in this respect, the high ASL group outperformed the lower ASL groups, generating propositions that "included novel and meaningful (although mostly content word) vocabulary" (p. 99). However, there were pervasive problems with grammatical accuracy and the use of function words, and these are evident in the written examples that are provided in the Appendix (e.g., Turtle and Rabbit Race Race Try Who win turtle). Although the writing of the high ASL group was better than the other two

groups of deaf learners, it did not match the level of the hearing students and could not be regarded as age-appropriate.

In a recent study, Scott and Hoffmeister [76] examined the use of superordinate precision in definitions writing in a cohort of 41 middle and high school students enrolled in bilingual schools for the deaf. The group had an average of 4.11 grade level equivalency in reading comprehension. Findings with respect to writing definitions (i.e., for three common nouns—anger, winter, and bicycle) indicated that the deaf students are "performing lower than hearing monolingual students on the same measure" (p. 179), although there was some variability with students at one site outperforming those at the other two. Examples of the written definitions were included in the article, and these are very helpful in highlighting the issues that remain with respect to grammar and syntax, even when the meaning of the word has been captured to some extent in the definition (e.g., "Bicycle is two wheel, and can any age can ride two wheel for fun with two wheel for fun or if can buy car then bicycle, so can ride go to school or work.") (see Table 2, p. 177).

The findings from these studies seem to suggest that it is challenging to represent meaning in English print if the ideas are generated in ASL. This is consistent with what is proposed in the SVW—that control of a discourse level of oral language in English is necessary for text generation. In terms of the composing process [20], ASL can be supportive (as is shown in these studies) in developing ideas in the meaning space, but it cannot function, as the language of ideation (text generation) when content must be realized in the rhetorical space (i.e., to write what is meant in English).

3.3. Intervention Research

Early work in this area focused on teaching writing via structured programs that were essentially teaching the language in tandem with providing instruction in how to write it. "Through the process of direct imitation, memorization and drill, usually in the framework of a strictly sequenced curriculum, the deaf child was expected to acquire a grammatically correct version of the language of society" [77] (p. 78). The well documented poor performance of deaf students during this period raises questions as to the efficacy of these approaches, and it was argued that the lack of improvement in writing for deaf students could be attributed to this flawed instructional system [78].

The early 1980s saw the implementation of process-oriented approaches to teaching writing [79], a move that was consistent with the more general shift to a whole language philosophy in literacy instruction in which there is an emphasis on using language purposefully and communicatively with language accuracy taking a backseat to making meaning [80]. While this pedagogical shift effected some positive change in the quality of writing done by deaf students (e.g., less formulaic, greater focus on content), achievement was still not age and grade appropriate with the writing continuing to exhibit many of the same lexical, morphological, and syntactical issues of the past [81].

Overall there has been no change in pedagogical approach that has demonstrated a significant improvement in outcomes. In their review of writing instruction that offered evidence to inform practice, Strassman and Schirmer [82] identified 16 studies over the past 25 years. They categorized them with respect to the nature of the instruction: a process approach, instruction on the characteristics of quality writing, feedback, and writing for learning content. In summarizing their review, they noted that there was a relatively limited amount of research, but that the findings from the available studies indicated that "outcomes were equivocal, and the evidence for practice is at best promising" (p. 176). They did not identify any approach that clearly made a positive difference in outcome (i.e., working at or closer to age-appropriate levels).

In a recent study not included in the aforementioned review, Wolbers et al. [83] investigated the use of Strategic and Interactive Writing Instruction (SIWI) with a cohort of 31 deaf students in third to fifth grade. It should be noted that this intervention was also used in a number of previous studies included in the Strassman and Schirmer [82] review. The aim of the two investigations reported in the Wolbers study was to consider the effect of SIWI on writing recounts/personal narratives, information reports, and persuasive genres. In the first study, pre- and post-data were compared, and improvements were

noted across the group. However, although the NAEP [84] rubrics were used to score the samples, only those traits related to development and organization of ideas were taken into account, and the language and convention traits were not considered. This was done to allow for the examination of "discourse-level writing skills without the influence of language on scorer decision making" [83] (p. 396). The second study was a single case design taking an in-depth look at the writing of five students. It was reported that all five made identifiable gains and samples of their writing are included in the appendix of the article.

In summarizing their conclusions, the authors note that the writing would still be rated as "marginal skill" and not "adequate skill" at the conclusion of the study. This assessment is born out in an examination of the pre- and post-writing samples that are provided. The post intervention sample for persuasive writing reads, "If fire drill to be alarm. If go to outside be far. Pelople can't tonch (touch) the fire alarm. Then stand on the grass. Last back inside" [83] (p. 398). The authors suggest that further SIWI instruction should continue to improve discourse-level writing skills, but acknowledge that there is not yet evidence that it will have an impact on form.

The clearest message that can be drawn from this look at the available intervention research is that, while some approaches appear to have promise, there is no pedagogical approach that has effected a change in outcomes so that deaf students' achievement is approaching or meeting that of their hearing age peers. In terms of the theoretical frameworks presented earlier, the positive gains that been made are related primarily to the content or meaning space, but the problems with text generation in English (i.e., morophology, grammar, syntax) remain.

4. Future Directions

In thinking about future directions, a worthwhile start would be to consider what this overview of the research on writing and deaf students reveals with respect to moving forward in a pedagogical climate that increasingly values an evidence base for informing both policy and practice. While the body of research is not extensive, it does suggest directions for both future research and practice that could serve to optimize outcomes for deaf learners, as research informs practice and practice becomes the testing ground for research.

4.1. Implications for Research

At the risk of stating the obvious, there is a clearly a need for more research with respect to the written language development and achievement of deaf students across the age and grade range from the early years through post-secondary education. While it is fair to say that the research evidence in the area of reading and deafness is not as robust as needs to be, it is considerably superior to that available for writing. It is challenging to find literature reviews that focus solely on the area of writing. Furthermore, writing is often not included in more general reviews of literacy outcomes, and when it is, the relative lack of attention becomes apparent. For example, in the review of the literacy outcomes of deaf students with cochlear implants described earlier, there were only three studies that addressed writing in contrast to 21 that focused on reading [71]. In an integrative review of the research literature on writing development, instruction and assessment of young deaf children, Williams and Mayer [85] identified only 17 studies published between 1990 and 2012. Paying more research attention to writing is one of the most critical recommendations that can be made as a consequence of this overview.

An approach to accomplishing this goal would be to encourage reading researchers and funding agencies to make writing assessments a feature of the research they do, given the accumulated evidence that supports a bidirectional model of reading and writing development [4]. The data collected in one domain would inform the other, and it stands to reason that the research picture would be more robust as a result. In a field as small as deaf education, this seems particularly expedient given the overall dearth of literacy research in both reading and writing. While some researchers have looked at both reading and writing in a single study, they tend to be in the minority.

In addition to making an appeal for more studies and studies that include both reading and writing, it would be useful to consider what else needs to be taken into account while doing writing research.

- One of challenges of conducting writing research is being able to assess and evaluate the written product, and there are far fewer standardized measures available for assessing writing than reading. However, in the interest of making comparisons across groups and tracking students over time, it would be worthwhile to make more use of these standardized assessments. Using these measures also allows for comparing deaf students with their hearing peers to determine whether performance is age-appropriate. This is increasingly important in an environment where the expectation is that deaf children should be able to achieve at the same level as their hearing counterparts.
- Despite their utility, standardized measures can be limited in their scope. Collecting writing samples and including them in the reporting of the research is critical. Although these examples of writing often provide the clearest evidence of level of performance, they are often not included. Of the studies described in this overview, it would be worth noting those that included representative written samples, and the extent to which including them enhanced the reporting of the results. However, while these written products are not difficult to collect, they can be challenging to assess and this may explain why researchers can be reluctant to include them. The typical measure is some form of rubric—in many ways a limited measure as the descriptions for each category can seem broad and open to interpretation. That said, including examples in conjunction with a rubric seems good research reporting practice, especially in investigations of deaf writers whose written productions can be idiosyncratic with respect to morphology, grammar, and syntax. These features are not well captured when simply reporting a score for conventions from a rubric.
- Given the importance of the language foundation for the development of writing, researchers should implement study designs such as structural equation modeling to investigate the extent to which this is the case (i.e., the applicability of the SVW), and to what degree deficits in language can inform our understanding of the chronically poor performance of deaf writers.
- There is also a need to broaden the scope of the research to (1) include longitudinal research that tracks cohorts over time, especially if the goal is to demonstrate the efficacy of a pedagogical intervention; (2) consider achievement across a range of written genres; and (3) investigate the writing process as well as the product in order to better understand the composing strategies of deaf writers to determine which are proving to be more effective.

4.2. Implications for Practice

The single most fundamental message that can be taken from this overview of the research is that the teaching of writing is a very challenging activity when the deaf writer does not first have control of the language of the text (e.g., English for the purposes of writing English). Both the historical and current evidence bears witness to this fact. Students lack the necessary implicit control of the discourse level oral language skills to be able to generate text meaningfully, accurately, and fluently. The findings from students who are fluent in ASL serve to further bolster this claim. Although the research indicates that they have a language in which to think about ideas and content (i.e., ASL), they are constrained by the fact that they do not have the requisite language to say what they mean [28,86]. In contrast, students who have a stronger English foundation as a result of improved auditory access to spoken language are evidencing writing outcomes that are significantly better than those of the past, often at or approaching age-appropriate levels.

The teaching of writing cannot be conflated with the teaching of the language. Composition is not an exercise in translation, but rather one of dictation (i.e., writers compose text intra-mentally and are essentially dictating to themselves as they commit these thoughts to paper). Adequate oral language skills are necessary to do this, and must be ensured before implementation of any approaches to the teaching of writing per se (e.g., a process approach, feedback). If not, the potential to achieve

age-appropriate outcomes will not be realized. This could provide some explanation for the findings from the intervention research reported in this area (i.e., that no approach has realized age-appropriate outcomes). It may be that the approach has demonstrated efficacy, but that the writers lack the requisite language foundation to reap its advantages. With respect to these approaches and the teaching of writing itself, two additional points are worth noting.

- More attention needs to be paid to teaching writing. Even for hearing children, it tends to receive less attention than the teaching of reading [1]. One way to increase the time spent on writing is to think more explicitly about teaching reading in tandem with writing as the two are mutually supportive and doing so can enhance outcomes in both. Based on their meta-analysis of the impact of reading interventions on writing, Graham et al. proposed, "reading and reading instruction should be part of a well-balanced instructional writing program" [4] (p. 274). In their best-evidence synthesis, Weiser and Mathes [87] concluded that encoding instruction increased the literacy performance of at-risk primary students, and improved outcomes in both reading and spelling for older students with learning disabilities. Albertini, Marschark, and Kincheloe [88] make similar arguments in the context of their study of fluency, coherence, and comprehension in the reading and writing of deaf college students, with one of their conclusions being that reading comprehension can be facilitated by having students write. Given the constraints teachers face in making adequate time for literacy instruction in general, and writing in particular, it would be expedient to think more explicitly about teaching reading and writing in tandem to take advantage of the benefits that can be accrued in doing so.
- Despite the mutually supportive relationship between the teaching of reading and writing, there is still a need to focus on writing interventions explicitly (i.e., separate from reading), with the evidence showing that writing is improved by directly teaching it [4,89]. However, teachers often express concerns that they are underprepared to teach writing, and while most have had some experience with process models of teaching writing, there can be challenges in their implementation [90]. This could be addressed to some extent if there was a more concentrated focus on the teaching of writing in teacher education programs and in ongoing professional development, dedicating at least as much attention to it as to the teaching of reading.

5. Conclusions

With respect to writing and deaf learners, the state of the research is wanting, lacking in almost every respect. There is a scant evidence base upon which to advocate for any pedagogical practice or intervention, if the litmus test is that a positive change in outcomes has been achieved. It is also not clear that the evidence we do have is being interpreted in ways that meaningfully inform practice. The only group identified in this overview, that is performing at or close to age-appropriate levels, is the cohort who has enhanced access to spoken language (e.g., those with cochlear implants). Arguably this access affords these learners the opportunity to develop the discourse level oral language, that allows for more fluent ideation (i.e., text generation) as per the SVW, thus making it possible for them to more clearly say what they mean as they engage in the act of composing. It would seem useful to take this into account in thinking about the implications for the future, especially in a climate where meaningful access to spoken language is possible for so many. Having this control of the language in which they are writing would afford many more deaf individuals access to the power of the written word in a digital age when communication has become increasingly text dependent.

Moving forward, attention needs to be paid not only to the teaching of writing and those approaches and strategies that are supportive of better outcomes, but to the reasons why so many deaf students have struggled. On the basis of the available theoretical and empirical evidence, deficits in language seem to be at the root of these challenges. Until this issue is addressed, it is likely that achievement for deaf learners will continue to lag behind that of their hearing peers. No writing intervention or approach, however well designed, will solve this language problem. In future, it would be important to design studies that test this proposition in order to establish the extent to which

language impacts writing performance, and then consider how this can be addressed in the context of teaching deaf students to write.

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Notes on Terminology

deaf	We use the term *deaf* to refer to any individual identified with a hearing loss, from mild to profound, irrespective of the use of amplification. For instance, individuals with cochlear implants are regarded as deaf. We are also not making a distinction between *deaf* and *Deaf*, as we do not consider this difference germane to our view of the development of writing.
oral language	When the term 'oral language' is used, it is done so to reflect the terminology employed in the original source (e.g., National Early Literacy Panel, a published study, etc.). This term is often used synonymously with 'spoken language' in the broader literature in the field of literacy. It is only in the field of deafness in which the distinction between oral and spoken language merits attention.

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Review

Deaf Children as 'English Learners': The Psycholinguistic Turn in Deaf Education

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Abstract: The purpose of this literature review is to present the arguments in support of conceptualizing deaf children as 'English Learners', to explore the educational implications of such conceptualizations, and to suggest directions for future inquiry. Three ways of interpreting the label 'English Learner' in relationship to deaf children are explored: (1) as applied to deaf children whose native language is American Sign Language; (2) as applied to deaf children whose parents speak a language other than English; and (3) as applied to deaf children who have limited access to the spoken English used by their parents. Recent research from the fields of linguistics and neuroscience on the effects of language deprivation is presented and conceptualized within a framework that we refer to as the psycholinguistic turn in deaf education. The implications for developing the literacy skills of signing deaf children are explored, particularly around the theoretical construct of a 'bridge' between sign language proficiency and print-based literacy. Finally, promising directions for future inquiry are presented.

Keywords: deaf education; critical period for language; sign bilingualism; deaf multilingual learner (DML); english learner (EL); age of acquisition; literacy; cognition; ableism

1. Introduction

The purpose of this literature review is to present the arguments in support of conceptualizing deaf children as 'English Learners', to explore the educational implications of such conceptualizations, and to suggest directions for future inquiry. Following Holcomb [1], the term 'deaf' will be used to refer to those whose hearing level qualifies them for specialized services that are typically provided through deaf education; the term 'Deaf' is reserved for references to Deaf culture. Hereafter, the term 'English Learner' (or 'EL') will only be used in direct reference to the federal government's use of this term. We will use, instead, the terms bilingual or multilingual, as they acknowledge children's linguistic assets [2]. Acronyms to refer to groups of children will also be avoided in line with the observation from critical literacy work that acronyms are almost exclusively used in reference to marginalized groups.

The literature reviewed here was drawn from the following databases: ERIC, Wilson Education, ProQuest, PsychInfo, EBSCO, JSTOR, and SAGE. The search terms used were the following: bilingual; deaf education; literacy; English as a Second Language; English Learner; written ASL; age of acquisition; second language acquisition; dual language; critical period for language; deaf multilingual learner; bimodal bilingualism; heritage ASL; and sign bilingualism. Included in the review are empirical research studies, reviews of the literature, dissertations, conference presentations, program descriptions, and position papers. The majority of the literature reviewed was published in the last two decades, but earlier works have been included if they are seminal in their field or if they offer important historical context for the present inquiries.

2. Why Deaf Children Are Compared to 'English Learners'

Deaf children are a heterogeneous group. While some would argue that all deaf children should be conceptualized as bi/multilingual, many of the comparisons made between deaf children and 'English Learners' are based on only subsets of the deaf population. First, research suggests that deaf children whose parents use American Sign Language (ASL) are highly similar to hearing bi/multilingual learners in their language and literacy development. Additionally, a growing number of deaf children in the United States are bi/multilingual in the exact same sense that a growing number of hearing children are bi/multilingual: their parents speak a language (or languages) other than English. Finally, there is a third group of deaf children—those whose parents speak English—who traditionally have not been compared to bi/multilingual learners, but who many argue should be, often citing psycholinguistic research in support of that claim. The arguments surrounding each of these three categories are presented in the following sections. Importantly, we are not suggesting that these three categories are mutually exclusive, or even that they should be conceptualized as representing separate "groups" of deaf children. Instead, our focus is on differentiating the three arguments for purposes of clarity.

2.1. Deaf Children Whose Home Language Is American Sign Language

Approximately 15% of deaf children in the United States have a parent, or parents, who use American Sign Language (ASL) [3]. These parents have made the choice to use ASL in the home either because they are deaf ASL-users themselves, because they want their child to have access to ASL and/or Deaf culture, or because the child's amplification has been unsuccessful and ASL will allow them to communicate with their child [4]. A large body of research indicates that deaf children who are raised with ASL as their first language, and who are exposed to English (via print and/or auditorily) as a second or simultaneous second language, share much in common with hearing children who are raised bilingually.

First, research has shown that speech and sound are not necessary for normal language acquisition and that signed language and spoken language nurture brain development in qualitatively similar ways [5]. Recent functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) research into the ways in which the brain organizes itself in the absence of auditory linguistic input has shown that the auditory cortex—the area of the brain activated by voice recognition—becomes selective for faces when the brain lacks access to spoken language [6]. Children with early exposure to sign language achieve all the same milestones, and according to the same time table, as hearing children who are exposed to spoken language (see [7]). Also, when children are exposed to a signed and a spoken language (via print and/or auditorily), they exhibit similar language acquisition and literacy development patterns to those who are exposed to two spoken languages (see [7]). Furthermore, sign bilinguals engage in the same kinds of code-switching, or translanguaging [8], behaviors that are observed with hearing bilinguals [9,10]. Finally, bilingualism—particularly simultaneous bilingualism—has been associated with cognitive and linguistic benefits for bilingual children who use two spoken languages [11–13], as well for those who use one signed and one spoken language (see [7]). Specifically, sign bilinguals are better at moderating their attention than their monolingual peers [14] and show more syntactic complexity in both languages [15].

The research cited above strongly suggests that it is appropriate to conceptualize deaf children who learn ASL as native language as bilingual learners of English. However, Knoors and Marschark [4] caution that the conditions necessary for transfer from L1 to L2 are not uniformly present for deaf children who use ASL at home. Proficiency in L1 and quality input in L2 are both important for effective transfer to occur, and Knoors and Marchark argue that these conditions are "rarely met" in regard to deaf children [4] (p. 292). While the level of ASL proficiency of hearing parents who choose to sign with their deaf children is an important consideration and warrants further investigation, research has shown that deaf native signers are proficient models of the language and serve as skilled communication partners for their deaf children. Research on the behaviors of deaf mothers—to which we will return later—demonstrates that they call their deaf children's attention to English print in a

rich, communicative context, arguably providing deaf children with the kinds of quality input in L2 required for language transfer.

2.2. Deaf Children Whose Home Language Is Neither English Nor ASL

Deaf children whose native language is ASL have long been considered learners of English as a second language by many researchers and practitioners in the field. There is another subset of the deaf population, though, who are receiving more research attention as our country becomes increasingly diverse: the group of deaf children whose parents use a language other than ASL or English at home. The term deaf multilingual learners, or DMLs, has been adopted by the research community to refer to members of this population.

On the whole, the number of children whose parents speak a language other than English has grown at least 150% over the past three decades [16]. The Gallaudet Research Institute's (GRI) [3] most recent report indicates that nearly 25% of deaf children have a home language other than English or ASL (17.9% Spanish, 5.7% Other). This represents an increase of at least 20 percentage points since 2000, when the number of deaf children with a home language other than English or ASL was reported at 2.7% by the GRI [17]. It is important to note, however, that the GRI's Annual Survey of Deaf and Hard of Hearing Children and Youth, while the most comprehensive database of its kind, only represents about 65% of deaf children nationwide [4]. Therefore, it is probable that the percentage of deaf multilingual learners is even higher. Compton [18], for instance, estimates that 47% of deaf children use ASL and a signed or spoken language other than English at home. In either case, Paul [19] is certainly justified in arguing that "the disputatious ASL-English combo represents only a small portion of the EL (or DML) situation in this country" [19] (p. 4).

Multilingual deaf children are worthy of continued research attention because they represent a kind of linguistic diversity that has not been adequately addressed by our nation's schools. Research over the past two decades has consistently demonstrated, for example, that Latinx deaf children demonstrate lower academic achievement than their White or African American deaf peers [20]. As many multilingual deaf children may arrive at school with no prior exposure to ASL or English, Gerner de Garcia [21] argues that a trilingual approach, including the child's home language, might be most appropriate. The limited research that exists on this growing population is outlined below. It consists of investigations into effective early intervention with infants and families, case studies on language and literacy development, single subject or pre- and post-test group studies to assess the efficacy of specific instructional interventions, and between-group comparisons of multilingual deaf learners who either are, or are not, receiving dual language support.

Over twenty-five years ago, Grant [22] noted the particular difficulties faced by parent-infant service providers in working with deaf multilingual learners, a group she referred to as "a small minority of an already small minority" [22] (p. 135). Like many of her colleagues since, Grant argued for service provision in the family's home language, explaining that even though the vast majority of parents want English to be the ultimate outcome for their children, it is not possible to offer counseling to parents in a language they do not understand. More recently, Sacks et al. [23] have worked on developing effective ways to help Spanish-speaking parents foster the spoken language development of their deaf children. In a pilot study on the effectiveness of Project ASPIRE (Achieving Superior Parental Involvement for Rehabilitative Excellence), the researchers worked with eleven parents of deaf children from typically underserved populations, including five parents who spoke Spanish at home. Sacks et al. used Language Environment Analysis (LENA) technology to record sixteen hours of each home's auditory environment. Quantitative summaries of the audio data were shared with parents in parent education sessions during four linguistic feedback reviews. These educational sessions were conducted in Spanish when Spanish was the parent's native language. Results indicated an increase in both child vocalization and parent-child linguistic interactions post-intervention.

Case studies have provided another means of understanding the language and literacy development of deaf multilingual learners. Wang, Andrews, Liu, and Liu [24] used questionnaires,

interviews, and self-appraisal instruments to uncover the language and literacy histories of two adults who had learned Chinese in its spoken and written forms, English in its written form, Chinese Sign Language, and American Sign Language. Their analysis revealed a number of factors that contributed to the participants' multilingual, bimodal, and biliterate development: the home literacy environment; support from parents, siblings, and educators; the presence of role models; visual access to the languages; and Deaf identity. In a single subject case study, Baker and Scott [25] examined interviews, assessments, school records, and anecdotal records to elucidate the factors influencing the K-12 language and literacy development of one deaf Latina student. Like Wang et al., their research points to the critical importance of early and continued support of L1, but they also note the importance of ongoing assessment to determine appropriate placements and instructional strategies for deaf multilingual learners.

Similarly, Cannon, Guardino, and Gallimore [26] offer detailed vignettes of three multilingual learners—Victor, David, and Javier—each based on real students. The researchers discuss each child's language and literacy development, beginning with early intervention and access to communication and language, then proceeding to school-age social and academic issues and assessment, and concluding with the student's transition to postsecondary contexts. They explain that a main purpose for their research is to make "a resounding call to recognize and address the need for the field to learn as much as possible about DMLs through the use of consistent and clear terminology, expansion of available demographic information, research-based instructional strategies, and examination of all issues through a multicultural lens so that a more open and inclusive environment for learning and development can be provided" [26] (p. 15).

Drawing from Linguistically Responsive Teaching (LRT) [27] as a theoretical and research base, Pizzo [16] argues that teachers of deaf multilingual learners need "a broad range of knowledge and skills, including deep content knowledge, pedagogical content knowledge, knowledge of how children and adolescents learn in a variety of settings, skills for creating a classroom community that is supportive of learning for diverse students, knowledge about multiple forms of assessment, and the ability to reflect on practice" [16] (p. 161). However, as Cannon and Guardino [28] note, the Report of the National Literacy Panel on Language-Minority Children and Youth, which presents research to support improved practices for linguistically diverse classrooms, does not contain any studies that focus on deaf multilingual learners. As a result, some researchers have turned to the broad body of research on hearing bi/multilingual learners, with and without disabilities, for guidance. In their synthesis of relevant evidence-based research, Cannon et al. [26] identified four strategies that might prove promising with deaf multilingual learners: guided reading, visual phonics, pre-teaching via chaining and multimedia tools, and peer tutoring that uses metacognitive strategies.

Research into effective instructional approaches for working with this population who has been historically overlooked in both deaf education and English as a second language research is emerging. Given the heterogeneity of the population, single subject designs have been an effective means of conducting such research. Cannon et al. [29] investigated the value of pre-teaching vocabulary with four deaf multilingual learners between the ages of 10 and 12. All four participants had recently immigrated to the United States and exhibited only emergent literacy skills. The results indicated that vocabulary recognition was enhanced when vocabulary was pre-taught, and that participants needed three pre-teaching sessions to demonstrate comprehension of the new vocabulary. Guardino, Cannon, and Eberst [30] replicated this study with five participants. Again, their results indicated that three sessions of pre-teaching were sufficient for participants to understand 90% to 100% of the new vocabulary.

Finally, the research community has focused on the question of whether or not deaf multilingual learners should receive listening and spoken language therapies in both English and their home language. While some research suggests that supporting the development of two spoken languages may be detrimental to deaf children (see [31]), there is also compelling research evidence to support the practice of developing both spoken languages. Bunta and Douglas [32], for example, compared the

performance of 20 bilingual Spanish–English-speaking and twenty monolingual English-speaking deaf children, all who used either cochlear implants or hearing aids, on a set of expressive and receptive language measures and found that the language skills of the two groups were similar across all measures. Bunta and Douglas explain that these results are particularly impressive given that they were unable to match the bilingual and monolingual children on maternal education level; the mothers of the bilingual participants had lower education levels than the mothers of the monolingual participants, yet the language outcomes of the bilingual children were commensurate with those of their monolingual peers. Thus, the researchers argue, "it can be reasonably hypothesized that supporting both languages via individual treatment with parent involvement as well as encouraging the parents to use Spanish at home could have resulted in the relative success of the bilingual children who participated in our study" [32] (pp. 287–288). In a follow-up study, Bunta et al. [31] performed a retrospective analysis of just the 20 bilingual Spanish–English-speaking children from their 2013 study to investigate the effects of dual-language instructional support across measures of receptive and expressive language. They found that the bilingual deaf children who had received dual-language support did significantly better on the assessments of Total Language and Expressive Communication than those who had not received dual-language support. There was no significant difference in the Auditory Comprehension scores of the two groups. In light of these results, the researchers argue that "dual-language support may yield better overall and expressive English language outcomes than English-only support for this population" [31] (p. 1).

2.3. Deaf Children Whose Home Language Is Spoken English

A third group of deaf children, those whose parents communicate solely via spoken English, is also relevant to this conversation due to some deaf childrens' limited auditory access to English. Developments in cochlear implant (CI) technology have meant that more deaf children have more auditory access than ever before, and that many deaf children raised in spoken English homes are meeting language milestones on par with their hearing peers and succeeding in mainstream educational contexts. This has led to cochlear implantation becoming the standard of care for deaf children in developed countries. In many cases, parents are discouraged from signing with their deaf children based a limited set of studies that suggest that the acquisition of sign language may interfere with speech development (see [33,34]). Even where parents are not explicitly discouraged from signing, the success of cochlear implants—coupled with the difficulties associated with acquiring a new language—mean that the vast majority of hearing parents are not choosing to sign with their deaf children [3]. However, for reasons not fully understood, not all deaf children receive the same auditory benefit from amplification, and thus many deaf children raised in spoken English households do not acquire English as L1. In this way, such children are still 'English Learners' when they enter school. The important distinction between this group of deaf 'English Learners' (who cannot rightly be called bilingual) and hearing 'English Learners' is that deaf 'English Learners' have no L1.

It is well-documented that early access to language input and linguistic interaction is critically important for the language and literacy development of children with typical hearing [35–40] and children who are deaf [41–50]. In fact, the linguistic benefits of early language exposure are the primary argument behind the push for earlier and earlier cochlear implantation [34,51–55]. It is certainly true that many children, particularly those implanted early, are highly successful with their implants, and that children who are successful with their cochlear implants can achieve literacy outcomes that surpass those of their peers without implants (see [4]).

However, other studies point to significant within group variation, demonstrating that not all infants who receive implants gain adequate access to the auditory language present in their environments [4,33,56–59]. Deaf children raised in spoken English environments who do not have full access to English exhibit language delays not only in the acquisition of English, but also in ASL [16,60]. In 2019, Hall, Hall, and Caselli [33] report that deaf children are still "significantly underperforming

on standardized assessments of speech and spoken language, even after early identification, early amplification, and early enrollment in intervention and support services" (p. 3).

For these reasons, it has been argued that cochlear implants are "an unreliable standalone first-language intervention for deaf children" [61] (p. 1). In their call to revisit language policy for deaf children following the rise of cochlear implantation, Knoors and Marshark [4] argue that parents should still be encouraged to sign with their deaf children, especially as a support to the spoken language. "Not only will sign language provide early identified deaf children with access to the fundamentals of language prior to implantation," they explain, "but learning to perceive spoken language after implantation takes time and sign language can serve as an effective bridge, perhaps with as yet unexplored long-term benefits" [4] (p. 299).

But some go beyond merely recommending the use of sign, insisting that access to sign language is the deaf child's right [62–64]. Historically, such arguments have centered primarily on the deaf child as a member of a cultural minority with rights to access the "linguistic identity of the deaf community" (Article 24, Section 3 in [65]). More recently, however, advances in linguistic and neuroimaging research have led to a new set of arguments that highlight not only the benefits of cultural identity, but also the extreme risks associated with lack of early exposure to language. These newer arguments, reviewed in the following section, lead to the conclusion that all deaf children should be multilingual learners, either in the sense that the spoken/written language is their L2, or as simultaneous bilinguals with concurrent exposure to both signed and spoken language(s).

3. The Psycholinguistic Turn in Deaf Education

What we are referring to here as the psycholinguistic turn in deaf education represents a shift away from the notion of 'language delay' toward a focus on the potentially lifelong effects of language deprivation. It is not new to acknowledge that many deaf children arrive at school without the foundational language skills to be successful, nor is it new to suggest that this early lack of language often leads to continued academic underachievement. What is new is the suggestion that deaf children are not merely struggling with language delays, but that early language deprivation has affected their cognitive and linguistic development in ways that are potentially irreversible.

3.1. The Critical Period Hypothesis

Much of the work motivating the psycholinguistic turn in deaf education comes out of the field of linguistics, where deaf children are interesting, in part, because they allow linguists to study the critical period hypothesis [66]. Over twenty years ago, Chomsky compared the seemingly effortless way in which young children seem to absorb the language of their environments with the difficulties faced by most adult learners of language. "For most people," he explained, "after adolescence, it becomes very hard. The system is just not working for some reason, so you have to teach the language as something strange" (p. 128) (as cited in [67]). For decades, linguists have been interested in post-childhood L2 acquisition, but deaf children offer a unique opportunity for linguists to study post-childhood L1 acquisition because deafness blocks the infants' exposure to the language of their environment [67]. If deaf children of hearing parents are exposed to sign language, it tends to be well past infancy [68].

By studying the language development of deaf children raised in spoken language environments, linguists can gain insight into "the extent to which the neural processing system for language requires linguistic experience during early life to develop fully" [69] (p. 1). In short, we can gain insight into the potential cognitive and linguistic effects of language deprivation. Language deprivation is a very rare phenomenon among hearing children, typically only seen in cases of severe abuse or neglect [59], and it would clearly be unethical to intentionally deprive a child of language for research purposes. But, as Hall et al. [33] note, language deprivation is "so common among DHH children and adults that it often fails to provoke the alarm it deserves" (p. 2).

Early research into the cognitive and linguistic effects of language deprivation in deaf children used a between-groups design to examine age of acquisition (AoA) effects. Three decades ago, Mayberry

and Fischer [70] compared the narrative shadowing abilities—simultaneously receiving and producing a narrative—of college-age native deaf signers with those of children who did not have access to ASL until later in their childhoods. The native signers outperformed the late signers on this task. In a later study, the researchers [71] examined the sentence recall skills of signers who had used ASL for a minimum of twenty years. They found that recall accuracy declined as a linear function of AoA and was not related to years of experience using the language. In a follow-up study, Mayberry [72] compared the sentence recall skills of 27 native deaf signers, who had acquired ASL at ages ranging from early infancy to late childhood, with those of nine subjects who had lost their hearing in late childhood and learned ASL as an L2 at that time. The researchers again found that participants' sentence processing skills declined as AoA increased, and they also found that the children who had learned ASL as an L2 in late childhood outperformed those who had learned ASL as L1 at the same age.

Ten years later, Mayberry and Lock [73] turned their attention to the effects of post-childhood L1 acquisition on L2 learning later in life. Participants—deaf and hearing adults who had learned English as an L2—performed grammaticality judgements and sentence to picture matching in English. Both the hearing and deaf adults who had acquired L1 early in life performed the L2 tasks at near-native levels, while the deaf participants who had little or no accessible language early in life performed poorly across tasks. Based on their findings, Mayberry and Lock argue that "the onset of language acquisition in early human development dramatically alters the capacity to learn language throughout life, independent of the sensory-motor form of the early experience" [73] (p. 369). In 2006, Boudreault and Mayberry [74] also found that the accuracy of grammaticality judgments in ASL among native and non-native deaf signers declined as a function of AoA, a finding corroborated by earlier research.

Researchers have also used language sample methodology to investigate the potential effects of language deprivation on deaf children. The results of these studies suggest that post-childhood L1 learners of ASL achieve many of the same linguistic milestones associated with infant L1 acquisition—relatively rapid acquisition of nouns and verbs combined in two-word utterances [75]—but that development seems to slow after this stage, with no evidence that the language of post-childhood L1 learners develops to the level of complex sentence structure [76,77]. As Mayberry and Kluender [68] note, these findings are in line with those of Curtiss [78], who noticed that Genie—a hearing child virtually deprived of language until the age of thirteen—could acquire new vocabulary and achieve basic word order patterns, but never succeeded in producing complex morphology or syntax. They explain:

> Late L1 learners exhibit initial rapid learning of lexical items in different grammatical categories and subsequent word combinations that are reminiscent of the acquisition of young child language learners, but at a faster pace. At the same time, however, accumulating evidence suggests that two major characteristics of language acquisition begun for the first time at age 12 or older are, first, rapid initial language acquisition, and second, a subsequent protracted period of limited language development, despite rich linguistic environments and language instruction. The language development of adolescent late L1 learners does not progress to complex morphosyntactic structures, but remains limited to simple structures. [78] (p. 896)

In the last ten years, neuroimaging has been increasingly used as a tool to better understand the cognitive and linguistic effects of early language deprivation. When reviewing neuroimaging studies involving deaf participants with varying AoAs, it is important to bear in mind that children of deaf parents—who constitute the majority of native signers—are typically genetically deaf, while children of hearing parents are more often deaf due to a traumatic or medically-related cause (e.g., low birth weight, high fever, oxygen deprivation) that may impact cognitive processes. Even so, the results of recent neuroimaging research strongly suggest that neurolinguistic processing is adversely affected by delayed L1 acquisition.

In two different studies, Ferjan Ramirez et al. employed anatomically constrained magnetoencephalography (aMEG) to investigate the "neural underpinnings" of ASL in two deaf adolescents who did not receive sustained language input until they were around 14 years old. In the

first study [79], they observed the brain activity of the two participants after two to three years of language, during which they were exposed to new sign vocabulary. The researchers found activation in different areas of the brain (i.e., the right superior parietal, anterior occipital, and dorsolateral prefrontal areas) than are typically activated in native ASL signers and hearing young adults learning ASL as a second language, namely a left frontotemporal pattern. In the second study [69], the researchers examined the adolescents' neural activity after fifteen more months of language experience, and the participants' neural responses remained atypical for less familiar signed words; only for highly familiar signed words did responses become more concentrated in the left perisylvian language network. Mayberry et al. saw further evidence of similar neural patterns in two different aMEG studies, one with a deaf adult who had been using sign language for thirty years, but who was not exposed to language until young adulthood [80] and one with two deaf adolescents who were not exposed to language until their early teens [68]. Considered together with the results of an earlier fMRI study of 22 signers with varying AoAs [81], these studies suggest that cognitive processing of linguistic information is negatively affected by post-childhood L1 acquisition, even though the left hemisphere does retain some capacity to process highly familiar words.

3.2. The Bilingual Paradox

According to Petitto et al. [82], the 'bilingual paradox' is "the perception that very early bilingual language exposure is both good and bad for a child" (p. 489). It is important to address the bilingual paradox here because the research on language development presented above indicates that deaf children would benefit from early access to sign language as L1, yet some argue that learning sign language interferes with spoken language development.

One study that is frequently cited to support arguments against signing with deaf children is that conducted by Geers et al. [83], in which the researchers consulted a national database of cochlear implant users and analyzed their academic progress in elementary school in light of their duration of early sign language exposure. They found that the children with the least sign language exposure outperformed the other groups in speech recognition, spoken language, reading, and speech intelligibility. The researchers concluded that their study offered "the most compelling support yet available in CI literature for the benefits of spoken language input for promoting verbal development in children implanted by 3 years of age" (p. 1). However, as Hall et al. [33] explain, the study presents no evidence that there is a causal relationship between the use of signing and lower achievement, and it is quite possible that Geers et al.'s results "reflect a self-selection effect, where children who fare best in spoken language gravitate to oral-only environments while children who struggle in spoken language remain in or seek out sign language and manual communication environments" [33] (p. 6).

According to Knoors and Marschark [4], "there is no published evidence that sign language interferes with spoken language," either for deaf children who receive implants or for those do not (cf. [34] (p. 294)). Indeed, some compelling recent research indicates that the development of sign language as an L1 can support the development of a spoken language L2 [84,85]. In fact, Hall [61] suggests that the "brain changes associated with language deprivation may be misrepresented as sign language interfering with spoken language outcomes of cochlear implants" (p. 1) and thus warns that professionals not spread misinformation by advocating for preventing sign language exposure before implementation. Given the vast research support for avoiding language deprivation, and the very limited research support for withholding sign language, Bley-Vroman's [67] summary of our current understanding of L1 and L2 development seems apt:

> From a 21st century vantage point, it is difficult to recall that, at least through the 1950s, knowledge of a first language was believed to be an obstacle to the acquisition of a second language, rather than a help. Habitual first-language language patterns interfered, rather than helped, in the formation of new habits. The picture, rather, is that post-childhood language acquisition cannot proceed as in childhood, but that an existing L1 can provide a kind of scaffold on which to build L2 knowledge. In Chomsky's metaphor, adults approach

> a foreign language as "something strange." Building on this metaphor, we might say that learning one language makes learning the second less strange. [67] (p. 914)

3.3. Cognitive Effects of Language Deprivation

Given the intimate relationship between thought and language, it is not surprising that lack of early access to language has also been associated with cognitive deficits in memory, executive function, and theory of mind. Importantly, the studies reviewed here involved deaf participants with no cognitive disabilities.

Early language deprivation has been associated not only with deficits in verbal memory [86], but also with deficits in non-verbal working memory (NVWM). Marshall et al. [87] designed a study to ascertain the effects of language deprivation on memory in which they controlled both for deafness itself and for language knowledge. By comparing hearing children with two groups of signing deaf children—native signers and non-native signers (those who experienced late acquisition)—on two NVWM tasks, they showed that there was no meaningful difference between the performance of the native signers and the hearing participants in NVWM function, but that the non-native signers performed less well than both of the other groups. According to the researchers, their results suggest that "whatever the language modality—spoken or signed—rich language experience from birth, and the good language skills that result from this early age of acquisition, play a critical role in the development of NVWM and in performance on NVWM tasks" (p. 1).

Deaf children are often described by practitioners and researchers as having difficulty with executive functions (EF) [88], and research has demonstrated that deaf children with and without cochlear implants struggle in this cognitive domain [89]. It is often assumed that deaf children's EF difficulties are associated with their auditory deprivation, but recent research strongly suggests that deaf children's EF difficulties are more likely a result of their lack of early language development. Research has consistently shown that bilinguals have more cognitive flexibility and control than monolinguals [11], and studies have suggested that EF skills and language are strongly correlated [90]. Until recently, however, cognitive science researchers have not been able to fully disentangle language skill and EF skill because most people with reduced linguistic skills also have associated cognitive deficits. Once again, deaf people offer researchers a unique opportunity because their reduced linguistic skills have a sensory, not a cognitive, basis. Based on this unique characteristic, Botting et al. [90] designed a study in which deaf (n = 108) and hearing (n = 125) 8 year-olds were assessed on both their language skills and a set of nonverbal EF tasks. Results showed that the deaf children performed significantly less well on EF tasks, even when controlling for nonverbal intelligence and processing speed. The researchers concluded that language "is key to EF performance" (p. 1689). Hall, Eigsti, Bortfeld, and Lillo-Martin [88] were also interested in disaggregating the effects of language deprivation from auditory deprivation on deaf children's EF skills. They used the BRIEF EF parent report questionnaire to assess behavioral problems in deaf native signers (n = 42) and a hearing sample (n = 45). The EF scores of the deaf native signers were not only age-appropriate, but similar to the scores of their hearing peers. The researchers argue that their findings "are most consistent with the language deprivation hypothesis" [88] (p. 1).

Theory of mind (ToM) is another area of weakness for deaf children [91,92]. Defined as the ability to "impute mental states to [oneself] and others" [93] (p. 515), it is often considered the basis of social cognition. As with the linguistic and social-emotional delays described above, however, research in the last two decades indicates that it is lack of access to language—rather than lack of access to audition—that causes delays in ToM development.

Courtin and colleagues have conducted several studies demonstrating a strong relationship between AoA and ToM development in deaf children. Comparing 155 deaf children between the ages of five and eight—grouped according to the hearing status of their parents—with 39 hearing children between four and six, Courtin [94] found that deaf children with deaf parents, but not deaf children with hearing parents, had ToM abilities comparable to those of hearing children. In a later

study of second generation deaf children, deaf children with hearing parents, and hearing children, Courtin and Melot [95] found that early exposure to language, either signed or oral, led to better performance on two ToM tasks. The native signers in this study performed equally to the hearing children in an appearance-reality task and surpassed them on a false belief task. Similarly, Schick, De Villiers, and Hoffmeister [96] conducted a study of 176 deaf children between three and eight years old and found that deaf children with deaf parents performed identically to hearing children on the ToM tasks, outperforming deaf children with hearing parents on a battery of tasks tapping false belief, knowledge states, and language skills. Furthermore, both vocabulary knowledge and the ability to comprehend syntactic structures were predictive of success on verbal and low-verbal ToM tasks. The strong connection between language skills and ToM development is corroborated by Courtin's [97] research on homesigners, which demonstrated that the use of homesigns is not sufficient to develop ToM. Further research suggests that it is not only the home language environment, but the language environment of school, that can influence ToM development. Tomasuolo, Valeri, Di Renzo, Pasquletti, and Voltera [98] compared six to 14 year-olds in a bilingual program (Italian Sign Language and Italian) and an oral program with one signing teaching assistant, and they found that the children who attended the bilingual school performed significantly better in tasks assessing lexical comprehension and ToM.

Taken together, the research on deaf children's ToM clearly indicates that language development is critically important for ToM development, but that ToM can be developed later in life even if children do not have early access to language. Some research suggests a critical period for ToM development at around ten years [97,99], but on the whole, it appears that the length of language exposure is more relevant to ToM development than AoA [91,98,100].

3.4. Social-Emotional Effects of Language Deprivation

While the linguistic and cognitive effects of lack of early language exposure have been thoroughly considered, the psycholinguistic turn also shines a light on the social-emotional effects. Not surprisingly, two predictors of sound mental health for deaf adolescents are early signed communication in the home and the ability of deaf teenagers to communicate effectively with their parents [4]. Furthermore, Allen, Letteri, Choi, and Dang [101] found a statistically significant relationship between early language development and the socialization of young deaf children, "including less impulsivity and greater social adaptation" (p. 352). There is also research to suggest that a strong Deaf identity, which often has its foundation in the use of a signed language within a Deaf community, leads to improved social relations, self-evaluation, academic achievement, and perceived family acceptance, as well as to higher levels of self-esteem, psychological well-being, and overall life-satisfaction [102].

Humphries et al. [59] explicate the dangers of not meeting the language needs of deaf children in terms of their psycho-social health, citing increases in depression, behavioral problems, juvenile delinquency, abuse, and lack of access to critical social, mental health, and educational services. Hall, Levin, and Anderson [103] go so far as to posit the existence of what they refer to as 'language deprivation syndrome,' which they argue may be present in deaf patients with severe language deprivation. Based on their review of thirty-five publications pertaining to the mental health of the deaf population, they argue that possible features of this syndrome may include "language dysfluency, fund of knowledge deficits, and disruptions in thinking, mood, and/or behavior" [103] (p. 761). The researchers admit that the empirical evidence in support of 'language deprivation syndrome' is very limited. Regardless, clear research evidence exists to suggest that early and effective communication with one's caregivers is a critically important component of a deaf person's mental health.

3.5. Ought Every Deaf Child Learn to Sign?

The mounting evidence regarding the linguistic, cognitive, and social-emotional effects of early language deprivation—coupled with what we now know about the benefits of bilingualism—has led many in the field to argue that all deaf children should have access to sign language as early in their

lives as possible. This suggestion may seem nonsensical to those who have witnessed the listening and spoken language development of deaf children who have been successful with their implants; why, they might ask, would we compel hearing parents to learn sign language when their children can be successful without it? There are important cultural and philosophical answers to that question (see [104–107]), but the answer offered by the psycholinguistic turn is that the risks associated with failure are simply too great. Success with cochlear implants is far from universal and, at present, there are no reliable means of predicting success. Of even greater concern, the diagnostic procedures available for assessing success cannot identify failure until children have potentially moved beyond the critical period for L1 development [4].

The LEAD-K campaign grew out of these concerns and is self-described as "a direct response to the alarming number of Deaf and hard of hearing children arriving at school without language" [108]. Researchers, educators, and pediatricians are also making social justice arguments about the need for parents to be informed about the risks associated with language deprivation. As Lillo-Martin [109] explains, "there are serious long-term effects of delayed access to linguistic input. There are crucial implications for the decisions to be made by hearing families who find out their child is deaf. Putting off input in sign language for later because "it can wait" won't do. Language deprivation has lifelong effects" (p. 925). A growing number of pediatricians are echoing these concerns [110,111].

One research team of specialists in education, linguistics, pediatric medicine, and psychology has joined forces in the past few years in a concerted effort to make sure that parents of deaf children are informed about critical issues that affect language and learning, including current understandings of how the brain's plasticity changes with age and what we know about the connection between language and cognition. The group has published in journals of medicine [112–116], linguistics [59], social services [117], speech language pathology [118], law [59], and ethics [119] and they work together on lobbying and legislative efforts, at all times arguing for the following set of recommendations:

> (1) Medical education must be updated and include linguistic considerations. Medical professionals should be trained in recent research about language acquisition, particularly with respect to the issues of linguistic deprivation for those children at risk, primarily deaf children. Medical schools, nursing schools, and schools of public health should include this information in their curriculum.
>
> (2) Delivery of medical care to deaf children should be coordinated across the relevant health professionals, including audiologists, psychologists, surgeons, and rehabilitation teams. These teams should stay in constant contact with and respond to input from parents, sign language teachers, and classroom teachers. This way, the risk of linguistic deprivation can be caught early and responded to appropriately.
>
> (3) Advice from medical professionals must be accurate and adequate. Parents of deaf newborns and newly deafened small children should be advised to teach their child sign language, regardless of whether the child also uses hearing aids or a CI. This means the entire family should learn sign language; and since the biological health of the language mechanism is at stake, this is properly a medical matter, so it is the medical profession's responsibility to tell the parents this. [59] (pp. 36–37)

4. Literacy Acquisition in a Bimodal Bi/Multilingual Context

To the extent that deaf children are 'English Learners', approaches to their literacy development should be informed by research on the English literacy development of other bi/multilingual learners [120]. Furthermore, when the deaf child's L1 is a signed language—as is often the case—research on the relationship between language modality and literacy will be informative. It is thus important to consider not only the ways in which signed languages can serve as foundations for literacy, but also the ways in which educators can draw on children's home languages—whether they be spoken and/or signed—in order to support their continued literacy development.

4.1. Sign Language as a Foundation for Literacy

There is no debate around the argument that spoken language serves as a foundation for literacy development. There are obvious connections between the ability to understand and speak a language and the ability to read and write with it. Less obvious are the connections between L1 knowledge and L2 literacy, particularly when the L1 and L2 make use of different communicative modalities. Nonetheless, the research suggests that there are important cognitive connections between these two forms of language knowledge. The focus in this section will be the current state of knowledge regarding the relationship between sign language knowledge—including the age of acquisition (AoA) of sign language—and deaf children's reading abilities.

It has long been recognized that deaf children's receptive and expressive ASL abilities are predictive of reading achievement [4,7,60,101,121–131]. Additionally, recent neuroimaging research has produced evidence that bilingualism, regardless of language modality, yields language-specific plasticity in the brain's left hemisphere that supports later literacy development [132–134]. Taken together, these research findings have led Humphries et al. [59] to argue that "the cognitive factor that correlates best to literacy among deaf children is a foundation in a first language" (p. 39). However, Knoors and Marchark [4] caution that, although knowledge of sign language appears to help deaf children develop their reading vocabularies in the early years of schooling, "after a period of growth, … stagnation occurs, and the reading skills tend to lag or asymptote among deaf children both with and without cochlear implants" (p. 297). If we are going to maximize the literacy outcomes for bi/multilingual deaf children, it will be important to understand both the mechanisms through which sign language supports literacy development and the reasons why so many signing deaf children do not become proficient readers and writers.

4.2. The Value of Shared Attention

Research suggests that it is not only the presence of ASL in the home that influences later literacy achievement, but the particular culturally-bound ways in which deaf parents interact with their children, particularly around books [101]. Research on the behaviors of deaf mothers, in particular, demonstrates that they are skilled at eliciting and sustaining their children's visual attention, especially during literacy activities [135]. Such behaviors call deaf children's attention to English print in a rich, communicative context, arguably providing deaf children with the kinds of quality input in L2 required for language transfer. Specifically, "the child's ability to alternate gaze between pictures and language input during joint storybook reading sets the basis for the acquisition of literacy skills" [125] (p. 11).

In a six-year case study, Bailes et al. [136] followed Ann, a deaf child with deaf parents, through three years of her early home life and three years of her life in preschool. Ann was of particular interest to the researchers because, upon entering preschool, her linguistic, cognitive, and literacy development were all on par with her hearing peers. As the researchers note, Ann was atypical by nature of the very fact that she showed typical development. It is also important to note that Ann had the advantage of growing up in a white, middle class family, with two college-educated, professional, ASL-English bilingual parents. Nonetheless, it is the characteristics of Ann's home language and literacy environment that are of particular interest here. The researchers found that Ann's parents "immersed her in meaning making" and "mediated her language acquisition and literacy learning through a shared visual language" [136] (p. 422). The researchers observed the ways in which Ann's parents used their own talk, in the form of ASL, to scaffold Ann's developing understanding of the things, people, and activities in her world. Furthermore, they guided her in making metalinguistic connections between her native language, ASL, and her emerging knowledge of written English. Essentially, Ann was raised with full access to language and communication, and her parents helped her to engage with printed English in much the same way that hearing parents engage their children with print: by helping them see connections between the print and what they already know about the world. "Because Ann and her parents could and did converse in a shared signed language," Bailes et al. conclude, "Ann developed in predictable ways for a child her age" [136] (p. 448).

4.3. The Critical Role of Linguistic Segmentation

It is widely acknowledged that phonological skills are highly correlated with reading ability (see [137]), and there is a substantial body of research that indicates a strong correlation between deaf children's phonological skills in English and their English reading skills [60,138–140]. However, recent research suggests that deaf children's phonological knowledge may not be as significant a predictor of reading ability as was once assumed. For example, in their meta-analysis of the factors influencing reading skills in deaf children, Mayberry, del Giudice, and Liberman [141] found only a modest relationship between spoken language phonological awareness and reading ability. Similarly, a recent study by Clark et al. [142] separated out the effects of early language access, phonological skills, and written orthography on reading development to determine the extent to which the deaf child's ability to understand letter-sound relationships was critical to reading success. The study included 857 participants—hearing with dyslexia, hearing without dyslexia, deaf early signers, and deaf late signers—from four countries whose written languages have both shallow and deep orthographies (American English, Hebrew, German, and Turkish). The researchers found that the deaf participants, unlike the hearing dyslexic participants, did not demonstrate a phonological processing deficit. Instead, they argued that the "early language access theory" best explained their results" [142] (p. 128). Indeed, as Petitto et al. [143] explain, "if regularity of sound-to-letter mapping is required [for reading], then we should find 'deep' orthographies to be comparatively unreadable as compared to 'shallow' orthographies. This is not the case" (p. 9).

A growing body of research suggests that, in fact, "phonological awareness is not to be equated with decoding" [60] (p. 108). For example, Morford, Wilkinson, Villwock, Piñar, and Kroll [144] have demonstrated that deaf bilinguals are actually activating ASL phonological representations during their processing of written English words. Similar processing strategies have been observed by deaf bilinguals in Germany and the Netherlands [145]. The activation of signed L1 phonology during reading predicts, accurately, that deaf children who do well on phonological assessments in their signed L1 perform comparable to hearing children on reading assessments [60]. Conversely, deaf children who lack L1 skills should perform poorly on assessments of reading when compared to deaf native signers, which they do (see [60]).

Petitto et al. [7,143] offer a compelling theoretical explanation for the cognitive mechanisms underlying reading. Their hypothesis explains the data not only from the language and literacy studies referenced above, but from qualitative studies aimed at gaining an emic perspective on strategies used by deaf readers (see [146]) and from their own neuroimaging studies. It is a "myth," they argue, that "speech and sound are absolutely necessary to become a healthy and successful reader" [7] (p. 4). Instead, Petitto et al. posit the existence of visual sign phonology (VSP):

> The crucial link for early reading success is not between segmental sounds and print. Instead the human brain's capacity to segment, categorize, and discern linguistic patterning makes possible the capacity to segment all languages. This biological process includes the segmentation of languages on the hands in signed languages. Exposure to natural sign language in early life equally affords the child's discovery of silent segmental units in visual sign phonology (VSP) that can also facilitate segmental decoding of print. [143] (p. 1)

In short, Petitto et al.'s [143] argument is that early access to sign language provides deaf children with the cognitive and linguistic tools necessary to segment written language into meaningful units for linguistic processing. Importantly, they argue that early access to spoken language provides hearing children with precisely the same sort of linguistic tools. Petitto et al. note that hearing readers, just like deaf readers, "use multiple pathways to successful reading" [7] (p. 9); in their view, the modality of those pathways is irrelevant. The researchers have hypothesized that the primary brain system for processing phonology, whether auditory or visual, is located in the superior temporal gyrus (STG), and their neuroimaging research has shown activation of this region when both hearing and deaf readers engage in phonological processing [143].

Further evidence that the STG is not modality-specific is offered by Kovelman and colleague's [147] recent analysis of the brain patterns of Chinese readers. Written Chinese differs from written English in that knowledge of morphological compounds is more salient to reading Chinese than knowledge of phonological compounds. Importantly, in Kovelman et al.'s study, the brain regions associated with auditory processing were not activated while Chinese speakers were reading, but the STG was. Kovelman et al. suggest, then, that what we've been referring to as "phonological processing" may actually be a more general brain function that has both phonological and morphological components, depending on the salient characteristics of a given language.

The observation that the brain segments written languages according to the salient features of those languages—and so not necessarily by their auditory features—has important implications for the nature of the elusive 'bridge' between sign language and written language. To wit, Petitto et al. [143] acknowledge a common argument against their hypothesis, which they refer to as "the mapping problem" (p. 8). This is the argument that the lack of 1:1 correspondence between individual signs (e.g., /CAT/) and English letters (e.g., 'c'), renders VSP useless for deaf readers. Petitto et al. respond that the mapping problem argument "represents a failure to recognize that sound-to-letter (sound to print) mapping is not obligatory for reading acquisition—neither in English, nor is it universal to reading in other world languages" (pp. 8–9). "Our model," they explain, "corroborates the classic observation that the orthographic-semantic link may be a quicker pathway in activating a semantic representation as compared to the ortho-phono-semantic pathway" (p. 10). The findings of neuroimaging research, thus, support Humphries' [125] argument that "the persistent belief that reading a spoken language like English requires phonological coding has distracted deaf education from considering other pathways that might be logical for deaf children in learning to read" (p. 11).

4.4. Qualitative Similarity or Qualitative Dissimilarity?

We would like to briefly consider the implications of accepting both the critical period hypothesis [66] and the VSP [143] for the Qualitative Similarity Hypothesis (QSH) [148], or the hypothesis that the process of learning to read is qualitatively similar for deaf and hearing children. The critical period hypothesis, coupled with the VSP, would predict that learning to read would be qualitatively different for deaf children who did not receive adequate access to language during the critical period because those children would not have developed either the spoken language phonology or the visual sign phonology (VSP) necessary to map the salient segmented features of print to meaning. For deaf native signers—or deaf children who had received adequate access to spoken language through amplification—learning to read should be qualitatively similar for deaf and hearing children, though, so long as the QSH is taken to be modality-independent (see also [101]).

However, it seems there is another important difference between hearing children and at least some deaf children in regard to learning to read, and it brings us back to the argument that a great many deaf children are rightly conceptualized as 'English Learners.' Whether they be native signers, children from homes where a language other than English is spoken or signed, or children with hearing parents whose spoken language is not fully accessible, many deaf children who approach the task of learning to read are—at the very same time—approaching the task of learning a new language. As Koulidobrova [60] notes, for many deaf children, "the process of learning to read and write is more a task of learning a new language that is based on orthography, rather than a task of mapping print onto spoken language" (p. 112). Hearing people, as well, sometimes experience learning a new language based on orthography, when they learn to read ancient Greek or Aramaic, for example. But none would argue that learning a new language based on orthography is qualitatively the same experience as learning to read the language one speaks.

In short, our answer to the question of whether the QSH holds true is that it depends, in part, on the child's pre-literate language experience. For any deaf child, though, who is learning to read a language they do not already know, the process will be qualitatively different from that experienced by

a child who already knows the language. We have long known that deaf readers are a diverse group, and their varied language experiences contribute in critically important ways to that diversity.

4.5. Bimodal Bi/Multilingual Reading Instruction

To the extent that deaf children are 'English Learners', their reading instruction should be appropriate to their bi/multilingual backgrounds. For children who come to school with no language, this will mean ensuring that they have access to an L1, most likely a signed language, so that literacy instruction can begin in earnest. For deaf children who come to school with an established L1 that is not spoken English, instructional approaches should take into account the linguistic resources children bring to the table as they work to develop L2 literacy. This section will review the existing research on effective bimodal bi/multilingual practices for the teaching of reading, which—though limited—provides rich insights into quality literacy instruction for deaf children who are learning with more than one language.

On the whole, practices that value and support the acquisition of both (or all) languages are beneficial for bi/multilingual deaf readers [149]. Bagga-Gupta [150] notes that the teachers' ability to embrace the 'linguistic complexities' in a bimodal bilingual classroom is one of the hallmarks of effective instruction in that context. In her observations of bilingual teachers in Sweden, Bagga-Gupta explained that four different modalities were the focus of ongoing comparison, contrast, and analysis: visual Swedish Sign Language, oral Swedish, written Swedish, and fingerspelling. Similarly, Evans [151], in her study of the literacy strategies used by teachers and parents with three elementary school deaf children in a bilingual/bicultural environment, found that the teachers used ASL as the language of instruction, because it was the most accessible language, and "made constant translation and switching between the two languages an ongoing part of the school day" (p. 21). Howerton-Fox [152] also noted this practice of constant translation in her observations of two experienced bilingual teachers at a school for the deaf in Sweden. The term 'code-switching', which typically refers to the switching back and forth between two or more languages that is often exhibited by people who know more than one language, has also been used to refer to this teaching strategy. Andrews and Rusher [153] define this second use of codeswitching as "a purpose-driven instructional technique in which the teacher strategically changes from ASL to English print for purposes of vocabulary and reading comprehension" (p. 407).

Research suggests that fingerspelling, as a visual representation of written English, is also an important language mode to be included in instructional codeswitching [154]. By representing written English at the orthographic level, fingerspelling may allow deaf readers to bypass phonology in their acquisition of print literacy. Studies on the reading practices of deaf readers indicate that they may make use of fingerspelling in the decoding process to help them access English at the phoneme level. In a series of immediate recall experiments, Sehyr, Petrich, and Emmorey [155] found a strong link between fingerspelling and English phonology for deaf adults who were skilled readers. Furthermore, in a hierarchical multiple regression analysis of the relationships among age of ASL exposure, ASL fluency, fingerspelling skill, and reading fluency, Stone et al. [156] found that fingerspelling skill significantly predicted reading fluency. Based on their results, the authors argue that "the development of English reading proficiency may be facilitated through strengthening of the relationship among fingerspelling, sign language, and orthographic decoding en route to reading mastery" (p. 1).

Chaining is a bimodal bilingual literacy strategy often observed in bimodal bilingual contexts that makes extensive use of fingerspelling. Chaining is described by Humphries and MacDougal [157] as a technique "for emphasizing, highlighting, objectifying and generally calling attention to equivalencies between languages" (p. 90). In practice, chaining can take multiple forms. A teacher may fingerspell a word and then immediately point to that word in print. Alternatively, a teacher may point to a printed word, fingerspell the word, offer the sign equivalent, and then point back to the printed word. The chain must have at least two parts, but it can have four or more. Sometimes, chains can take the form of a similar technique, called a 'sandwich' [158], in which a word is signed, fingerspelled, and then

signed again, or vice versa. Bagga-Gupta [150] also observed what they refer to as 'local-chaining' in their ethnographic analysis of the bilingual instructional interactions in Sweden, and Padden and Ramsey [127] observed teachers explicitly linking written words, fingerspelling, and signs together in their descriptive study of teaching practices in residential and public educational settings for bilingual deaf students. By engaging in continuous cross-lingual, cross-modal comparisons, teachers can continually "cultivate associations between signs and words" to help students develop their vocabulary across languages [129] (p. 194).

Constant comparison among languages is not limited to vocabulary support, however. In what they call 'cultivated transfer,' Hermans et al. [129] describe an intentional process on the part of teachers and speech language pathologists to make use of deaf children's knowledge of the grammar of sign language to support their acquisition of spoken language, in written (and perhaps oral) form. Citing Cummins [159], they explain that automatic transfer will be limited to cognitive skills and conceptual knowledge. Therefore, if teachers want deaf children to learn the grammar of written language, they must explicitly teach that grammar in comparison to the grammar the children already know. As they note, the more proficient the children are in their signed language, the "more efficient" such techniques will be (p. 195). Research has clearly demonstrated that hearing bilingual children benefit from explicit grammar instruction [160,161], and recent research suggests that deaf bilingual children do, too. Specifically, Silvestri and Wang [146,162], in their grounded theory study of the factors that influence high reading achievement for profoundly deaf readers who do not use hearing technology, identified "explicit instruction in language patterns" as one of the most effective literacy strategies for deaf bilingual learners. The researchers note that the effectiveness of this approach was based largely on the extent to which the explicit instruction was both accessible and meaningful.

Shared Book Reading (SBR) is another instructional approach with demonstrated success in the bimodal bilingual context. In the SBR approach, the teacher and students interact in sign language during a shared reading of a printed text. Schleper [163] details fifteen components of SBR, drawn from observations of deaf parents reading with their deaf children. Among the fifteen are many of the elements of effective bimodal bilingual literacy instruction outlined above: the regular use of fingerspelling, repeated readings with a growing focus on the print, following the child's lead, making the implicit explicit, connecting the story to the child's experience, and maintaining attention. Wolsey, Clark, and Andrews [164] wanted to evaluate the applicability of this approach—which had previously focused on reading at home—to the classroom setting. They designed a quasi-experimental pre- and post-test study to analyze the effectiveness of a 10-week American Sign Language (ASL) and English bilingual SBR intervention. Using a combination of standardized and research-made instruments, the researchers found that participants showed improvements in receptive ASL skills, book reading, and the ability to draw and describe drawings in both languages. The researchers argue that growth in visual phonology was also evident in the students' drawings, as the number of alphabet letters and ASL handshapes included in their drawings increased.

Finally, pre-teaching of vocabulary, an instructional strategy with demonstrated success in hearing bilingual contexts, has also been shown to be effective in a deaf bilingual context. Cannon, Fredrink, and Easterbrooks [29] used single study design to measure the effectiveness of a DVD-based ASL storytelling curriculum with four deaf multilingual learners. Each DVD gave participants an opportunity to view the printed target vocabulary words along with the associated sign. The researchers found, however, that the DVDs alone were less effective for teaching vocabulary than when they were accompanied by explicit pre-teaching of the target vocabulary.

4.6. Bimodal Bi/Multilingual Writing Instruction

Research on effective writing instruction for bi/multilingual deaf students is fairly limited, much of it focused on Strategic and Interactive Writing Instruction (SIWI) [165]. SIWI is an approach to writing instruction specifically designed for deaf children. The approach draws upon the following evidence-based practices in writing instruction: explicit instruction in writing strategies and skills,

focus on the writing process, writing for authentic purposes, learning from model texts, and interactive writing. SIWI also incorporates "the language zone," an interactive, meaning-focused space where deaf students who struggle to communicate their ideas in language can use multimodal resources—including gestures, role play, images, and videos—to make themselves understood [166]. Research has shown that SIWI helps students to do all of the following: write longer pieces with more complex syntax; improve their writing skills across multiple genres; transfer writing strategies across genres; develop positive writer identities; gain writing independence; improve their editing and revising skills; and develop their ASL skills [167–175].

A second, related, focus of research on the SIWI curriculum involves the sign language features that tend to appear in deaf children's writing—just as hearing bilinguals include L1 features in their L2 writing [176]—and the responsiveness to instruction of those features. In examining the writing of 29 bilingual deaf adolescents, Wolbers, Graham, Dostal, and Bowers [177] found the following six categories of language transfer, in order of prevalence: unique glossing and substitution, adjectives, plurality and adverbs, topicalization, and conjunctions. They also found that all six categories responded similarly to instruction [178]. Based on their findings, the researchers argue that "bilingual literacy programs where there is an emphasis on implicit language competence and metalinguistic knowledge can support d/hh students in the development of written English" (p. 410).

5. Questions for Future Research

5.1. What Is the Nature of the 'Bridge' from Sign to Print?

The fact that "the cognitive and cross-linguistic mechanisms permitting the mapping of a visual-manual language onto a sound-based language have yet to be elucidated" [156] (p. 1) remains one of the most pressing problems in our field. Despite improvements in amplification technology, many children born deaf still do not have sufficient access to sound to use sound-based phonology as a reliable tool in cracking the code of print. From an ethical standpoint, too, parents should not feel compelled to choose surgery for their infants because it is the only way to ensure their child's academic success. It is thus incumbent on the field to identify, describe, and make effective use of the cross-modal mechanisms at play when profoundly deaf readers learn to read.

Neuroimaging research is promising in this regard. Specifically, Petitto et al.'s [143] work on visual sign phonology (VSP) and Kovelman et al.'s [147] recent work suggesting that the superior temporal gyrus (STG) is responsible for processing both phonological and morphological segmentation depending on the salient features of the given language, may give rise to new understandings not only about how sign language exposure influences brain development, but also about how native signers may best be helped to transfer their linguistic knowledge to the segmentation of print features required for reading. Continuing to look closely at how skilled deaf readers make sense of print will also be beneficial. Banner and Wang [179] lament a "lack of investigation into the reading strategies utilized by deaf readers in text comprehension" and a concurrent "overemphasis of most research on studying less skilled deaf readers" (p. 2). Further study of the eye movements of skilled deaf readers [180] may be fruitful, as well. Taken together, it is plausible that such research could flip the script, as it were, on the qualitative similarity hypothesis. As we learn more about the cognitive processing employed by skilled deaf readers, we may find that such research actually informs a more expansive understanding of the strategies used by hearing readers; the pathways to literacy may indeed be less modality-constrained than we once assumed.

Finally, further research is warranted into the question of whether or not written signed language (WSL) would be a useful instructional tool to help bilingual deaf children transfer their signed L1 skills to their written L2. The argument in favor of developing WSL and employing it as an instructional tool, based largely on Cummin's linguistic interdependence hypothesis [181], is that WSL will help deaf readers to develop phonological en/decoding skills in their signed L1 and that these skills will then be more readily transferable to phonological en/decoding skills in their written L2. Grushkin [182],

a proponent of WSL as an instructional tool, argues further that, even if language segments beyond the phoneme (i.e., semantic, morphological, or syntactic) turn out to be more essential to deaf readers than phonemes, WSL would still be effective in helping to make the linguistic differences between signed and spoken language more readily apparent in a static format. Other researchers in the field argue that the use of WSL in literacy instruction for bilingual deaf students lacks a strong theoretical base [183–185]. As of yet, however, there is no research evidence available to answer the question that Grushkin himself poses: "Does the development of writing for signed languages hold any true benefits for Deaf people, as individuals and as a community?" [182] (p. 521).

5.2. Is the Bimodal Bilingual Approach Effective?

Before our discussion regarding much-needed research on the bilingual approach, it is important to heed Humphries et al.'s [59] reminder that "the questions of how to ensure access to language in the early years of life and how to educate deaf children are distinct" (p. 39). In other words, those who insist that all deaf children should have early access to sign do not (necessarily) also insist that all deaf children should be educated in bilingual programs. These are important arguments to disentangle, as the two concepts are often conflated in the literature. For example, in Delana, Gentry, and Andrews [186], the authors include a table entitled, "Investigations that Present Empirical Data on ASL/English Bilingual *Methodology*" [italics added] (p. 75). However, of the 11 studies listed in the table, only two were inquiries into bilingual methodology; the other nine were inquiries into the relationship between depth of ASL knowledge and reading ability.

Merging these two questions is particularly dangerous given the extent to which bilingual education for deaf children continues to be a "hot button" topic [4] (p. 293). It is important to remember that one can reject deaf bilingual education as an approach without also rejecting the notion that all children should have unencumbered early access to language. By the same token, while evidence that native ASL users are better readers provides theoretical support for the viability of bilingual deaf education, it does not provide empirical support for the effectiveness of the model; it supports the argument that bilingual deaf education should be effective, not that it is. We emphasize this distinction not because we do not believe in the value of bilingual education for deaf children, but because we do believe in its value and bemoan the lack of evidence in its favor. Bilingual deaf education programs have been under-studied, and there is very little research regarding how, or if, they lead to successful outcomes for deaf children.

Mixed results on the effectiveness of bilingual deaf education have come out of Sweden, where the national schools for the deaf adopted a bilingual approach over 35 years ago. In 1998, it was found that the first experimental group of children educated via a bilingual approach attained reading levels corresponding to those of their hearing same-age peers [187]. Ten years later, national exam results indicated that 66% of bilingually-educated deaf students passed the Swedish test (compared with 96.5% of hearing students), while 59% of deaf students passed the English test (compared with 94.3% of hearing students) [188]. These results were disconcerting to the Swedish government, and so it initiated a study to compare the achievement of deaf and hearing students across different deaf education contexts [187]. In Sweden, the majority of deaf children are in mainstream environments; only about 10% are educated in the five national bilingual schools [189]. This national study found that a large disparity existed between deaf and hearing students regardless of educational placement. A similar disparity was found by Rydberg, Gellerstedt, and Danermark [190] across educational contexts. Svartholm [187], however, points to a different data set to argue for the positive impact of bilingual deaf education: the marked increase in the number of signing deaf adults attending Swedish universities. In 1993–1994, there were 48 students using sign language interpreters in higher education settings; in 2003, that number had tripled to 149 [187]. The number remained constant for at least the next ten years, with 141 signing deaf students enrolled in Swedish universities in 2013 [191].

Denmark also transitioned to a bilingual approach in its national schools for the deaf in the mid-1980s. However, a shift back to focusing on spoken language for deaf children began in the

mid-2000s, motivated largely by improvements in cochlear implant technology, even though very little empirical data existed on the effectiveness of the bilingual programs. Recently, Dammeyer and Marschark [192] attempted to redress this lack of data by conducting a study of 408 deaf people who attended school either before or during the period of bilingual deaf education in Denmark. They found that deaf people who received a bilingual education made significantly greater educational gains than the deaf people educated before the introduction of bilingual education. However, "while the percentage of more highly educated deaf people increased 11% (from 22.9% to 34.2%), the percentage of more highly educated hearing people also increased 11% (from 41.9% to 53.2%)" (p. 397). As a result, in comparison to the hearing population, the deaf population did not make any gains during the period of bilingual education.

Limited research on the literacy gains of children in bilingual deaf programs in the United States has also had mixed results. Delana et al. [186] evaluated the reading comprehension gains of 25 deaf students enrolled in a bilingual program within a public school over the course of 7 years. They found that all but a few participants made reading progress of approximately one grade equivalency per year of the study, although only 25% of the students were reading on grade level. Similarly, Nover, Andrews, Baker, Everhart, and Bradford [193] analyzed the reading comprehension scores of eight to 12-year-olds enrolled in a bilingual program and found that their scores were significantly above the national norms for deaf children. Finally, a study of seven deaf children enrolled in a bilingual program in Texas found that they all finished first grade reading at grade level [194]. However, as the researchers note "the real test . . . [would] be the children's reading levels in elementary school" (p. 25). To the best of our knowledge, no further studies were published on these children.

5.3. Who Are Deaf Bimodal Bi/Multicultural Learners?

Cannon et al. [26] make clear that "research related to DMLs (deaf multilingual learners) is severely lacking" (p. 14). First of all, they explain, we do not even have a good sense of who the deaf multilingual children in this country are because the data currently being collected are not specific enough. While districts have to report on the number of 'English Learners' they are serving, they do not have to report on how many of those children have disabilities. Furthermore, the Gallaudet Research Institute [3] survey only asks what language is spoken at home. Cannon et al. urge the Office of Research Support and International Affairs to ask the much more specific questions recommended in the English Learner Toolkit published by the National Clearinghouse for English Language Acquisition [195]: "Which language did your child learn first? Which language does your child use most frequently at home? Which language do you most frequently speak to your child? In what language would you prefer to get information from the school?" (p. 12). Including such questions in the Annual Survey, alongside questions pertaining to deafness, would offer a much clearer picture of who the multilingual deaf children are in the United States.

Beyond that, Cannon and Guardino [28] call for more descriptive case studies focused on multilingual deaf children and their families to "provide a foundation for informing researchers what type of background and needs this unique population exhibits" (p. 94). Such studies should include, they argue, descriptions of the metacognitive strategies multilingual deaf children employ while making sense of text. Longitudinal studies, as well, on how deaf children acquire multiple languages and the factors that influence their learning would be helpful. We simply do not know what the effects are of multiple languages being used across settings on a child's language learning and literacy development [26]. Finally, Cannon et al. [28] strongly encourage researchers in the field to begin developing the evidence-base of effective strategies for working with multilingual deaf children, particularly through single subject design, given the low-incidence of the population. Specifically, their review of the literature revealed four promising interventions for use with this population that are in need of further research: guided repeated reading, visual phonics, pre-teaching vocabulary, and peer-tutoring.

5.4. How Can Hearing Parents Become Proficient Signers?

At present, only about 23% of families regularly sign with their deaf children [3]. A persistent argument against the use of sign with all deaf infants is that hearing parents cannot or will not learn sign language, at least not to the level of proficiency necessary to serve as a foundation for later literacy development [4]. Koulidobrova et al. [60] argue that more resources need to be allocated to parents who want to learn ASL and that more research needs to be done on how families can be helped to make the "shift to more visually based forms of communication" (p. 112). Humphries et al. [59] argue that government resources should be used to fund sign language instruction for families of deaf children, which should continue until at least age 12. They also call for more research on adult second language learning in a second modality so that we can improve the effectiveness of sign language instruction for hearing adults. In a similar vein, Hall et al. [33] argue for research into the effectiveness of the parent-infant services currently being offered to families of deaf children:

> For families who choose not to risk language deprivation by exposing their child to a sign language, it is critical to evaluate whether the professionals working with the family are equipped to offer support in sign language acquisition. Do they have native or near-native proficiency in the signed language used in the region? Do they have training and expertise to support sign language acquisition (i.e., deep understanding of the linguistic structures of the relevant signed language and the methods for evaluating and promoting acquisition of these structures)? If not, are they able to refer the family to people who have such expertise? If they are hearing, do they know and seek guidance from DHH adults who have lived experience of being DHH? (pp. 17–18)

As a possible alternative to expecting hearing parents to become fluent signers, Knoors and Marschark [4] suggest that it might be sufficient for parents to learn how to use simultaneous communication (Sim-Com). Although the researchers acknowledge that this is another "hot button" issue, they note the lack of research evidence for or against it. Further research into the advantages and disadvantages of hearing parents using Sim-Com with deaf children might be instructive in this regard, particularly with parents who would otherwise be unwilling to sign, and particularly with children who have enough auditory access that the signs may act as a support to spoken language development.

5.5. How Can Deaf Ontologies and Epistemologies Improve Deaf Education?

We would also like to make a call for research that takes more deeply into account the lived experiences, ways of being, and ways of knowing of deaf people. There is a lack of such research in our field, and there is much of value to be gained from it.

> Aspects of the Deaf episteme, not caused by deafness but by Deafhood, have a positive impact on how deaf individuals learn, resist audism, stay healthy, and navigate the world. [196] (p. 486)

> The vast knowledge generated by the collective experience of deaf people, all of whom have varying degrees of hearing and speaking capabilities, has the potential to provide the truth needed to achieve improved educational success for all deaf children. [1] (p. 476)

> Studies of the everyday interactions within Deaf families can provide insight into the learning potential of deaf children when they have the same advantages at birth as hearing, speaking children, that is, when caregivers have the linguistic and cultural knowledge to fulfill the visual language needs of their deaf infant from the moment they are born. [136] (p. 447)

> "A repertoire of teacher knowledge, skills, and tools that primarily originate in the Deaf community can infuse and enrich educational practice with the outcome of life-long learning, equity and social justice". [125] (p. 8)

6. Concluding Thoughts

To the extent that an individual deaf child is an 'English Learner' (according to the government's definition), it seems clear that child is entitled to at least the same supports, inadequate as they may be, that are mandated for hearing 'English Learners'. As Koulidobrova et al. [60] explain, however, that level of support is not currently being offered:

> Efforts on behalf of the US government and local educational agencies to improve outcomes for ELs are well documented. However, one type of student population has over the years not been included in policy discussions and therefore remains unaffected by the reforms and changes in the educational infrastructure that have otherwise—more or less positively—affected lives of school-aged ELs. These are users of American Sign Language (ASL) who are learning English. Literature has suggested that over 500,000 individuals use ASL as their L1 in the US, yet no data are currently available at the state or federal level that identifies children who fit such a profile as ELs. (p. 100)

It also seems clear, though, that the task of learning a spoken/written L2 by a child with a signed L1 is qualitatively different from the task of learning a spoken/written L2 by a child with a spoken/written L1. Singleton, Supalla, Litchfield, and Schley [197] acknowledge this difference, arguing that we should not think of deaf children as 'English language learners', but as learners of 'English as a spoken language.' In this argument, they are not emphasizing that acquiring speech skills is what differentiates the language learning task, but that the structural forms of spoken and signed languages differ in important ways that will require teachers of the deaf to use "instructional techniques beyond 'ESL methodologies'" (p. 21) to allow students to build semantic, morphological, and syntactic bridges between the two languages.

Finally, we would feel remiss if we did not address the role of ableism in all conversations about the nature of deaf children's learning. The dominate deficit model in deaf education perpetuates the fallacy that hearing people are superior to deaf people, and associates deafness with "ill-health, incapacity, and dependence" [107] (p. 88). This perspective leads to the generalized assumption that deaf people's under-achievement in education is a result of deficits within the children themselves, rather than a result of the 'disabling pedagogy' to which they are routinely subjected [198] (p. 91). We acknowledge that the ableist perspective is very often a subconscious mindset. We are not saying that individuals intentionally perform disabling pedagogies out of malice; it is much more likely that they do so out of charity. But the results are the same.

We can and must do better by deaf children. It is not enough, nor is it ethically responsible, to hope that hearing technologies will improve to the point that the nature of 'deaf education' becomes a non-issue. "Deafness is a part of, not apart from, humanity" [199]; we are not comfortable with a research agenda that, explicitly or implicitly, works toward the eradication of deafness. In the words of Humphries [105], one of the most resounding Deaf voices in our field: "Large numbers of deaf children continue to be harmed and isolated until they are old enough to take charge of their own lives. We cannot morally or ethically continue to leave the lives of these children to others who imagine futures for them that are based on hope. The other side of hope is risk" (p. 71).

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Review

Children Who Are Deaf/Hard of Hearing with Disabilities: Paths to Language and Literacy

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Abstract: Students who are Deaf with Disabilities (DWD) comprise an extremely heterogeneous population. Similar to students who are d/Deaf or hard of hearing (DHH), students who are DWD vary in terms of degree, type, and age at onset of hearing loss, amplification, and preferred communication method. However, students who are DWD are also diverse in terms of type, etiology, and number and severity of disability(ies). Presented in this article is an overview of DWD followed by foci on Deaf with learning disabilities, Deaf with intellectual disabilities, Deaf with autism spectrum disorder, and deafblindness. Particular attention is given to communication, language, and literacy development.

Keywords: deaf with disabilities; deafblind; autism spectrum disorder; learning disabilities; intellectual disabilities

1. Introduction

The population of students who are dDeaf/hard of hearing with disabilities (DWD) is difficult to characterize and quantify, yet is thought to comprise between 40% to 50% of the population of students who are d/Deaf or hard of hearing (DHH) in the United States [1–4]. Students who are DWD are extremely diverse and reflect both diversity of the DHH population as well as variation in type and severity of the various accompanying disabilities (e.g., variation in expression of autism spectrum disorder) [5]. Further, etiologies of deafness are considered to be possible risk indicators for concomitant disabilities [2,6,7]. Such etiologies include hereditary syndromes (e.g., Usher, CHARGE, Goldenhar, and Down syndromes), maternal infections (e.g., congenital rubella, cytomegalovirus, toxoplasmosis), prematurity, meningitis, anoxia, and trauma [2,6–9]. Identified concomitant morbidities include intellectual or developmental disabilities, autism spectrum disorder (ASD), specific learning disabilities, attention deficit disorder (ADD), attention deficit hyperactive disorder (ADHD), orthopedic impairments, emotional disabilities, speech and language impairments, traumatic brain injury, health impairments, low vision, legal blindness, and deafblindness [4–6]. The disabilities may include one or several of those listed and each of the disabilities vary in presentation and degree. However, it is important to note that the disabilities are multiplicative rather than additive as each interacts with the hearing loss to impact communication, cognition, social development, behavior, and physical development [4,6,10,11]. Moreover, the presence of disabilities makes compensation for loss of hearing much more difficult [9,12]. In recent years, there has been an increase in attention and research focused on the area of DWD [13,14]; however, there remains much to be known about prevalence, accurate assessment methodology, and effective intervention [3,10,12,15]. In addition, there is a shortage of teachers prepared to teach this unique student population and few teacher preparation programs provide coursework related to working with students who are DWD [5,6,10,14]. Included in this article is an overview of the population of children and youth who are DWD including estimated prevalence, difficulties encountered in accurate assessment, and education, language, and literacy considerations. Attention is then turned to four of the most prevalent concomitant disabilities—learning disabilities

(LD), intellectual disabilities (ID), ASD, and deafblindness. The extant research base in each area is presented with particular emphasis on communication and literacy development.

2. Prevalence and Identification

Estimated prevalence of students who are DWD varies in the literature with a reported range of 25% to 51% of students who are DHH [2,3,6,7,10,15]. In a 2010 study of 100 children with severe to profound sensorineural hearing loss, Chilosi et al. [2] found that 48% of the sample had one or more additional disabilities. The majority of other studies reporting DWD prevalence cite the Annual Survey of Deaf and Hard of Hearing Children and Youth (Annual Survey) conducted by the Gallaudet Research Institute (GRI) as their source. Since the survey began including data on students who are DWD in 1999, prevalence has remained relatively constant with a mean of 42% across the years from 1999 to 2013 [3]. The latest available statistic from the GRI count is 2013 which reports that 59% of the DHH population had no accompanying disabilities and therefore, 40% had identified concomitant disabilities [4]. However, the population of students who are DHH in this count is much lower than in previous counts. Researchers in the field posit that the GRI count is likely under representative of the population because not all respondents complete the section on disabilities [3,15]. In addition, there are differences among the child count surveys reporting student disability in the United States. For example, in the 2009–2010 school year, The United States Department of Education Child Count reported 79,431 children receiving services under the category of deaf-hard of hearing. In the same year, the GRI reported 37,608 students as deaf-hard of hearing. In looking at the population of students who are deafblind in 2009–2010, the Child Count [16] reported 1575 students as deafblind, the GRI, 1778 [17], and the Deaf-Blind census conducted by the federally funded National Consortium on Deaf-Blindness (NCDB) reported 9195 children and youth as deafblind [18]. This discrepancy is likely because the Department of Education Child Count only counts children by primary disability (e.g., deaf/hard of hearing or deaf-blind), and NCDB has focused national attention on identifying students as deaf-blind. However, given the relatively high deaf-blind count by NCDB, it could be argued that other accompanying disabilities might also see higher prevalence numbers if attention was focused on their identification. Importantly, in examining the variance across data sources and the lack of concrete prevalence figures, it is likely that the population is underserved as well as under-identified [19].

Early intervention is critical to communication, language, and social-emotional development in children who are DHH [20,21]. Further, early intervention has been demonstrated to positively impact outcomes across domains of children with disabilities [22,23]. However, identification of disabilities in children who are DHH is challenging, and hence, diagnosis and subsequent early intervention frequently occurs at an older age than children who are DHH alone [8,24–26]. Therefore, opportunities for early, comprehensible language input are missed [5,24,27]. Challenges in identification of children who are DWD include: (a) Diagnostic overshadowing [27,28], (b) difficulties obtaining accurate auditory assessment information [29,30], and (c) limitations inherent in existing assessment instruments [10,12,15]. Diagnostic overshadowing occurs when two disabilities share common indicators and the first identified or the most prominent "overshadows" identification of the second. For example, because communication and social skills are affected in both ASD and DHH, ASD might be missed in a child who is deaf or vice versa [8,25,27,28,31]. Further, auditory assessment is difficult when a child, because of physical, communication, or cognitive difficulties, is unable to reliably indicate responses to auditory stimuli. Therefore, determination of degree and type of hearing loss can be inaccurate [29,32,33]. Finally, available assessment tools for disabilities are often not designed to accommodate for the complex needs of children who are DWD [10,12,13,15,28,34] and in fact, some assessment instruments specifically advise that instruments not be used to evaluate children with a hearing loss (e.g., the Autism Diagnostic Observation Schedule (ADOS)) [35]. Given such challenges, there is inherent danger that children will be misdiagnosed and receive education that is inadequate and inappropriate in meeting all of the needs that result from the disabilities [12,14,19,36]. Further,

because the diagnosis of DWD is often delayed, research on effective intervention strategies has tended to focus on older children and thus, evidence-based strategies for early intervention for children who are DWD are scarce [5]. However, even among the school-age population, there is a distinct lack of knowledge regarding effective curriculum methods and teaching strategies [10].

3. Educational, Language, and Literacy Considerations

3.1. Educational Considerations

According to the Individuals with Disabilities Education Act of 2004 (IDEA, 2004) schools must provide special education and related services that are designed to meet the needs of children with disabilities as adequately as the needs of students without disabilities are met [37]. IDEA further requires that the Individualized Education Program (IEP) address all education needs that result from the child's disability(ies), but while IDEA provides definitions of educational disability labels, it is silent on primary and secondary disability [38]. Therefore, a child can be classified on the IEP as DHH, but if other disabilities are present, IDEA requires that the full range of needs be addressed regardless of assigned label. Further, IDEA 2004 mandates that students with disabilities be educated in the least restrictive environment (LRE) and that a continuum of placements be available. IDEA 2004 also specifically delineates that for students who are DHH, teams must consider a student's language and communication in developing the IEP (Title 1,B,614,(d),(3)(B)(iv)). Increasingly, students who are DWD are educated in inclusive settings with typically developing peers and as of 2013, the majority of students who are DWD were included in general education settings (ASD and ID, to a lesser extent) [3,4]. Given the range and intensity of needs, including communication, it is imperative that teachers collaboratively team with professionals across disciplines if individual needs, including communication and literacy needs, resulting from the hearing loss as well as accompanying disabilities are to be met in any of the settings along the placement continuum [6,10,14,38,39].

3.2. Communication Considerations

Children who are DHH vary widely in degree of hearing loss, age at onset of hearing loss, presence of assistive listening devices including hearing aids and cochlear implants, home language, and chosen communication modalities [39]. However, across the range, language development is often delayed due to reduced access to language [1,20]. Such delays are likely to be magnified in children who are DWD who might struggle with receptive and expressive language as well as both visual and auditory language [1,11]. Children who are DWD with physical disabilities may have difficulty with fine motor control that can inhibit both sign and spoken language [11]. Children with ASD may struggle with visual attention to faces and gestures and both communication and social delays are known hallmarks of ASD [5,27,40]. Finally, children with intellectual disabilities may have difficulties with joint attention and might need additional processing time to receive and express language [1,26]. Studies examining auditory receptive and expressive language development of children who were DWD and received cochlear implants or hearing aids prior to 3 years of age found that as a group, at age 3 and 5, language scores on standardized tests improved; however, when examined by type of disability, language scores of children with ASD, developmental disabilities, and cerebral palsy in addition to hearing loss, declined relative to typically developing peers. Better outcomes were significantly associated with higher maternal education [13,41]. Such findings suggest that more research in the field is needed in order to enhance early intervention with families in these particular disability areas in order to improve language outcomes. Moreover, although still relatively uncharted territory [15], research is emerging across deafness and disabilities in terms of effective strategies for enhancing visual language, cochlear implantation habilitation, and use of augmentative and alternative communication (AAC).

3.3. Literacy Considerations

Language is a critical foundation for reading, whether it is expressed in signed language or spoken language [42–44]. Traditional or conventional literacy is often defined as reading and writing. Emergent literacy is a term applied to a stage of literacy development that occurs before conventional reading and writing and involves experiences with literacy and a growing knowledge of the components of early literacy, including identification of letters, learning letter sounds, and writing one's name [45]. Children then develop increasingly complex reading and writing skills in a variety of genres. In some fields the definition of literacy has expanded to include participation in literacy activities and communication [46]. Digital literacy refers to competencies in the use of online resources to accomplish literacy tasks [47]. Whether signed or spoken, language is the foundation of literacy [42–44]. If we are to prepare children for the literacy demands of this century, there is a dire need to increase the attention paid to their experiences, concept development, vocabulary, and deeper level comprehension [45].

Literacy challenges in the DHH population may stem from a lack of early identification, reduced exposure and engagement in language and literacy, inappropriate educational supports for the development of communication and language, and additional disabilities [48,49]. Moreover, disabilities compound the literacy challenges faced by DWD. While the professional literature addresses literacy development for children with each of the disabilities addressed in this paper, there is very little information available about teaching literacy to students who are DWD. One is left to apply the literacy research in the disability area with what is known about teaching literacy to DHH.

4. d/Deaf/Hard of Hearing with Learning Disabilities

The Individuals with Disabilities Education Improvement Act defines a specific learning disability as a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations (Sec. 602 (30)(a)) [37].

The literacy delays that are often experienced by children who are DHH make identification of a learning disability difficult. Additionally, the disability and English proficiency exclusion criteria in the Individuals with Disabilities Education Act may erroneously result in some professional teams attributing literacy delays solely to DHH or to English learning instead of considering an additional contributing disability [48,50]. In previous authorizations of IDEA, the discrepancy model was followed, meaning that a student must demonstrate a discrepancy between their ability and academic performance prior to identification of a specific learning disability. With the reauthorization in 2004, professional teams may now identify a learning disability based on the child's response to a research-based intervention [51].

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) [52] includes a diagnostic criteria for a "specific learning disorder" (p. 66) that involves the child exhibiting at least one of six characteristics for six or more months and persisting after interventions have been implemented, with substantially delayed academic performance, and onset of learning difficulties in the school years. The six characteristics involve difficulties in reading words, reading comprehension, spelling, writing, numbers and calculations, and mathematical reasoning. The diagnostic criteria include an exclusion principle stating that the characteristics cannot be explained better by a different diagnosis.

In addition to the learning implications stated by IDEA and the DSM-V, The Learning Disabilities Association of America includes implications of specific learning disabilities that include "reasoning, attention, memory, coordination, social skills, and emotional maturity" [53]. Memory challenges may include both visual and auditory information [51]. Some social-emotional challenges may occur due to repeated experiences with academic failure. Professional teams must also be mindful of comorbidity with attention deficit/hyperactivity disorder.

Deafness is an auditory perceptual problem, whereas a learning disability is a processing issue, that may include "visual-perceptual problems, attention deficits, perceptual-motor difficulties, severe inability to learn vocabulary and English-language structures, consistent retention and memory

problems, or consistent distractive behaviors or emotional factors" [50] (Identification, assessment p. 57). In 1989, Laughton suggested the following description of learners who are DHH-LD: Individuals who are DHH with learning disabilities have significant difficulties with acquisition, integration, and use of language and/or nonlinguistic abilities. These disorders are presumed to be caused by the coexisting conditions of central nervous system dysfunction and peripheral sensorineural hearing impairment, and not by either condition exclusively [50] (Identification, assessment p. 57).

Specific learning disability is the most common disability in children and youth who are DHH, with dyslexia (involving difficulties in learning to read) being the most common type of learning disability [48]. Other learning disabilities include dysgraphia (involving difficulties in writing, including fine motor skills) and dyscalculia (difficulties in understanding mathematics). Estimates of prevalence vary. It has been estimated that about 7–8% of DHH children have a learning disability [54]; and that 10% of the deaf population is thought to specifically have dyslexia [55].

4.1. Assessment and Identification

Much of the professional literature on DHH-LD addresses assessment and identification. Teachers of DHH children are critical to the referral process, assessment, and potential identification of a learning disability. In a survey study of 91 teachers, Soukup and Feinstein [50] found that teachers most offered referred children based on observations of visual perceptual issues (which are not associated with DHH) and behavior. These teachers suggested neuropsychological screening as well as assessment of communication and language as being important to identifying a learning disability.

When considering potential referrals, Sheetz [56] suggests observing for learning characteristics that are associated with learning disabilities, but not with DHH, such as difficulties with social skills, metacognition, visual-perception, severe difficulty in learning vocabulary, and inattentiveness (the latter being due to the co-occurrence of LD with attention deficit disorder). Further, Sheetz suggests comparing literacy achievements with DHH peers. Additional potential cues to a learning disability could be serial memory deficits, weak signing and conversational skills, poor comprehension of questions and pronouns, weak spelling skills, and academic achievement and reading scores that are lower than DHH peers [50,57].

When assessing DHH children for a potential learning disability, the following types of data are needed: Case history (including onset of hearing loss), educational history, measures of intelligence, achievement tests, neuropsychological screening (including visual-motor screening), testing for adaptive behavior functioning, audiological and visual screening, and assessment of communication and language (including a measure of mean length of utterance) [44,48,50,57,58]. Additionally, relatively slow visual perceptual speed has been suggested as a potential biomarker of a learning disability in both individuals who are hearing and individuals who are DHH [55]. Caemmerer et al. [48] suggest considering the child's experiences with English and if the parent and child share communication forms, information that should be included within the child's case history. When assessing for dyslexia in DHH learners, instruments used to measure intelligence and to identify dyslexia should be appropriate for DHH learners [50,55].

Information on appropriate assessment instruments and processes is available through the Center on Literacy and Deafness (CLAD). This site (https://clad.education.gsu.edu) [59] includes a checklist "Documentation Guidelines for Learning Disabilities". Additional information on appropriate literacy tests for use with learners who are DHH can be found in Morere and Allan's book, Assessing Literacy in Deaf Individuals: Neurocognitive Measurement and Predictors [60]. This text provides guidance on how to assess academic knowledge, executive functioning, literacy, visual-spatial functioning, among many other areas of relevance when identifying a potential learning disability.

4.2. Literacy

The identification of a learning disability in a DHH child will occur once that child is school-age and has already acquired language. Thus, this section will address reading and writing.

4.2.1. Reading

"Reading is matching speech sounds with print and involves a complex set of skills involving perception (looking at the text); cognition (i.e., logical reasoning, background knowledge, knowledge of concepts, memory); social skills (i.e., theory of mind); and language skills (i.e., phonology, semantics, syntax, and pragmatics or discourse)" [61] (Deaf and hard of hearing students p. 346). The National Institute of Child Health and Human Development identified the following six factors as being the most important to literacy development in hearing children: "Phonological awareness, alphabetics, vocabulary, fluency, text comprehension, and motivation" [42] (Literacy and deaf and hard of hearing p. 151). Each of these factors has become subject to research and debate in the field of deafness, both to evaluate their relative importance to the development of literacy in the DHH child, and to identify how deafness impacts the development of each factor, including the impact of communication modalities on each of the six factors.

Mohammed, Campbell, Macsweeney, Barry, and Coleman [62] describe two camps of thought to explain reading difficulties as being either being phonological in nature (which is the dominant viewpoint and in accordance with the National Reading Panel), or due to perceptual difficulties, either visual or auditory. Dyslexia was thought to be caused by a visual-spatial deficit and now more commonly is thought to be caused by an auditory phonetic processing problem or central linguistic deficit [63]. While Lomas et al. [61] acknowledge that phonological knowledge supports the decoding of new words and recommend direct phonological instruction, they assert that Deaf children learn to read visually as a substitute for applying phonological knowledge, with some applying sign language, fingerspelling, and visual phonics to support reading [42,49,61]. Even with cochlear implantation and an associated increase in speech, this does not necessarily carry over to improved reading [61]. Miller's [64] study suggests that reading comprehension is a perceptual issue (rather than being due to phonological deficits) for both individuals who are DHH and individuals who have LD.

There are three major curricular approaches to teaching literacy to DHH students that are also referenced in the LD literature. The text-based approach (also known as the bottom-up approach) starts with the building blocks of reading, such as morphemes and phonemes, with phonics taught early. While this approach is effective with most hearing children, it is not effective with Deaf children due to their lack of knowledge of the English phonological system [65], which would also be a challenge for children who are Deaf with LD.

The second approach is the subject-based approach (also known as the top-down approach), which recognizes the importance of context and prior knowledge). DHH children may not have the prior knowledge or contextual information to make this approach meaningful [65]. This same limitation may be experienced by children who are DHH-LD.

The third approach is the interactive or compensatory-interactive approach, combining elements of the text-based and subject-based approaches. The interactive approach recognizes that all forms of language (reading, writing, spelling, speaking, and listening) are inter-related [65]. Attention to context and use of the child's language are foundational to this approach. Paul [44] suggests that a sight word approach is limited and other approaches are needed for higher literacy achievements. Strategies associated with the interactive approach include writing to support reading and reading to support writing (such as reading and writing journals), use of high interest readings (such as trade books), and thematic units [65]. In their longitudinal study of children at risk of developmental dyslexia, ages 5–8 years, Helland, Tjus, Hovden, Ofte, and Heimann [66] found that the bottom-up approach was most effective to making gains in phonological awareness and working memory; whereas the top-down approach was most effective in verbal learning, knowledge of letters, and literacy. More research is needed to determine the application of the interactive approach to children who are DHH-LD.

The general approach to teaching children with specific learning disabilities is to offer explicit and systematic instruction with ample opportunities to practice. "Explicit instruction refers to instruction that is clear and direct and in which expected outcomes are conspicuous to students" [51] (Specific learning disabilities, p. 296). Systematic instruction builds on the child's knowledge and applies

behavioral principles, such prompting and reinforcement. Reading approaches and programs for children with dyslexia are based on auditory input, but this approach is not helpful to most Deaf learners, including those with learning disabilities, because of the reliance on linking speech to print.

Shared reading has been recognized as important to the reading development of both children who are DHH and children with LD. When parents engage their child in shared reading, they can support active involvement of the child, expand the child's utterances, and gradually expect more of the child's participation over time. During shared reading the child will learn about handling books, that books are read top to bottom and left to right, how language in books is different from speech or sign language, prediction, drawing inferences, gaining vocabulary, while improving listening comprehension and other literacy skills [67]. Parents can support literacy by providing a literacy rich environment with plenty of books in the home, although this is linked to the parents' economic situation. Robertson recommends that shared readings occur more than once daily, that the parent follows the child's interests, and that preschool children with hearing loss need even more hours with literacy materials than hearing children. Parental involvement is also important when the child enters school. Marschark and Knoors state: "We know that parents' involvement in their children's language development, learning, and education is perhaps the best predictor of their educational outcomes" [43] (Educating deaf learners, p. 233).

Pakulski and Kaderavek [68] suggest beginning with stories about the child's actual experiences, called language experience stories, moving to storybooks later. Such books may be shared in the home or at school. Language experience stories are highly engaging to the child. Parents and others should modify their language to the correct level for the child, and provide connections between objects, pictures, print, and sign. Adults must provide a great deal of practice with concepts and vocabulary. When sharing experience stories with a signing child, the adult must consider where to locate signs while referencing objects and pictures in the book. The sign may occur next to or on top of pictures in books, with connections supported by pointing to pictures. When moving on to storybooks, it is helpful to select texts that are predictable (to reduce vocabulary demands), such as those with repeated phrases or refrains [65]. Easterbrooks and Stephenson [69] present the following ten evidence-based literacy practices for students who are DHH, many of which will also apply to learners who are DHH/LD "independent reading, use of technology, phonemic awareness and phonics, metacognitive reading strategies, writing to promote reading, reading in the content areas, shared reading and writing, semantic (meaning-based) approach to vocabulary, morphographemic approach (learning roots, suffixes and prefixes) to vocabulary and fluency" (Examination of twenty approaches, pp. 386–391).

4.2.2. Writing

There is very little research and professional literature about how to teach writing to students who are DHH-LD. Teachers of the DHH should be aware of the writing struggles experienced by students who are DHH and students with learning disabilities. Deaf students tend to exhibit rigid writing, write in shorter sentences, use a limited vocabulary, exhibit issues with clauses, may need support in sequencing of words, and they have difficulty in writing in a passive voice [44,70]. Students with learning disabilities also tend to produce writings that are shorter, with partial or fragmented coverage of topics. They require support with all phases of writing, from planning to revision and across all genres [71]. Background knowledge, memory, and executive functions impact the writing of students with LD [71]. Graham, Collins, and Rigby-Wills [72] conducted a meta-analysis of 53 studies, comparing the writing of students with LD and peers without disabilities. In addition to needing support with all phases of writing, they found that writing "required the orchestration of handwriting, typing, spelling, and sentence construction skills" (Writing characteristics, p. 199) combined with the role of motivation.

Moores [70] suggests that the three approaches in reading have a parallel in teaching writing to students who are DHH and that neither the bottom-up or top-down has resulted in writing performance

on par with hearing children. The interactive-compensatory approach includes, "instruction on sign to print, fingerspelling to print, sound to print, and morphological awareness as well as on functional pragmatic aspects" (Specific learning disabilities, p. 51). Performance in written language is similar to reading performance and reading and writing instruction should be integrated [44,67]. Given the varied forms of communication used by students who are DHH-LD, an interactive approach seems worthy of additional research.

Writing strategies from the field of LD, such as the use of graphic organizers, will support some learners who are DHH-LD. Dexter and Hughes [73] conducted a meta-analysis of 16 articles about the effects of graphic organizers across content areas. They found that graphic organizers are effective in improving recall, vocabulary, and higher thinking skills, such as inference.

Teachers will find the Innovation Configuration on Writing, published by the CEEDAR Center to include evidence-based practices in writing that are application to DHH/LD learners, including information about vocabulary instruction, teaching prewriting, and metacognitive reflection. In this document, Troia [74] presents a detailed table of evidence-based writing practices derived from a review of 16 meta-analyses. While these studies are not specific to students who are DHH-LD, this document may suggest potentially effective strategies as well as potential topics for future research. Further it suggests that technology will support the writing performance of students who are DHH-LD. "Technology runs the gamut from basic word processing with grammar and spell checkers to more sophisticated applications such as digital stylus for transcribing notes on a tablet device and then using software to convert the handwritten text to typewritten text, automated scoring of writing samples with feedback and collaborative writing platforms" [74] (Evidence-based practices, writing p. 11). Multi-media instruction will also support students who are DHH-LD to learn to write.

5. d/Deaf/Hard of Hearing with Intellectual Disabilities

According to the American Association on Intellectual and Developmental Disabilities, intellectual disabilities (ID) originate before the age of 18 and are characterized by limitations in (a) adaptive behavior including conceptual skills, social skills and practical skills, and (b) intellectual functioning. An IQ score of 70 to 75 indicates limitations in intellectual functioning [75]. However, the population of individuals with ID is broad, with some individuals requiring limited, intermittent support, and others, more intensive, consistent support [9,76]. In addition, some students with ID have multiple disabilities who, because of the combination of disabilities, often have intensive support needs [2,12,76]. Prematurity is the single most common cause of DHH-ID, however, there are multiple other etiologies including genetic (either syndromic or non-syndromic), causes. One syndrome commonly implicated in DHH-ID is Down syndrome or trisomy 21 [1,9,12]. It is estimated that about two thirds of children with Down syndrome have either a sensorineural or conductive hearing loss [77].

5.1. Assessment and Identification

Identification of ID in children who are DHH is particularly difficult and intellectual disabilities may be under- or over-identified. For example, delays in language and reading might be inappropriately attributed to ID rather than deafness or conversely, in children, with ID, hearing loss might be missed because language delays are attributed to ID rather than possible hearing loss [1,8,12]. It is therefore important that assessments be carried out by an interdisciplinary team comprised of individuals with knowledge of both deafness and ID [1,12]. Further, when using standardized, norm-referenced testing, it is critical that children with DHH be compared to other children who are DHH rather than children who are hearing [1,12].

If undetected and untreated, hearing loss can severely interfere with cognitive, communication, and social development of individuals with intellectual development [1,57,78]. In 2012, Herer [78] published a study in which the hearing of 9,961 Special Olympic athletes with ID across seven sports venues was evaluated [78]. The audiological protocol followed involved ear canal inspection followed by otoacoustic emission (OAE) screening. The hearing of each athlete not passing the OAE was

then further tested using pure tone audiometry followed by tympanometry screening if pure tone testing was failed. Results revealed that 24% of the athletes had previously undetected hearing loss; a rate that is much higher than would be expected in the general population. Of these, 12.8% had sensorineural hearing loss and 10.9% had conductive/mixed loss. Such results suggest that regular hearing evaluations could significantly improve the quality of life of individuals with ID. Moreover, a team approach to audiological evaluation might be necessary to ensure accurate results. In addition, children with ID might need advanced training in play audiometry in order to successfully participate in auditory assessment [1,12,33].

While there is a clear relationship between some etiologies of deafness and the presence of comorbid disabilities, identification of the accompanying disabilities might be delayed [2,25,28]. Chilosi et al. [2] studied 100 children with severe/profound sensorineural hearing loss using a diagnostic protocol that included neurodevelopmental, genetic, neurometabolic, and brain magnetic resonance imaging (MRI) assessment. Forty-eight percent of the sample were found to have one or more additional disabilities. Further, of the 80 children who had MRIs, 37 showed signal abnormalities. The frequency and type of disability were positively correlated with etiology of the hearing loss. The researchers concluded that for children with particular etiologies, assessment that includes brain MRI can detect cortical abnormalities and thereby, contribute to therapeutic intervention.

The link between assessment and intervention is critical to achievement of successful outcomes and improved quality of life of individuals with DHH-ID [1,12] and intervention based on appropriate assessment can contribute to the development of cognition, communication, and literacy skills; skills that are inextricably bound to one another and necessary for high quality of life [13,19,79,80]. However, although research into effective intervention for students who are DWD is low across the disability areas, it is the lowest in the area of DHH-ID [3].

5.2. Communication and Language

Children who are DHH with ID receive and express communication through various means. They may perceive language visually or through the use of assistive hearing devices such as hearing aids and cochlear implants [5,13,26,31]. Expressive communication might be nonsymbolic through facial expressions, gestures, and body movements or symbolic through various sign language systems, spoken language, pictures, and/or AAC [1,5,9,12].

5.2.1. Cochlear Implants

The use of cochlear implants by individuals who are DWD is increasing and concomitantly, an increasing number of research studies examining its effectiveness with the population have been conducted. In a 2008 study, Wily et al. [26] performed a retrospective study of 42 children who received cochlear implants at 36 months of age or younger. Outcomes were measured through an auditory skills checklist that used a combination of parent interview and clinician observation. Findings of the study concluded that regardless of disability type, the children who were DWD made measurable progress in auditory skill development. However, amount of progress was significantly affected by the developmental quotient (DQ) of the children. Children with a DQ of at least 80 progressed at a similar rate to typically developing deaf children. Children with a DQ of less than 80 had approximately half the rate of progress seen in the typically developing deaf children although the rate of progress was commensurate with their developmental delay level [26]. These results are similar to the studies mentioned earlier that found variation in benefit from implantation among disability types [13,41]. A further study by Meinzen-Derr et al. [31] examined post-implant language gains between children with development delays who had cochlear implants and a cognitively matched control group of hearing children. Results indicated that the children with cochlear implants had significantly lower levels of language development than the control group of hearing peers with ID; suggesting that delays were significantly lower than their cognitive potential [31]. Berrettini et al. [81] examined the impact of cochlear implants on speech perception skills using pre-post testing and parent survey

in 23 children with neuropsychiatric disorders. Additionally, the results from ten children with intellectual disabilities were disaggregated and analyzed. The results of all participants were variable but gains were seen in speech perception, communication abilities, and quality of life. The children with intellectual disabilities saw similar gains when compared to other study participants. Of note is that 100% of families reported gains with 74% reporting increases in child speech, 96% in child interaction skills, and 100% in both attention and social skills with classmates [81]. An additional 2014 study by Zaidman-Zait et al. [82] exclusively examined parental perception of cochlear implants in children with a variety of additional disabilities. Parents reported increases in communication skills, enjoyment of music, and safety. Challenges reported were managing the devices, getting children to use them, funding, and multiple appointments [82]. Consistent themes across DHH-ID cochlear implant studies are (a) variation in type of disability, (b) need for knowledge in how to maximize post-implant gains in children with DWD including ID, and (c) recognition of diverse types of benefit that can be attained [13,26,31,41,81,82].

5.2.2. Sign Language and Augmentative and Alternative Communication (AAC)

Augmentative and Alternative Communication or AAC can be broadly divided into unaided and aided types. Unaided types included gestures and signs and aided types utilize an external device. Aided types can be simple devices not dependent on technology (e.g., line drawings, objects) or more high-technology devices that include speech generating devices (SGD) or voice outcome communication devices (VOCA) [1,11,83]. Sign language frequently plays an important role in communication in children with DHH-ID, however, important considerations when teaching sign language are degree of ID, short-term memory skills, ability to physically form signs, and the environment. Therefore, signs may need to be adapted and other communication methods may need to be available to augment sign [9,80]. Such other communication methods might include aided AAC devices. Lee et al. [83] examined the use of a VOCA device with five deaf children with multiple disabilities who had received cochlear implantation and found that use of the VOCA improved speech perception, speech production, receptive vocabulary kills, and communicative behaviors. At preintervention, the children were at a pre-symbolic level of communication and by the end of intervention, all five were able to use the VOCA to express communicative intents [83]. Davis et al. [11] reviewed 14 experimental studies of AAC use among individuals with hearing loss and one or more additional disabilities. Half of the reviewed studies used a non-electronic communication device including photographs, line drawings, or printed words. Of the seven that used an electronic device, six involved an SGD. Most of the participants were teens or young adults which runs contrary to research findings that AAC is more effective when introduced in early intervention before other communication methods fail [84]. An additional finding in the review was that although SGD was used in the studies, only one referenced the issue that the children with DWD might not have access to the speech output. Without such access, the user might not to know if the device was properly working or be able to repair communication breakdown if unable to monitor the communication message [11]. In general, findings of the various studies in the Davis et al., review and the other studies in this section suggest that AAC use does not hamper either speech or sign use but rather increases communication initiation and use. However, there is a need for continued research into AAC use with the population of individuals who are DHH with ID [11,80,83].

5.3. Literacy

The extant research-base on literacy development in children who are DHH-ID is limited to the extreme. However, four studies are of note. The first study blended communication and literacy. Using a low-technology picture dictionary, Highnote and Allgood et al. [80] found students with DHH-ID at a community vocational center were successfully able to use the dictionary to initiate communications. In addition, improvements were seen in spelling of target vocabulary words. The participants also used American Sign Language but since co-workers did not know sign language, the addition of the picture dictionary allowed for increased communications The second study is a pilot study that examined a

curriculum developed at St. Joseph's School for the Deaf that used a reading and writing workshop approach [79]. Participating students ranged in age from seven to twelve and were determined to have significant support needs. The curriculum integrated cognition and literacy development. Lessons in the curriculum were scaffolded and students collaborated with each other throughout. Reading abilities were assessed using a curriculum-based reading assessment and at the end of the study, all students accurately answered reading comprehension questions and had increased ability to illustrate story points through drawing [79]. The third study, a single-case design study by Evmenova and Behrmann [85] included two postsecondary students with Down syndrome who were also hard of hearing. The intervention studied involved the use of video narration, two types of captions (highlighted text and picture/word-based captions, and interactive video searching for answers to questions. Factual and inferential comprehension of non-fiction videos increased through the use of adapted and interactive video clips [85]. The final study examined statewide alternate reading assessment and students who were DHH with cognitive disability [86]. Participants (N = 214) were measured on an alternative assessment that involved three literacy levels. Level A included concrete tasks related to personal experiences, matching, orienting, sorting, and receptive labeling. Level B included picture representation, limited content area vocabulary, and receptive and expressive labeling, sorting, classifying, and identifying function. Level C included symbolic representation using complex pictures, extensive content area vocabulary, and production of responses to open-ended questions. Participant data over a 6-year period were then analyzed. Findings indicated that even though depth of content knowledge increased and test items were, by design, increasingly complex across grade levels, students had a stable proficiency level. However, reading performance of the students with DWD was lower than that of other students with significant disabilities who took the alternative test. The authors posit that this finding supports a multidisciplinary approach to reading instruction that includes special educators, teachers of the deaf, and speech and language pathologists [86]. In summary, from the limited quantity of research specifically examining literacy development and children and youth who are DHH-ID, it is apparent that much more targeted research is needed if teachers are to effectively support the students in attaining crucial literacy skills including those that are early emergent.

6. d/Deaf/Hard of Hearing with Autism Spectrum Disorder

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) defines autism spectrum disorder (ASD) as (a) persistent deficits in social communication and social interaction across multiple contexts including deficits in reciprocity, non-verbal communication, and deficits in maintaining and understanding relationships, (b) restricted repetitive patterns of behavior, interests, or activity including stereotyped behavior, insistence on sameness, highly restricted, fixated interests, and hyper-or hyporeactivity to sensory input, (c) symptoms must be present in early developmental period, (d) symptoms must cause clinically significant impairment in social, occupational or other areas of importance to current functioning, and (e) disturbances are not better explained by intellectual disability or global developmental delay [52]. In 2018, the Centers for Disease Control and Prevention (CDC) estimated that 1 in 59 children have ASD (1.7%) and it is four times more common in boys than girls [87]. The 2013 GRI count reported an incidence of 3% of ASD in the DHH student population [4] and similarly, other researchers have reported a higher incidence of ASD in the DHH population than is found in the population of hearing students [8,25,88] but there is not consensus in the literature of whether prevalence is actually higher [30]. However, it is also thought that the diagnosis of ASD is often overlooked in the population of students who are DHH [25,88] and diagnosis is complicated by the lack of standardized assessment instruments for ASD that are appropriate for the DHH population, difficulties in audiological assessment, overlapping characteristics of ASD and DHH, and diagnostic overshadowing [25,27,28,30,40,88]. The literature base in DHH-ASD is limited but includes identification and assessment [28,30,31,89], social interaction and behavior [90–93], speech development [13,32,41], sign language [94–96], AAC [97], family supports [98,99], and teacher perceptions [34,100]. A search of the research revealed no research specific to literature skills and

DHH-ASD, therefore, what is included in the literacy section below is extrapolated from the literature on ASD.

6.1. Assessment and Identification

Early and intensive intervention is known to be beneficial in ameliorating the impacts of ASD on language, cognitive, and behavioral skills [101] and the average age of ASD diagnosis in hearing children is 56 months. However, in a retrospective review of children diagnosed with permanent hearing loss and ASD, Meinzen-Derr et al. [31] found an average of 66.5 months of age for ASD diagnosis in the DHH population even though many of the children in the study displayed ASD symptoms prior to diagnosis. The authors theorize that speech, language and social development differences were fully attributed to the hearing loss rather than as possible indicators of ASD (diagnostic overshadowing). Diagnosis is further complicated by the lack of diagnostic and screening instruments for ASD that are appropriate for the population of children who are DHH. In a review of 14 ASD assessment instruments, de Vaan et al. [28] found that most ASD assessment instruments did not have norms for children who are DHH and at least a quarter of the test items on the instruments were invalid for the population Therefore, much caution is needed in interpreting such existing instruments and there is an urgent need for instruments that are valid and reliable for use with the DHH population [28,40]. In addition, there is a need for assessors who have training and experience with both individuals with DHH and ASD and if possible, the assessment should be conducted by an evaluator who can communicate in the child's preferred communication modality [40]. Because it is uncommon for professionals to have expertise in both ASD and DHH, professional collaboration in conducting and interpreting the assessment results is necessary [28,40].

Although universal hearing screening has allowed for early identification of hearing loss in many infants, many children with ASD may be delayed in receiving a diagnosis of hearing impairment, and therefore, intervention is delayed [30,88]. In order to maximize auditory assessment results, Beers et al. [30] recommend that the audiological test setting and procedures be modified as children with ASD might become upset in the sound booth. Such suggested modifications include reading social stories about the assessment children prior to assessment, providing picture schedules outlining steps in the assessment, allowing parents or siblings to come into the booth, and allowing breaks as necessary. In addition, parents can introduce headphones at home to accustom the child to wearing them [30,32]. Because behavioral testing results in children with ASD tend to have low reliability, test batteries should include objective measures such as otoacoustic emissions testing and tone-burst auditory brainstem testing [30].

Although many of the symptoms of ASD overlap with DHH including delayed language, pragmatic language difficulties, delayed joint attention, and delayed theory of mind, there are subtle differences that can distinguish the two [25,40,89]. Children who are DHH and receive appropriate early intervention will have a language development trajectory that is more typical than is seen in children with ASD. In addition, delay of theory of mind is not as pronounced in children with DHH as it is in children with ASD. Further, children who are DHH alone also do not exhibit the difficulties maintaining social relationships that are seen in children with ASD. Patterns of stereotyped movements and rigidity in schedules are also not characteristic of children who are DHH without ASD [40,96]. Finally, in addition, to language and communication differences noted in the language section below, Kellogg et al. [89] found that children with ASD had delays in symbolic play not typically seen in children DHH without ASD and two of the three participating children in their study of children with DHH-ASD, lost skills over time.

6.2. Communication and Language Development

As detailed below, recent research on receptive access to communicion for children who DHH-ASD has primarily focused on effectiveness of cochlear implantion. A relatively large body of research on expressive communication has centered around the use of sign language and AAC.

6.2.1. Cochlear Implants

Historically, DHH with associated ASD was considered a contraindication for receiving a cochlear implant because of additional difficulties in language and communication. However, increasing numbers of children who are DHH-ASD are now receiving implants. Results on its effectiveness in improving speech and language have been mixed as might be expected in a disorder as broad as ASD [31,102,103]. In a 2004 study, Donaldson et al. [103] found that children who could complete standardized receptive and expressive vocabulary tests did see improved scores, and children who could not complete the tests, improved in raw scores when compared with themselves post-cochlear implantation. Researchers have therefore concluded that open set speech may not be a primary goal but rather, becoming more engaged with the environment through sound, recognizing parental voices, and having increased safety and quality of life [31,103]. In addition, more knowledge of rehabilitation [102] and multi-system communication including speech, sign, and AAC post-implantation is needed [31].

6.2.2. Sign Language and AAC

Several recent studies have examined sign language and children who are DHH with ASD. The participating children in the studies were from families of Deaf signers and exposed to sign language from birth. Shield and colleagues conducted three studies looking at palm reversal, pronouns, and sign language echolalia in children who are DHH with ASD [96,104,105]. In the first study that examined palm reversal, Shield and Meier [105] found that the three participating children with DHH-ASD demonstrated errors across several sign parameters including location, handshape, movement, and palm orientation at a higher rate than would be expected in children who are DHH. More than half of the errors were in palm orientation including palm reversal of finger spelled words which was not seen in a comparison group of DHH students. Such reversals suggest that the children with DHH-ASD were producing the sign from their own perspective rather that reversing the palm. In the second study, Shield, Meier, and Tager-Flusberg [104] looked at the use of sign language pronouns by children who were DHH-ASD. Conclusions drawn from the study were that the children were able to point but avoided using pronouns in favor of names. Children with higher language skills were more likely to point. This finding is surprising giving that sign pronouns are often transparent and involve indexical point to self or others. The third study by Shield et al. [106] examined sign language echolalia in children who are DHH-ASD [96]. Echolalia or repeating the utterances of others has been shown to occur in the majority of verbal hearing children with ASD in early childhood. As language skills increase, echolalia decreases. Although the participating children in the Shield et al. study were older, 7 of the 17 children with DHH-ASD showed evidence of manual echolalia and the children who produced echolalic signs had lower receptive language than those who did not. Age, intelligence, and severity of ASD were not related to the echolalia, but rather the relationship appeared related to language comprehension. Results of this study indicated that the children were repeating signs with little comprehension as evidenced by frequency in errors of directionality (e.g., child imitated outward movement of adult's sign as outward movement from the child), reduplication (e.g., several repetitions of the sign for more), and timing (e.g., children repeated signs at the same time the adult was signing). Similar to children who are DHH alone, echolalia was seen less frequently in children with higher linguistic skills. Across the studies, significant differences between DHH children and DHH-ASD children suggest that palm reversals, paucity of pronoun use, and echolalia are characteristics of ASD rather than deafness.

Deaf individuals use their hands, face, eyes, and body to convey a wide range of emotions, but the hands and the face are particularly important [95]. In 2014, Denmark et al. [95] studied facial emotional comprehension of 12 individuals who were DHH and 13 individuals with DHH-ASD using videotape of an individual signing. In one videoed sequence, only the hands of the signer were visible, in the second, both hands and face were visible. They found that the DHH only group identified more emotions when both hands and face were visible, and in both conditions, the DHH only group correctly identified more emotions than the DHH-ASD group. A follow-up study by Denmark et al. [107]

found that participating children with DHH-ASD produced fewer facial expressions when retelling a video story using sign language than did a peer group who were DHH only. Salient and common expressions such as surprise and disgust were shown by the children with DHH-ASD more than other expressions that involved more complex theory of mind. The findings of these studies suggest that children with DHH-ASD might need particular intervention on how to interpret and convey emotional information [107]. In addition, support in developing theory of mind might be needed.

A final study by Bhat et al. [94] looked at differences between praxis performance and receptive language of native signing Deaf children with and without ASD. Praxis performance was observed in finger spelling using American Sign Language. The participants with DHH-ASD had lower receptive language scores than their peers who were Deaf alone. They also made more praxis errors and were slower in finger spelling. Praxis errors included errors in sequencing, body part use, orientation of fingers, and movement space. Errors involving proximal joints were also more frequent. The authors suggest that findings indicate a need for motor interventions and the use of complementary communication strategies such as visual pictures.

It is estimated that up to 30% of children with ASD have very limited expressive language [108] and the Shield et al. study found a similar percentage of non-verbal children with DHH-ASD [104]. Therefore, as suggested above, an additional communication modality is often necessary for many children with the dual diagnoses. Malandraki and Okalidou [97] described the usage of the Picture Exchange Communication System (PECS) [109] in a case study of a child with DHH-ASD. In the study, PECS was modified through replacement of verbal reinforcement, prompts, and trainer responses with multi-modal communication, gradual replacement of pictures with written words, and greatly increased intervention time. Preintervention, the ten-year-old participant had limited and non-functional communication. By the end of the four-month training period, the child was using the PECS communication book spontaneously. In addition, he demonstrated increases in play and interaction with peers, increased vocalizations, and decreased stereotypical movements. The use of such visual communication systems is supported by the research of Maljaars et al. [110] suggesting that individuals who are DHH with both ID and ASD have enhanced visual perception when compared to hearing individuals with ID. Further, individuals with low adaptive functioning and ASD, with and without hearing loss, have enhanced visual perception.

6.3. Literacy Development

Unfortunately, there is a dearth of research on children who are DHH-ASD and therefore, educators must look to research on children who are DHH, children who are d/Deaf with disabilities other than ASD, and the field of ASD. As noted previously, the population of children with DHH-ASD is very broad and there is not a one size fits all instructional model for the population. It is plausible, that depending on severity of ASD, strategies suggested in the DHH-LD section of the article could be helpful.

In looking at emerging literacy in particular, it is also likely that many of the evidence-based visual strategies used with hearing children with ASD for communication, behavior, and social development such as picture symbol systems [97,109], picture schedule systems [111–113], social stories [114–116], and video modeling [92,117,118] might have the concomitant effect of helping children with DHH-ASD along the path to literacy as they promote attention to pictures, tracking print and pictures from left to right, and story comprehension. However, the take-away point in this section is that an evidence-base is needed in order to teach effectively teach literacy and emergent literacy skills to children who are DHH-ASD.

7. Deafblindness

Deafblindness is defined in the Individuals with Disabilities Education Act (IDEA 2004) as "concomitant hearing and visual impairments, the combination of which causes such severe communication and other developmental and educational needs that they cannot be accommodated in

special education programs solely for children with deafness or children with blindness" (IDEA 2004, p. 46756) [37].

Like deafness, deafblindness may be congenital or adventitious. Deafbindness reduces access to sensory information and incidental learning, while also impacting motor development, engagement in daily activities, concept development, communication, and language [39,119,120]. Vision and hearing are the distance senses for learning; thus, the impact of having reduced functioning in both distance senses cannot be understood by adding up the impact of the hearing loss and vision loss; rather the impact is sometimes described as multiplicative [121].

According to the 2017 National Child Count of Children and Youth who are Deaf-Blind [122] that presents the census data from state deafblind technical assistance projects, there are 10,000 children and youth, ages 0–21 years, identified as being deafblind in the United States. Of these, 4590 have either a moderate-severe, severe, or profound hearing loss and 1098 have cochlear implants. Low vision is the most common category for visual impairment, with 3204 identified, and another 2449 being identified as legally blind. An additional 1050 children have either light perception only or total blindness. The vast majority of children identified have some functional hearing and/or vision to support the development of language and literacy. The most commonly identified cause of deafblindness is complications of prematurity, followed by hereditary syndromes. Additional disabilities complicate learning with 87% of the children and youth having at least one additional disability and 43% having four or more additional disabilities. According to this census, the most common additional disabilities are speech-language impairments, cognitive impairments, and orthopedic or physical impairments. The racial and ethnic diversity mirrors that of the U.S. population. In short, this is a small population of great heterogeneity.

7.1. Assessment and Identification

Identification of deafblindness is dependent on medical and school professionals understanding the IDEA definition of deafblindness. Hearing loss is usually identified early through newborn screening [1]; however, early identification of deafblindness continues to be a problem, with half of the children on the national census identified after the age of five years [122]. Children who are deafblind may not respond to behaviorally based vision and hearing testing. In many cases, they will require an electrophysiological test, such as the auditory brain stem response test, to identify auditory thresholds [120]. They will require an extensive set of vision tests to identify their acuity, visual field, and the potential presence of cortical visual impairment. Additionally, they require conduction of both functional hearing and vision assessments across familiar daily activities and environments for the purpose of determining how they use their hearing and vision in daily life. Children who are deafblind need to be identified as early as possible to avoid more severe developmental consequences. They must then be served by professionals who understand the interactive effects of their complex disabilities. These children will benefit from early intervention programs that emphasize the use of residual vision and hearing, and the development of tactual skills to support the development of concepts, communication, language, and literacy.

7.2. Communication and Language

The field of deafblindness generally follows a developmental and child-guided approach to communication intervention. The van Dijk approach to assessment and communication intervention has been adopted internationally and is intended to support the development of presymbolic to early linguistic communicators. Van Dijk's approach emphasizes the establishment of trust, responsiveness to the child's communicative attempts, sharing of emotional states, communicating using the child's expressive forms, building different types of conversations based on the child's interests, coactive techniques (including coactive movement routines), sequential memory strategies, the use of drawings, and the achievement of symbolic understanding and expression [123–126]. Early conversations are

sensitive to the child's emotional state and need for safety, focus on the child's preferred topics, integrate the use of movement and objects, and establish turn taking [125,127].

Communication and language intervention are based on thorough assessment. The Communication Matrix [128] measures seven developmental levels, from preintentional behavior to early language, including the growth from unconventional to conventional communication. The assessment results in a profile that supports the educational team to plan individualized interventions [129]. Comprehensive communication programming will address expressive and receptive forms, intents and functions, content or vocabulary, and context (including the physical environment, activities and routines, communication partner skills, and pragmatics [46].

In calculating the level of evidence for research-based practices in visual impairments, DHH, and deafblindness, Ferrell, Bruce, and Luckner [130] found that research on communication was an area of relative strength in deafblindness. The reader is referred to Ferrell et al. for a complete explanation of how each evidence level was defined. Research evidence for the child-guided approach and its role in promoting conversation is at the limited level, with the exception of its application to improving communication partner skills, which is now at the moderate level due to studies by Janssen and colleagues [46]. There is a moderate level of evidence for applying principles of systematic instruction for increasing rate and the variety of communicative intents/functions, and vocabulary [130]. There is also a moderate level of evidence for the role of tactile approaches and strategies (see [131,132]), including the use of touch cues, tactual materials, attending to the use of the hands in learning, tangible representations or symbols, in improving communication [133].

7.2.1. Cochlear Implants

Auditory perception, communication, and speech are valued outcomes of cochlear implantation [134]. There are differences in the outcomes valued by parents of children who are DHH and parents of children who are deafblind. Across studies, parents of children who are deafblind report that they value non-speech outcomes, such as evidence of "improvements in attention; interactions with objects; listening, which may break down isolation and enhance engagement; responsiveness; increased awareness of environmental sounds, which may improve safety; and increased vocalizations" [130] (Evidence-based practices, p.68). The outcomes of cochlear implantation in children who are deafblind vary greatly; however, there are etiological outcomes patterns and other predictor variables that should be shared with parents when they are considering the possibility of cochlear implantation [130]. Parents need direct instruction about the potential benefits of cochlear implants, how to conduct daily checks on their functioning, and instructional strategies to support their use [135].

7.2.2. Augmentative and Alternative Communication (AAC)

Children and young adults who are deafblind use a range of expressive and receptive communication forms, including objects, partial objects, textures, photographs, line drawings, gestures (invented and conventional), signs, sign language, spoken language, and speech generating devices. The educational team will consider the learner's characteristics, including vision, hearing, tactual skills, and motor skills when selecting receptive and expressive forms. Many children who are deafblind use tangible representations or symbols to communicate. Tangible representations are iconic, meaning they share a physical resemblance to the referent (what they represent). This shared resemblance may be visual or tactual. Tangible representations include photographs, pictures, objects, and partial objects. Rowland and Schweigert [136,137] developed interventions that demonstrated how to use tangible representations in daily schedules and within daily routines. Object cues are object representations that are used receptively; whereas touch cues are tactual hints about something that is about to occur (such as gently touching the face with a washcloth, just prior to washing).

Sign or sign language is another frequently used form of communication by individuals who are deafblind. Child characteristics, such as vision, size of hands, and learning style impact how signs are introduced. The adult may model the sign or present the sign (for the child to see and touch) and

then shape the sign on the child's hands. The adult may be positioned face-to-face or behind the child (in which case the child may be able to perceive how the signs are formed more easily [138]). Children with Usher syndrome may change how they respond to receptive sign language, requiring tracking of the hands or differences in signing space. Use of signs involves understanding their handshape, orientation of the sign to the body, movement of the sign, sense of touch if using tactual sign, and balance [139].

Language and culture are intertwined. Souria [140] explained that the cultural sign language of individuals who are deafblind is not static, but is rather a "language in the making" (p. 21) because it is not learned through sharing language with others who are deafblind. Instead it borrows from other languages, such as modifying signs used by the Deaf. Sign language for individuals who are deafblind is co-constructed with their communication partners and includes signs that were invented by the individual who is deafblind.

7.3. Literacy

The field of deafblindness has adopted an expansive definition of literacy to include communication and the application of low and high technologies to support interactions and conversation [46]. "A new, more inclusive view of literacy includes all learners [141,142], begins at birth [143], and recognizes that the materials and media of literacy differ across learners" [130] (Evidence-based practices, p. 76). Emerson and Bishop [144] referred to literacy that is experienced though technology as the new literacy. Miles [142] discussed the social aspects of literacy, and the benefits to both the child who is deafblind and to society which will benefit from knowing more about the thoughts and experiences of individuals who are deafblind. The state of evidence for literacy practices in the field of deafblindness is at the emerging level, relying on professional literature with few intervention studies to inform practice [130].

Literacy is grounded in a rich array of experiences involving many opportunities for hands-on learning [142]. All children benefit from literacy rich environments in the home and school. For children who are deafblind, this would include books in print and braille, auditory books, tactile books, accessible labeling of literacy materials, interactive software, and adapted commercial books [145]). In a 2019 study of emergent literacy materials and strategies in classrooms with students who are deafblind or with multiple disabilities and visual impairment, McKenzie found that teachers most often provided lessons on the daily news, morning circle, read alouds, and schedules. Supported writing activities, shared reading, and choice-making were offered less frequently. She suggested the need for literacy centers, accessible labeling, increased read alouds, opportunities to scribble, increased IEP objectives on literacy, and a learning media assessment to determine the best medium for presenting and producing literacy to each child [145].

Literacy approaches in deafblindness are both individualized and personalized [146]. Individualization includes the selection of materials, approaches, and technologies that match the strengths and needs of each child. Personalization includes readings and writings about the child's preferences and his experiences, thus greatly reducing memory load. Literacy lessons in the field of deafblindness include daily schedules and calendar systems, story boxes, experience stories, journals, choice-making opportunities [133], and shared reading. Teacher-made materials will be important to personalizing the literacy program and to ensure that text is at the correct level [147].

The daily schedule, which may be expressed in multiple communication forms, provides opportunities for the child to learn about sequence, left to right displays, representations of daily events, locations, and people [148,149] while providing enhanced predictability to the child's life. The daily schedule is far more than a tool to support transition between activities. Before and after each represented activity, the child should engage with the schedule and share a conversation about each activity. In this way the child practices the representations for common daily activities, learns key vocabulary, and shares conversations rooted in daily events. Often representations in the daily schedule appear in two or more communication or literacy forms, such as objects with print and braille labels.

Story boxes are collections of objects that relate to the content of a personalized or commercially produced book. They allow the child an opportunity for additional tactual information about the text. Closely related, experience books which are also known as memory books, are texts about something the child has experienced, such as a trip to the zoo. The representations must be salient, e.g., capture what was most significant to the child about that particular experience (as opposed to what hearing and sighted people found to be salient). These personalized forms of literacy are co-constructed with the child, often include labeling in print and braille, and are enjoyed with others through with repeated shared readings [133,150].

Interactive journals, also known as home-school books, allow an adult at home or school to engage in shared reading with the child who is deafblind about an event that occurred in the other environment and associated vocabulary [147]. This is important to building distancing across time and space, a necessary milestone to the development of language [151]. Bruce and Conlon [152] described a school-home journal with pages that included an object representation, an auditory device with a simple message the child could repeat, and print and braille labels. Like experience books, interactive journals are a form of personalized literacy that reduce cognitive load.

Most classrooms provide daily opportunities for children to make choices. The challenge is to ensure that choice-making is authentic, e.g., the child actually selects a preferred option. This requires that the child has preferences, has experiences that are referenced by the representations, is presented with accessible options, comprehends the specific representations for the presented options, and has a clear indicating response [133,153].

Children who are deafblind have far fewer opportunities to observe why people engage in writing due to reduced observation. Therefore, they need adults who will communicate with them about the purposes of daily writing activities and include them in creating drawings and writings. Early expressive writing experiences will include writing one's name and the names of a few other people important in the child's life, words on the daily schedule, and words that represent preferences [147]. Later, the child may engage in writing about personal experiences and may co-construct journals and other literacy materials.

Some children who are deafblind will become braille readers and writers. Steinman, LeJeune, and Kimbrough [154] presented Chall's [155] reader-based, or top-down, developmental approach to print and braille literacy. Braille reading is more cognitively demanding than print reading because braille is cognitively processed one cell at a time; whereas multiple print characters can be processed at the same time [154]. Thus, it takes a significant number of years to completely master the braille literacy code, and longer for the Nemeth code for mathematics. The American Printing House for the Blind is a resource for pre-braille curricula and materials, as well as specialized curricula for the instruction of braille literacy. Additional literacy resources include the Paths to Literacy project (www.pathstoliteracy) and Project Salute (www.projectsalute.net).

8. Recommendations for Practice and Research

8.1. Recommendations for Practice

Despite the heterogeneity of the population of students who are DWD, there are several implications for practice across the disabilities. Due to the importance of early identification of both hearing loss and disabilities, practitioners must be aware of current assessment practices and be knowledgeable about learner characteristics that should evoke a referral to initiate an evaluation for a disability. Communication and language development are frequently delayed in children with DWD and may take varied forms depending on the needs of the children. However, it is essential to quality of life and learning. Therefore, teachers should be prepared to support communication development across forms and in children with a variety of learning and physical needs. Further, assistive technologies must be selected based on the unique needs of each DWD learner and a plan developed to support their implementation across environments. Depending on severity of disabilities, literacy development may

need to be seen in a broad context with the understanding that text reading and literacy may not always be synonymous. Teachers must be skillful in the implementation of both child-guided and systematic instructional approaches, and of common literacy lessons such as calendar systems, shared reading, and experience books. In addition, practitioners should be knowledgeable about major approaches to traditional reading and writing (text-based, subject-based, and compensatory-interactive), the relative merits of each, and the nuances of implementing each approach with a child who is deaf with an identified disability. This is especially true given that most approaches used with children who are deaf are visually-based, but vision may not be functional or a preferred learning modality for some learners who are DWD. Finally, it is critical that teachers appreciate that the effects of being deaf with a disability are best understood as being complex and interactive. The complex needs of learners who are DWD call on teams to engage in interprofessional collaborative practices.

8.2. Recommendations for Research

Although there is a growing body of literature about assessment for identification of a disability, there is a need for research on how to assess learners who are DHH with specific disabilities to determine individualized instructional programming and provide ongoing measurement of learning progress. While the research evidence is relatively strong in the area of communication for learners who are DHH with ASD or who are deafblind, there is an ongoing need for additional research on communication and language in learners who are DHH with ID or LD. There is a dire need for research on teaching traditional literacies (reading, writing, and spelling) to children with each of the disabilities that may co-occur with deafness. This research is critical to the development of literacy curricula. Further, there is a continued need to understand how technologies can support learners who are DWD in receptive and expressive communication across communication forms, and in traditional literacy. Finally, research teams will need to continue to document how outcomes associated with the implementation of assistive technologies vary across learners who are DWD and are different from the outcomes experienced by learners who are DHH.

9. Conclusions

Students who DWD are diverse, but because of the complex and interactive nature of their disabilities, share a need for interventions that specifically target communication and literacy. Evidence-based interventions from the different disability areas may be applicable and effective, but their use must be tempered by consideration of sensory and learning characteristics of individuals who are DWD. As seen in the sections above, the research base on DWD is increasing, but there is much to be known in terms of prevalence, identification, assessment, and evidence-based practices in communication and literacy across the disabilities. Moreover, there is a strong need for teachers of the DHH to be prepared to teach DWD learners in order for students who are DWD to achieve maximization of potential.

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Review

Assistive Hearing Technology for Deaf and Hard-of-Hearing Spoken Language Learners

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Abstract: Radical advancements in hearing technology in the last 30 years have offered some deaf and hard-of-hearing (DHH) children the adequate auditory access necessary to acquire spoken language with high-quality early intervention. However, meaningful achievement gaps in reading and spoken language persist despite the engineering marvel of modern hearing aids and cochlear implants. Moreover, there is enormous unexplained variability in spoken language and literacy outcomes. Aspects of signal processing in both hearing aids and cochlear implants are discussed as they relate to spoken language outcomes in preschool and school-age children. In suggesting areas for future research, a case is made for not only expanding the search for mechanisms of influence on outcomes outside of traditional device- and child-related factors, but also for framing the search within Biopsychosocial systems theories. This theoretical approach incorporates systems of risk factors across many levels, as well as the bidirectional and complex ways in which factors influence each other. The combination of sophisticated hearing technology and a fuller understanding of the complex environmental and biological factors that shape development will help maximize spoken language outcomes in DHH children and contribute to laying the groundwork for successful literacy and academic development.

Keywords: digital hearing aids; cochlear implants; spoken language development; biopsychosocial systems theory

1. Introduction

Assistive hearing technology for deaf and hard-of-hearing (DHH) children has seen great advancements in the last 50 years. Certainly, there are educators nearing retirement who remember when young DHH children regularly wore body aids and there are mid-career educators who remember when DHH children wore large, analog, linear hearing aids as the standard, or even just one hearing aid, despite having bilateral hearing loss. Today, there are no children in US classrooms wearing body aids and very few wearing analog, linear hearing aids that dangle below their earlobes. Technology has come a long way not only in form, but also in function. While form certainly matters (many children like the flexibility of being able to add stickers to their devices, wear hearing aids that are the same size as or even smaller than their ears, and select multi-colored earmolds—so do some adults!), radical advances in hearing technology has opened the door to the possibility of spoken language development for many (but not all) DHH children whose parents desire it.

This review focuses on current-day hearing technology for children with permanent hearing loss, also known as sensorineural hearing loss. Typically, this type of hearing loss is due to damage to the cochlea but can also include damage to the auditory nerve and, occasionally, structures in the central auditory system. Sensorineural hearing loss not only results in reduced audibility, but also reduced spectral resolution (frequency or "pitch" is not heard as clearly as it is with typical hearing), poor temporal processing (difficulty following changes in sound that occur over time),

reduced binaural abilities (using both ears in tandem for locating where a sound originates in space and listening effectively in background noise), and loudness recruitment (an abnormally fast growth in loudness—the perception of intensity—of sound) [1]. The combined effects of sensorineural hearing loss on speech perception are far reaching. First, not all speech sounds (or phonemes) are equally audible. Soft sounds, such as the "th" in the word "thawed," will likely be inaudible. Depending on the degree (mild to profound loss) and configuration (shape of the loss—flat or sloping) of the hearing loss, some moderate-level sounds (such as the "d" in "thawed") could be inaudible as well. Louder sounds, such as the "aw" in "thawed," could be audible, but for those with more severe losses, will also not be audible. Very loud sounds will reach uncomfortable levels quickly, further reducing the range over which listeners have usable hearing (their dynamic range). Furthermore, distortion caused by reduced spectral resolution and temporal processing can cause even audible sounds to be difficult to understand and loud sounds can be further distorted. Reduced audibility and binaural abilities and poor temporal and pitch processing can all cause difficulty listening in background noise. Hearing technology is very good at addressing reduced audibility and is an "engineering marvel" [1] (p. 207). However, reduced dynamic range (particularly in the case of listeners with severe-to-profound hearing loss), and temporal and spectral resolution are some of the biggest challenges in successfully fitting listeners with hearing technology. The remaining challenge, or what many refer to as the "holy grail" [2] (p. 36), is addressing listeners' difficulty hearing in background noise.

The two primary types of hearing technology used by school-age children are hearing aids and cochlear implants. Hearing aids and cochlear implants each take fundamentally different approaches to delivering acoustic signals to the listener. Hearing aids amplify signals and transmit them to the listener's ear canal, whereas cochlear implants convert the acoustic signal into pulses of electrical current that are emitted directly into the listener's organ of hearing—their cochlea. The electrical pulses stimulate neural units from the auditory nerve along a portion of the cochlea. Those neural units then propagate information from the signal up the auditory pathway to the auditory cortex in the brain. The reason cochlear implants directly stimulate auditory nerve fibers is because they are intended to bypass irreparably damaged structures in the cochlea of listeners with severe-to-profound sensorineural hearing loss. In other words, cochlear implants are intended for listeners who do not benefit from hearing aids.

2. Hearing Aids

There are many ways to classify hearing aids: by where they are worn on the body, by the type of amplifier they use, by the type of signal processing they employ, by their size, or even by a combination of these factors. For modern hearing aids, most are worn on or in the ear. There are implantable styles of hearing aids but many of them are not yet Food and Drug Administration (FDA)-approved for widespread use in young children, so we will concern ourselves with hearing aids that are worn on or in the ear, because they are the most commonly encountered ones today with children. Hearing aids that are custom fit to sit inside the ear canal or in the "bowl" of the ear around the entrance of the ear canal are not typically worn by children. There are several reasons for this: (1) children's ears are constantly growing, particularly quickly when they are infants and toddlers, through to 8–10 years of age [3]. This style of custom hearing aid would require constantly re-casing the hearing aid to keep up with ear growth, which is impractical. (2) Often times these styles of hearing aids cannot couple with digital modulation (DM) systems used in classrooms. Therefore, far and away the most common style of hearing aid used by school-age children, toddlers, and infants are behind-the-ear (BTE) hearing aids [4]. BTE hearing aids include the standard style, which contains an ear hook that connects the hearing aid to an earmold that delivers the amplified signal to the ear canal. The ear hook sits on top of the ear and allows the hearing aid to hang behind the ear (hence the name of the device). This style of BTE is the most flexible and durable hearing aid on the market. Another style of BTE moves the receiver from the casing behind the ear to inside the ear/ear canal (RITE/RIC). RITEs/RICs use the same type of BTE casing that sits behind the ear, but rather than the traditional

tubing used on standard BTEs, they use a thin "wire" (plastic, not metal) that connects to a flexible plastic "dome." Domes are offered in various sizes depending on the degree of hearing loss and size of the ear canal. The less severe the hearing loss, the smaller the dome and the more porous the dome can be. RITE/RIC technology grew out of the confluence of noise suppression technology and the ability to miniaturize hearing technology [5]. The result is hearing technology that minimally occludes the ear canal without feedback (that squeal that can be heard when an amplified acoustic signal is fed back into the microphone). BTEs as a group vary in size, but in general are the largest of the ear-level devices (hearing aids that are worn on or in the ear), thereby making them quite durable, usually with larger and thus longer-lasting batteries than other styles that use smaller batteries.

As mentioned earlier, most children are fit with standard BTEs [4]. Some audiologists have been fitting RITEs/RICs on children after they found success fitting them on adults, and manufacturers have recently marketed RITEs/RICs for children. However, few peer-reviewed studies have been carried out with these devices to evaluate their efficacy in children. Concerns that have been raised about their use with children include [5]: they may not include a telecoil or direct audio input, which allows them to couple to audio and assistive listening devices; they may not be compatible with DM systems in the classroom; the cost of replacing the coupling system as the child grows (particularly RITE receivers) can be significant; a lack of durability for some devices can be of great concern with children who tend to be hard on technology; smaller battery size means a shorter battery life; the potential for transient middle-ear problems is great in the pediatric population, as is progressive hearing loss for some children, and the open fit combined with the gain algorithms used do not provide amplification below 1000 Hz—combined, this could result in inadequate amplification for children in the mid-to low-frequencies. Finally, probe mic measurements are vital with RITEs/RICs in children because fitting ranges for open-fit hearing aids are based on measurements from couplers (hard-walled closed cavities), which do not approximate gain well, particularly in the low frequencies. In summary, more research is needed on the efficacy of RITEs/RICs in the pediatric population.

BTEs (or any style of hearing aid, for that matter) employ an amplifier (the component that increases the strength of the acoustic signal). Amplifiers are either linear or nonlinear. At any given frequency, a linear amplifier amplifies an acoustic input by the same amount, regardless of the level of the input or what other sounds are present; a nonlinear amplifier varies the amount of amplification depending on the level of the input signal. Finally, most hearing aids use digital signal processing (much like a CD player or iPod) and many utilize wireless technology for certain applications. Digital signal processing takes a continuous electrical signal (an analog signal) and converts it to numerical values that occur at discrete moments in time. The virtue of this processing is that it allows the development and application of algorithms that can do mathematical manipulations of those numbers in ways that cannot be done with analog processing. In this way, digital signal processing has opened the door to many sophisticated processing algorithms for addressing problems that listeners with sensorineural hearing loss experience, such as problems listening in background noise.

2.1. Basic Components of Hearing Aids

All hearing aids, regardless of type, contain the same basic parts:

- A *microphone* or multiple microphones to convert the acoustic signal into an electrical signal
- An *amplifier* to differentially increase the power of the electrical signal across frequencies
- A *receiver*, which is like a small loudspeaker, to convert the electrical signal back into an acoustic signal
- A *battery* to provide power to the amplifier

2.2. Signal Processing in Hearing Aids and Spoken Language Outcomes in School-Age Children

Likely, the area of hearing aid design of most interest to educators relates to how hearing aids address background noise. Background noise consists of any deleterious sound that interferes with the

ability to hear and understand the signal of interest. Most background noise sources include heating, ventilation, and air conditioning (HVAC) systems, fluorescent lights, other children in the classroom, next-door classrooms and hallways, noise from the outdoors (cars, airplanes, playground, etc.), chairs and desks sliding on the floors, and classroom pets. Background noise negatively affects spoken language processing (e.g., [6–8]) and academic achievement [9,10] in school-age children by interfering with the signal of interest, which is often the teacher in a classroom setting but can also be the student's classmates during classroom discussion or other peer interactions. Unfortunately, classroom noise levels vary from −7 to +10 dB SNR across studies [11,12], despite the recommended level being +15 to +30 dB SNR [13]. SNR stands for "signal-to-noise ratio," which is a misnomer, because it is not a ratio, it is a difference value. SNR refers to the difference in level between a signal of interest and the ambient noise in the environment. In this case, it refers to the average difference in level between the teacher's voice and the ambient noise in the classroom environment. If the SNR is +2 dB, it means the teacher's voice is 2 dB more intense than the noise in the classroom, if the SNR is 0 dB, it means the teacher's voice and the noise are equal in level, and if the SNR is −2 dB, it means the teacher's voice is 2 dB less intense than the noise in the classroom. Based on the data from these classroom noise studies, even the most acoustically friendly classrooms still have background noise levels that are 5 dB too high for ideal learning. These noise levels are detrimental for spoken language processing and academic success for all students. However, they are particularly problematic for children with hearing loss who are already at risk for missing auditory information. Further, children are not the only ones experiencing difficulty in typical American classrooms. Teacher vocal fatigue can be a byproduct of having to overcome the high noise levels in classrooms, which can lead to vocal nodules and other overuse injuries to the vocal folds. Current hearing aids address background noise in two different ways. The first is by using directional microphones and the second is by using digital noise reduction technology.

3. Directional Microphones

In BTE hearing aids the microphone(s) sits on the plastic case just above the ear, collects acoustic signals, and converts them into electrical signals. Hearing aid microphones can be omnidirectional, meaning that they collect signals equally 360 degrees in a plane around them, or directional, meaning that they suppress signals coming from a specific direction (typically from behind the listener). The reason directionality might be employed is based on the assumption that the majority of the auditory signals of interest are thought to originate from in front of the listener (e.g., a friend talking with a child or a teacher giving a math lesson, etc.). To the degree that this is in fact true, reducing the amount of sound coming from behind the listener (e.g., background noise that could interfere with the signal of interest) that gets processed by the hearing aid from the outset could provide an enhanced signal for the listener. Directional microphones improve the SNR by 2–3 dB [14]. However, for directional microphones to provide this small increase in audibility, the child either needs to orient themselves toward the signal of interest regularly and/or their automatic directional algorithm needs to reliably detect from where the signal of interest originates and respond appropriately. Ching et al. [15] reported that both hearing and DHH 1- to 6-year-olds only look at the talker approximately 40% of the time. However, recent findings suggest that despite rarely looking at the talker (using eye-tracking), school-age children are able to follow auditory instructions in a behavioral task, with hearing children outperforming DHH children [16]. In sum, children look at the signal of interest less than half of the time, including those with hearing loss [15–17]. These results suggest that children with hearing aids will not naturally benefit from directionality a good portion of the time. However, directional microphones have not been demonstrated to negatively impact speech perception and thus, are routinely recommended for pediatric hearing aid fittings [4,18].

4. Digital Noise Reduction

Digital noise reduction encompasses a wide array of signal processing strategies intended to categorize what components of a signal are speech and what are noise, and to reduce the amount

of gain the hearing aid provides when it detects primarily noise. The vast majority of research on digital noise reduction to date has been completed on adults. Those data suggest that digital noise reduction does not improve listeners' spoken word recognition, nor does it hamper it, rather, it makes the listening experience more pleasant under high levels of noise (e.g., [19]). Similarly, in the few investigations that have been carried out with DHH children, digital noise reduction did not enhance nor hinder spoken word recognition [20], nor children's ability to learn novel words [21]. Therefore, digital noise reduction requires further research before strong conclusions can be made regarding its impact on spoken language development in children.

Perhaps the most promising work to date to address listening in noise has been carried out by Healy and Wang and their colleagues. They have developed a novel algorithm to cleverly segregate the speech signal of interest from background interfering speech (which is often the source of background noise) that has demonstrated significantly improved speech intelligibility for adults in laboratory settings (e.g., [22]). Tests of this algorithm on ear-level devices (e.g., hearing aids and cochlear implants) are forthcoming. It will be exciting to test this algorithm with children at some point in the future.

5. Prescribing Gain: The Importance of Audibility

The primary goal of hearing aids is to restore audibility to DHH listeners. For the purpose of developing spoken language, restoring audibility is often described in reference to the speech signal: the goal is to make the long-term average spectrum of speech (LTASS) audible. Full access to the speech signal is the first of many steps in providing children the necessary input required to begin developing spoken language [23]. Prescriptive fitting rules that are used for calculating how much gain to prescribe by the amplifier at each frequency are concerned with making the LTASS audible, but not uncomfortably loud. In laboratory settings, there tends to be little difference in average speech intelligibility, language, and speech production across the available fitting rules that are used explicitly with children (e.g., [24]). However, reports in real-world clinical settings suggest that less than half of children's hearing aids are fit such that at least one ear is within +/− 5 dB of their prescriptive gain targets and that the rate of poor match-to-target increases at higher frequencies (e.g., [25,26]). These findings hold true regardless of the degree of hearing loss. Results such as these suggest that there is important work to be done in fitting and verification of pediatric amplification. If children do not have access to the signal of interest—speech—it clearly makes the task of learning spoken language exponentially harder. Once the hearing aid fit is verified in the clinical setting, validating it in the classroom setting not only ensures that the child's hearing aid meets their everyday needs in their learning environment(s), it also confirms for both their caregiver(s) and teacher(s) and that they have adequate access to the LTASS, and maximizes the partnership between audiologists, families, and school personnel. A word of caution that brings us back to the beginning of this section on audibility: full access to the LTASS is the first of many steps in achieving spoken language competency and academic growth; it is a necessary first step, but much more therapy and education is required.

Stelmachowicz and colleagues' work, as well as that of many other research teams, has been formative in our understanding of the role of speech audibility—the primary purpose of amplification—in spoken language development. All listeners need access to some degree of an audible signal in order to understand a speaker. However, children need a more audible signal—or a greater portion of the LTASS to be audible—than do adults, in order to maximize their spoken word recognition [27]. This is because children have less experience with spoken language and the world more generally than adults, and are less facile with filling in missing or missed linguistic information. Furthermore, adequate access to high-frequency speech information is particularly informative for both speech perception [28] and spoken language production [29]. Hearing aids do not amplify signals above approximately 5 kHz, due primarily to technical limitations. This has a consequence for perception, but also impacts the ability to self-monitor one's own speech. For example, Elfenbein, Hardin-Jones, and Davis [30] demonstrated that even children with mild hearing losses misarticulate and/or omit high-frequency fricatives. Their findings support the view that DHH children might not

have access to the high-frequency cues necessary to monitor one's own speech that are required to develop a full phonological inventory.

Phonological development is markedly delayed in DHH children relative to hearing peers [29,31]. Delays tend to correlate with the relative audibility of phonemes across the frequency spectrum with delays being shortest for vowels (primarily low-frequency concentration) and greatest for fricatives (primarily high-frequency concentration). Unfortunately, roughly half of the consonants used in spoken English are fricatives [29], therefore, delays in acquiring them can have substantial effects on spoken language development. Moeller et al.'s [31] data suggest that fricative acquisition is strikingly delayed in DHH children relative to hearing children, even in DHH children who were fit with amplification before six months of age. Other speech sound classes were delayed as well, but the rate of acquisition of those classes were similar to hearing children. Supporting the importance of audibility, Moeller et al. [31] argued that the lack of access to high-frequency amplification due to limitations of the devices themselves were the primary underlying cause of children's marked delay in fricative acquisition. Fricatives are not only important because they are used so often in running speech, some of them, such as /s/ and /z/, also are morphological markers for items such as plurals and possessives, making them important for the acquisition of morphosyntax [32].

6. Frequency Lowering

A critical reader might ask, if high frequencies are so important for perception, why don't hearing aid manufacturers increase the bandwidth of hearing aids beyond 5000 Hz? The simple answer is that there are technical limitations, an increased susceptibility to acoustic feedback, and limits on output that have restricted the ability of engineers to widen hearing aid bandwidths. A clever end-around to this problem, called "frequency lowering," has been implemented in modern hearing aid technology. There are multiple approaches to frequency lowering, but generally, frequency lowering takes high-frequency acoustic information that is not typically accessible to the listener and spectrally lowers it down to a region that is audible. It has been estimated that frequency lowering is used on upwards of 80% of a common manufacturer's pediatric fittings [33]. Despite this, there are few studies that have carefully examined the effects of frequency lowering on spoken language in DHH children. Whereas these studies report advantages for frequency lowering, they have some limitations. Across these seminal investigations, the fitting scheme and the type of frequency lowering varied, making comparisons across studies difficult (e.g., [34–36]), or evaluated outcomes based on aided pure-tone averages (e.g., [35]), which is limited for predicting speech audibility under typical listening conditions because thresholds are obtained for input levels measurably below the average input level for conversational speech [37]. Furthermore, studies that examined spoken language did not include control conditions that address practice effects and maturation (e.g., [38]). Despite this, in their review of frequency lowering technology for children, McCreery, Venediktov, Coleman, and Leech [39] argued that many studies found that children reported that they preferred frequency lowering technology over conventional frequency mapping. These early results of the effects of frequency lowering in children are somewhat promising and offer the opportunity for further research in this area to determine who is likely to benefit the most from it. Recent work by Scollie et al. [40] have attempted to develop guidelines for verifying fit of frequency lowering technology that maximizes the contrasts between high-frequency fricatives. Future work on this approach with children is warranted.

7. Amplitude Compression

As discussed earlier, one of the consequences of sensorineural hearing loss is reduced dynamic range—or the ranges of intensities over which one is able to hear. A healthy ear has a dynamic range of approximately 120 dB, while the dynamic range of speech of an individual talker is about 30 dB. Across talkers, the dynamic range of speech is upwards of 60 dB. As sensorineural hearing loss sets in, soft sounds become inaudible and audible sounds reach maximum comfort levels faster than normal, and the dynamic range of hearing can start to encroach upon the dynamic range of the speech. In the case of

severe-to-profound hearing loss, the dynamic range of speech can eclipse the dynamic range of hearing. In this case, the audiologist faces a dilemma: amplify soft sounds so that they are audible, while making loud sounds uncomfortably or painfully loud (resulting in the user not wearing the hearing aids), or amplify loud sounds to the point just below discomfort while sacrificing the ability to hear soft sounds (resulting in the user not having access to the full LTASS, and thus having less-than-ideal spoken word recognition)? This was the dilemma that audiologists faced when fitting linear hearing aids. Today, all modern hearing aids use a technology called "amplitude compression." Amplitude compression is a non-linear approach to signal processing in which soft sounds are provided more amplification or gain than moderate-level sounds and certainly than loud sounds. Theoretically, this allows the audiologist the ability to give the listener access to the entire LTASS, while also making sure that all sounds are maintained at a comfortable volume. Because compression alters the original signal [41], it is reasonable to question if it has an effect on spoken language development. In a review of amplitude compression versus conventional linear amplification for pediatrics by McCreery, Venediktov, Coleman, and Leech [42], over 376 potential papers were winnowed down to just eight that met the stringent inclusion criteria. There was some variability in spoken word recognition across the investigations for different presentation levels (e.g., low, medium, and high), with some studies finding better results for devices that used compression over linear processing for low and high levels, and more mixed results for medium-level inputs. Few studies investigated speech production, but that which did revealed improved articulation with the use of amplitude compression over linear processing [43]. McCreery et al. [42] concluded that there is a moderate level of evidence to support the use of amplitude compression over conventional linear processing for school-age children using hearing aids in certain areas of audibility, spoken word recognition, and speech and language development.

8. Summary of Spoken Language Outcomes in DHH Children with Hearing Aids

Hearing aid technology has changed dramatically in the last 30 years. Whereas this has made it feasible for many current DHH children to attain spoken language and academic achievements greater than the previous generation of DHH children [44], there remains an achievement gap between the majority of DHH children and their hearing peers who are matched on chronological age and socioeconomic status (e.g., [24,45,46]). There are occasional findings of null results in the literature regarding language differences between hearing children and children with mild to severe hearing loss who wear hearing aids (e.g., [47]), but the vast majority of investigations report different developmental patterns in spoken language development (perception and production) in DHH children with hearing aids from differences in phonological skills (e.g., [29,31,48]), morphosyntactic skills (e.g., [46]), vocabulary and grammar development [30,44,49], and spoken word recognition (e.g., [27]). Despite these delays and differences, longitudinal data from the Outcomes of Children with Hearing Loss (OCHL) study suggest that the auditory access provided by hearing aids, specifically those that are well fit and worn consistently, are absolutely critical for the development of spoken language (e.g., [46,50]).

9. Cochlear Implants

For children (and adults) whose degree of hearing loss is so severe that they do not benefit from hearing aids, cochlear implants offer an opportunity to receive access to sound. The phrase, "access to sound" was used intentionally because the development of spoken language does not generally occur automatically in children who receive cochlear implants. It is the product of years of aural (re-)habilitation, speech-language therapy, family dedication, and hard work on the part of the child, the family, and many professionals, including educators. Whereas aural (re-)habilitation should be a part of intervention for all DHH children, including those with hearing aids, aural (re-)habilitation is particularly critical for children with cochlear implants. They generally have sensorineural hearing loss that is severe-to-profound in degree, resulting in a period of time that they have not had adequate access to conversational speech, even that which is amplified by a hearing aid. Furthermore, the

cochlear implant provides an entirely different signal than hearing aids. Thus, learning to listen to a new signal through an impaired auditory system generally requires an amount of training, effort, and time.

9.1. Cochlear Implant Candidacy through Surgery

Cochlear implant candidacy criteria are always evolving, are manufacturer-specific, and vary with candidate age, particular device, and whether the candidate has private insurance or is using Medicare. In general, the current pediatric audiological criteria for implantation according to the US Food and Drug Administration are as follows: 12- to 23-month-old infants must have bilateral, profound, sensorineural hearing loss and display little-to-no evidence of auditory development with appropriately fitted hearing aids; children ages two years and older must meet the same requirements except that their hearing loss can be severe in degree. For children who are too young to be tested with formal spoken word recognition tests, parental questionnaires that pose questions about auditory development are used. There is some evidence that infants implanted before 12 months of age develop better spoken language, but not better speech perception, than those implanted after 12 months of age (e.g., [45,51–54]). Furthermore, spoken language outcomes of children with cochlear implants are similar to those of children with hearing aids who have pure-tone averages in the moderately-severe range (e.g., [55,56]). Both of these lines of research suggest that the current FDA-approved age and audiometric criteria might be too stringent. That being said, most clinics use the guidelines described above to determine who qualifies for cochlear implantation.

Depending on the age of the child, candidacy for cochlear implantation is determined with a team approach that at minimum typically includes audiology, speech-language pathology, and otolaryngology. Oftentimes, large teams also include developmental psychology, social work, and other professionals. From an audiological standpoint, the child will undergo a large battery of behavioral and physiological testing to confirm the degree, type, and configuration of hearing loss, a thorough hearing aid trial with hearing aids in which the fit has been verified, and a large, hierarchical battery of spoken language tests called the Pediatric Minimum Speech Test Battery [57,58]. Speech-language pathology will provide a communication and spoken language assessment. All of these assessments not only help determine candidacy, they also help determine baseline performance in children who eventually go on for cochlear implantation. The surgeon will do a head and neck examination to look for otitis media and congenital anomalies, take a thorough family and medical history, check overall health, order imaging (Computerized Tomography scan [CT scan] or Magnetic Resonance Imaging [MRI]), and occasionally order vestibular (balance) testing. Once candidacy is determined, the family is provided with a wealth of information to help decide if they want to proceed with surgery.

Surgery is usually an outpatient procedure, lasting 2–3 h. It is minimally invasive, using a small, curved incision just behind the ear. Before the surgeon completes the procedure, most centers will confirm that the device is working by checking the integrity of the implanted electrodes and verifying the stimulation of the auditory nerve. Many surgeons will also obtain an X-ray or fluoroscopy of the internal device once it has been placed to ensure that it is indeed located where it is supposed to be inside of the cochlea. Cochlear implants themselves contain two major portions—an internal and an external portion. Only the internal portion is implanted inside the recipient's head.

9.2. The Cochlear Implant

9.2.1. Internal Components

The internal device of the cochlear implant looks different across manufacturers and across a single manufacturer's different models, but they all contain the same basic components:

- A *magnet* that helps keep the external device on the user's head
- An *internal receiver* that receives radio frequency waves from the external component's transmitter and converts it into electrical energy

- A flexible *electrode array* containing between 12–24 intracochlear *electrodes*, which deliver electrical pulses to auditory nerve fibers within the cochlea that are in close proximity to each electrode.

9.2.2. External Components

The external device of the cochlear implant (often called the speech processor or sound processor) also looks different across manufacturers, as well as across the different types of processors within a single manufacturer. However, they all contain the same basic components:

- A *microphone* to convert acoustic signals into an electrical signals
- A *sound processor* that processes the electrical signal based on some logic regarding speech sound processing
- A *transmitter* that sends the signal across the skin on the head via radio frequency waves to the surgically implanted portion of the device
- A *magnet* that helps maintain the external device on the user's head.

10. How It Works: Device Basics

Cochlear implants work very differently from hearing aids. Whereas there is variability across manufacturers and across processing strategies regarding the specifics of how cochlear implants process acoustic signals and stimulate auditory nerve fibers, all cochlear implants do the same basic processing. After converting acoustic sound waves into electrical energy at the microphone, they all filter the electrical signal into contiguous frequency bands, amplitude compress the frequency bands, extract the envelopes of the filters, and modulate pulses from each electrode based on the extracted envelope. Importantly, the electrodes are located in physically distinct locations along the cochlea. Beginning at the cochlea and going all the way to the auditory cortex, the auditory system is organized in a "tonotopic" fashion, meaning that certain anatomical structures respond maximally to certain frequencies [1]. In the cochlea, which is shaped like a snail shell with 2.5 turns, the first turn is maximally sensitive to high (treble) frequencies and the last turn is maximally sensitive to low (base) frequencies. The cochlear implant electrode array is threaded into the first 1 to 1.5 turns of the cochlea (or 20–30 mm into the cochlea), such that low-frequency neural units are not necessarily directly stimulated. The entire purpose of modern-day cochlear implants having multiple electrodes inside of the cochlea is to stimulate distinct populations of neural units that are maximally sensitive to different frequencies within the cochlea. The intent is to provide the listener with the opportunity to perceive some frequency cues from the speech signal. Without electrodes placed in physically distinct locations along the cochlea, there would be no opportunity for the listener to perceive frequency cues, and it is known that perceiving frequency cues is important for speech perception (e.g., [59]).

Cochlear implants vary in how well they convey different cues in the speech spectrum to the listener. In general, they tend to be best at conveying speech cues that are conveyed well by temporal envelope cues, and are poorest at those that rely heavily on conveying fine frequency cues. The sounds that make up words—phonemes—can be classified into: manner of articulation, voicing, and place of articulation. Manner of articulation relies heavily on temporal envelope cues, whereas place of articulation (where in the mouth a sound is uttered) relies only on fine frequency cues [59]. From a functional standpoint, cochlear implant recipients generally can perceive manner of articulation relatively well, followed by voicing (are the vocal folds used or not to utter the sound), and are poorest at perceiving place of articulation. This means that they are going to me more likely to confuse the words "top" and "cop" than the words "mom" and "bomb," because the first phonemes of "top" and "cop" only vary in place of articulation, whereas in "mom" and "bomb," the first phonemes vary in manner of articulation.

10.1. Post-Operative Procedures: The MAP

For the first week following surgery, patients are instructed to undergo minimal activity. After 2–3 weeks, they visit the surgeon for a post-operative check to see how the incision site is healing and to evaluate general recovery. Approximately one month following surgery they visit the audiologist to receive the external portion of the device—this will be the first time they receive stimulation from the cochlear implant that allows them to perceive sound. One major reason for the delay is that the surgical site needs to heal and swelling needs to recede before the external magnet is placed on the head. During the visit in which they receive the external portion, the electrodes are "mapped," meaning that the appropriate amount of current for each electrode is determined by the audiologist. This is a difficult process and one that is done both behaviorally and using physiological measurements. This will not be the child's final MAP (a term that is used to describe the levels set on each electrode as a whole). The amount of current required to detect sound decreases over time, which will impact children's MAPs [60,61]. MAPs are evaluated, modified, and adjusted at every single visit to the audiologist. Because current level needs are changing frequently in children, they are seen often early on for MAP evaluations. Input from parents, teachers, speech-language pathologists, and other individuals who know the child well can be useful in setting MAPs, particularly in preverbal children. Simple tests, such as the Ling 6-sound test [62], can be used to check whether the child can detect phonemes across the speech spectrum and includes the phonemes, "ee," "oo," "ah," "s," "sh," and "m." As with hearing aids, the goal is to make speech audible and comfortable, and to make auditory signals as clear as possible. However, whereas cochlear implants are arguably the most successful sensory prosthesis developed to date, they still produce a rather crude representation of sound.

Cochlear implant processing has improved markedly since the first single-channel device was implanted in a child in the United States by William House, M.D. in 1980. All modern cochlear implants are multichannel devices. Current cochlear implants offer multiple types of processing strategies, which can provide differences in perception for individual users, but on average the processing strategies result in similar outcomes across cochlear implant recipients (e.g., [63]). Regardless of the processing strategy, the signal provided by a cochlear implant lacks the spectral/frequency detail of the original signal—the utterance originating from the child's mother's mouth, the song being played by an orchestra or CD player, or the television broadcasting the child's favorite program. Moreover, the signal sent from the electrodes is processed through an auditory system that is significantly impaired. Fortunately, we do not hear with our ears, rather, we hear with our brains. As one of the cochlear implant (CI) signal processing pioneers, Dr. Blake Wilson, ruminated, "in retrospect, the job of designers of CIs was to present just enough information in a clear format at the periphery such that brain could 'take over' and do the rest of the job in perceiving speech and other sounds with adequate accuracy and fidelity . . . The brain 'saved us' in producing the wonderful outcomes provided by the present-day CIs" [64] (p. 53). More simply stated by Dr. David Pisoni and the research team at the Indiana University School of Medicine, "the ear is connected to the brain" [65] (p. 446). Indeed, the fact that so many DHH children are able to make use of the degraded signal provided by cochlear implants for the development of spoken language suggests an amount of neural plasticity never imagined by those working with young DHH children early on in cochlear implant development.

10.2. Spoken Language Outcomes in Pediatric Cochlear Implantation

Spoken language outcomes in pediatric cochlear implant recipients are as variable as they can possibly be. For example, receptive and expressive language scores range from floor to ceiling in one of the largest studies to date of 188 children who received cochlear implants before age five years (e.g., [66]). These results are representative of most studies. Device characteristics, such as the number of active electrodes and the size of the dynamic range [67], and the number of distinct frequency channels [68], only account for a small fraction of the variability in outcomes. Whereas adult cochlear implant users are believed to only need approximately four spectral channels of information to perform maximally on spoken word recognition in quiet [69], young children need approximately

eight frequency channels of information while listening in quiet settings (e.g., [68]), with more required in ambient noise to optimize their understanding of speech.

Factors that account for the variability in outcomes are nearly as diverse as the outcomes themselves. The most studied include: age at cochlear implantation, which also can be thought of as the length of auditory deprivation in many cases—in general, earlier implantation results in better language outcomes (e.g., [51,52,70,71]); degree of hearing loss prior to surgery—in general, those with more residual hearing see better spoken language and speech perception outcomes [66,72,73]; the family's choice of communication modality—admittedly a difficult area to study because of confounding factors, but in general, oral approaches result in better spoken language and speech perception outcomes (e.g., [52,67,74–78]); the family's role in therapy—in general, children from families who are actively engaged in the intervention process have better spoken language outcomes (e.g., [79,80]); socio-economic status—in general, children from families with more resources have better language outcomes, much like their hearing peers (e.g., [52,66,67,81]); ethnic minority status—one of the only studies to examine pediatric cochlear implant users who are ethnic minorities found that when compared to the large Childhood Development after Cochlear Implantation (CDaCI) Study sample of cochlear implant users, those from ethnic minorities had more delayed spoken language [81]; maternal education level—in general, better spoken language outcomes are observed in children whose mothers attained higher levels of education (e.g., [67,82,83]); gender—in general, girls achieved better language outcomes [82,84]; cognitive ability—as expected, children with higher cognitive abilities had better language outcomes [82,85,86]; ratings of parental sensitivity—children whose parents responded appropriately to their child's communication attempts had better spoken language outcomes [66,87]; dynamics within the family itself—children whose families that reported lower levels of rigid behavioral control over their children, but higher levels of organization within the family itself, had better spoken language outcomes [88,89], and etiology—etiology works almost as a proxy for other factors (many identified here) in that the mechanism(s) through which the etiology of hearing loss influences hearing structures themselves, other systems, and development in general will influence outcomes (e.g., etiologies that influence the central nervous system more generally or that involve specific aspects of the central auditory system specifically, or that have associated cognitive delays/difficulties will result in poorer outcomes) [82,85,86]. Together, these factors only account for about half of the variability in spoken language outcomes. Keeping both the enormous individual differences and these predictive factors in mind, this section will summarize the average spoken language outcomes of pediatric cochlear implant recipients.

The average spoken language growth trajectories of children who receive cochlear implants dramatically change following cochlear implantation: spoken language growth is very slow prior to cochlear implantation regardless of the age at which the child receives the device, however, very quickly following cochlear implantation both average spoken language and speech perception trajectories improve (e.g., [52,66]). These positive post-operative growth trajectories are observed for both receptive and expressive language, as well as vocabulary. Additionally, children who receive their devices before 18 months of age have post-operative trajectories on average that begin to parallel the growth rates of hearing children (e.g., [52,66]), although they still lag behind in absolute language scores because they started behind when they received the device. Spoken language growth trajectories are shallower for children implanted through 36 to 48 months of age relative to those implanted before 18–24 months of age [52,66]. Together, these data reveal that the language gap between hearing children and DHH children implanted before approximately 18 months of age does not widen with development. In contrast, DHH children implanted after 18 months of age see language gaps that widen over time. This means that when implantation is delayed past approximately 18 months of age, not only are DHH children already far behind their hearing peers in language skills, their rate of spoken language acquisition is slower than their hearing peers, even with a cochlear implant. On average, the language gap on standardized measures is approximately 1 standard deviation (SD) below the mean [52,55,66,82,90,91]. This 1-SD gap has remained relatively consistent for the last decade or so

despite some of the most sophisticated signal processing to date. Again, these are simply averages, so educators will encounter children from across the spectrum: those who are scoring even higher than their age would suggest to those who struggle to even discriminate among words with different stress patterns, and thus, primarily use their device as an aid to speechreading or Total communication. This is why educators and intervention specialists have to be flexible with education and intervention plans for children with cochlear implants. Each child needs a truly individualized plan.

The vast majority of the literature on speech and language outcomes in children with cochlear implants uses standardized tests of spoken language. These tests have some advantages over non-standardized measures in that they allow the tester/researcher to compare the results to hearing children. Additionally, standardized spoken language tests are often used to determine if children receive services through the schools. These tests also have some disadvantages, though. They often do not test high-level language skills needed to develop deep peer relationships or to soar academically. Furthermore, they lack the ability to evaluate specific aspects of language development with which a particular child might struggle or specific aspects of language development particularly at-risk in children with hearing loss. Therefore, some investigators have argued that going beyond these standardized measures is important for quantifying their development across multiple domains of language [92], as well as capturing the full breadth of language development needed to optimize and provide efficient intervention [82].

Despite the ability to provide access to high-frequency cues not available in hearing aids, cochlear implants still lack the frequency resolution needed for perceiving fine frequency cues. Thus, children with cochlear implants display difficulties with morphological development, specifically those marking possessives, plurals, verb tense, and pronouns [93–96]. Additionally, children with cochlear implants show difficulties in syntactic development [82,94,96], correct use of verbs and adverbs [93,97], and prepositions [97]. This leads to children with cochlear implants having smaller lexicon sizes than hearing children [31,98]. Finally, children with cochlear implants tend to have shorter average utterance lengths than hearing children [99]. Across these different areas of language development, Nittrouer, Muir, Tietgens, Moberly, and Lowenstein [100] reported that through middle school, the types and magnitudes of deficits experienced by children with cochlear implants remain relatively consistent. Furthermore, there was a hierarchy of difficulty: children displayed the largest deficits with phonological skills, moderate deficits with lexical skills, and the least for morphosyntactic skills. Children with cochlear implants are particularly vulnerable to deficits in phonological development across childhood [101–103]. Importantly, acquiring literacy skills was strongly supported by phonological and lexical development—the two areas of greatest difficulty for children with cochlear implants [100].

Speech production of children with cochlear implants is also highly variable [104]. Articulation is often significantly impaired in children with cochlear implants [105], resulting in it being estimated that only about half of preschooler's speech is intelligible [91]. Part of the reason for some children being difficult to understand, even those who have had their devices for an extended period of time, is that their phonetic inventories are not only missing sounds from their ambient language, but also contain sounds that do not appear in their ambient language [106]. Furthermore, there appears to be an effect of communication modality: inventories of oral communicators tend to contain more English segments than those of Total communicators. Conversely, non-English segments (such as uvular stops) appear more commonly in Total communicators' than oral communicators' inventories. This also extended to consonant clusters, in which oral communicators are more likely to successfully produce initial onset clusters correctly than Total communicators [107]. Finally, like hearing children much younger than themselves [108,109], children with cochlear implants tend to omit function words from their productions, thus producing more content than function words [110]. Word omission correlated with intelligibility. Together, these factors contribute to some DHH children's difficulty in being understood.

11. Literacy Development in DHH Children Who Use Hearing Aids and Cochlear Implants

Similar to the outcomes in research on spoken language (and unsurprisingly), literacy outcomes in DHH children remain a significant area of risk despite recent efforts to emphasize literacy development and many changes in educational intervention [111]. There are conflicting reports in the literature regarding literacy achievement in DHH children. Some studies report that only a small fraction—approximately 10%—of graduating DHH high schoolers (of all linguistic backgrounds) read at grade level, and that the majority read at just the fourth-grade level, particularly as the degree of loss increases in severity (e.g., [112,113]). Other studies hold greater promise for more positive literacy prognoses. For example, in a large investigation of 181 children who received cochlear implants before age five years, Geers [114] showed that regardless of communication modality (oral or simultaneous/Total communication), just over half of the children had reading scores commensurate with their hearing peers. This proportion of children demonstrating literacy success is much higher than has been reported in other studies, certainly in earlier studies on cochlear implantation. To be certain, their success is due in part to their committed families, early interventionists, and their own hard work, but much of it is also due to children's access to the ambient language around them and the component phonemes provided by the modern hearing technology that they have been fitted with at an early age that is simultaneously being conveyed through the orthography of the letters they are learning to decode and read as words, phrases, sentences, and passages. Despite the hopeful literacy gains made in the last decade or so by DHH children, achievement gaps between DHH children with hearing technology and hearing peers still persist (e.g., [44,114–117]). Moreover, as with spoken language outcomes, there is enormous variability in literacy achievement, with approximately half of DHH children with hearing technology achieving age-appropriate literacy skills, some approximately a year behind their hearing peers, and a smaller subset "exhibiting barely developed reading skills" in the studies with the more promising outcomes [114], (p. 66S). Typically, reading score gaps increase with age [118], although certain types of interventions have seen more positive outcomes using visual phonics-based instruction (e.g., [119–121]).

Literacy development relies on many skills and experiences. However, the two key building blocks are general language abilities (oral language and vocabulary) and phonological knowledge to break down printed words into parts, sometimes called phonological coding and awareness [116]. The role that each—top-down language and bottom-up phonological coding and awareness—plays in reading is hotly contested (e.g., [122]). DHH children have been used to test hypotheses about the role of each in literacy acquisition because they have language delays and deficits in phonological processing and encoding. They have also been studied because of the long-standing achievement gaps observed in their reading development.

Easterbrooks, Lederberg, Miller, Bergeron, and Connor [123], Nittrouer et al. [101,102], Nittrouer and Caldwell-Tarr [103], and others have demonstrated that DHH children with hearing technology have differing abilities to access the building blocks of reading. Factors that have been found to influence reading scores in DHH children with cochlear implants and hearing aids include: the educational environment (oral versus simultaneous communication in the classroom) [114,124,125], phonological awareness [114,122,126,127], speech intelligibility and language comprehension [114,126], and vocabulary and speechreading skills [128]. In a meta-analysis that examined DHH children's reading scores but did not separate out hearing technology users from DHH children who used ASL and did not use hearing technology (a limitation of this meta-analysis), found that language accounted for most of the variability in reading scores across seven studies [129]. In a study that examined the contributions of many potential contributing factors, 72% of the variance in reading scores of children who received cochlear implants before age five years together was due to: age at onset of deafness, intelligence quotient, family socioeconomic status, gender, cochlear implant processing strategy, width of the dynamic range of the child's MAP, working memory, phonological processing, speech production, and language abilities. In fact, together, language and speech production accounted for 45% of the variance in reading scores (note that speech perception was not significant) [114]. These

results suggest that children's oral language success contributed, as well as their speech intelligibility, almost half of the variability in reading scores of DHH children with cochlear implants. Moreover, phonological processing contributed additional variability, as did demographic factors. Results such as these support the tenet that phonological coding and awareness, as well as lexical knowledge, contribute heavily to reading ability, but so do a multitude of other factors that help support access to perceptual learning, attention, and general cognitive mechanisms that are important to becoming a competent reader.

Evidence from both hearing [129] and DHH populations [122] suggests that the development of phonemic awareness and reading are reciprocal or bidirectional processes that appear to support each other. In controlled studies across two different languages, children with hearing technology who received reading training showed enhanced phonological and morphological skill development [129,130]. These results suggest that the relationship between reading and phonological and morphological skill development is a complicated one that seems to work in an almost cyclical fashion that can feed off of itself

One method that has been effective in assisting DHH children in accessing the phonology of their auditory language and applying it to reading is an instruction method based in visual phonics [118–120]. This intervention method is exciting in part because the results show that it is beginning to close the achievement gap in reading for some DHH children with hearing technology [110–120], but also because of results like those of Kyle and Harris [131] that found that speechreading was the strongest single predictor of single-word reading ability, whereas vocabulary knowledge best predicted written sentence comprehension. The ability to use visual speech cues acts as a mediator for phonological awareness when auditory information is unreliable or inaccessible due to hearing loss, or as a supplement for all listeners under any situation, but especially under degraded listening situations. Combining the visual phonics with knowledge of the lexicon together contributes to the necessary decoding and comprehension necessary for reading.

Despite the strides that have been made in literacy research, significant unexplained variability and a large achievement gap remains for many DHH children. The majority of the data suggest that the language and literacy gaps are related to one another. That being said, some have argued that DHH children's reading challenges might in fact *not* be reading-specific [132]. For example, Marschark and colleagues [133] have proposed that the reading difficulties experienced by DHH children might instead be a result of more language-general and cognitive factors—cognitive processing, language comprehension, and learning factors that contribute to reading. Certainly working memory and the phonological loop have been implicated in reading [134]. Further research is needed to better understand the role of these additional factors in literacy development. The differing views on the relative importance of top-down (language) and bottom-up (phonological coding and awareness) processes to reading for DHH children with cochlear implants and hearing aids is probably exacerbated by the variability in access to the LTASS experienced across children. A limitation of most of the investigations on this issue is that they: (1) do not describe the participant population in sufficient detail to glean their potential ability to use their hearing technology to develop phonemic coding and awareness competency; (2) do not separate out children in groups who are likely to differ in their language and phonological coding and awareness skills based on their auditory and audiovisual spoken language experience; and (3) do not include neurocognitive and sociodemographic factors known to influence language development in the analyses, which could indirectly (or perhaps directly) influence reading development. As more investigations converge on the sources of variability in reading outcomes, it will be exciting for new or modified evidence-based intervention strategies to be developed and applied to larger numbers of DHH children with hearing technology that is targeted to meet their individual needs.

12. Implications for Research

This review of current hearing technology for DHH children and its influence on spoken language and literacy development has highlighted some gaps in knowledge. Below are some of the most pressing research needs to fill those holes:

- Investigations into why clinical and laboratory results are so discrepant regarding children's match-to-target of their hearing aid fittings.
- The first step in the marriage of hearing technology and spoken language development is making the LTASS fully audible. Access to high-quality auditory information is critical to spoken language development and an optimal hearing aid fitting that matches the prescribed gain target is step one in that process [50]. Over half of the time, clinical audiologists do *not* match the gain targets across frequency, meaning that the majority of children do not have optimal access to the LTASS [25,26]. This is a serious problem and one that needs to be addressed in research and training.
- The effects of digital noise reduction on speech perception, spoken language development, and learning environments in children who use hearing aids.
- The consequences of frequency lowering to speech perception and spoken language development, and its links to literacy in children who use hearing aids.
- The achievement gap between DHH and hearing children and relatedly, identifying sources of individual differences in spoken language and literacy outcomes in DHH children.
- Literacy intervention investigations that take into account individual differences of DHH children.
- Expanding the search for factors that influence literacy achievement in DHH children outside of traditional language and phonological awareness measures.
- At this time, approximately half of the variability in outcomes of DHH children has been identified, leaving much of the remaining variability unexplained.
- Identifying other sources of individual differences could lead to novel interventions for DHH children and their families, which could contribute to narrowing, or ideally closing, the achievement gap in spoken language and literacy.

13. Conclusions

Impressive advances in hearing technology have occurred in the last 30 years offering the opportunity for DHH children to have the adequate auditory access necessary to acquire spoken language with high-quality early intervention. While some children achieve outstanding spoken language and literacy outcomes, there remains a significant achievement gap between many DHH children and their hearing peers, even those who are identified early and receive appropriate early intervention with sophisticated technology. Addressing this achievement gap and identifying the sources of individual differences are two areas ripe for basic and translational research efforts. At present, we have a limited understanding of the development of DHH children in part because fields concerned with the development of DHH children have just begun to employ the widely-held view that human development is shaped by dynamic interactions between biology and environment [135]. This limitation contributes to intellectual isolation from other related scientific disciplines and thus neglects a key opportunity for understanding individual variability in pediatric DHH outcomes. There is a need for a comprehensive theoretical model that specifies factors that contribute to at-risk outcomes and their mechanisms of influence that can be empirically tested. Models that hold promise for this purpose are Biopsychosocial systems-based, because they incorporate the dynamic bidirectional relationships between systems that influence developmental trajectories [136,137]. A Systems approach recognizes that development does not occur in a vacuum [138], but rather emerges within rings of environmental influence from the level of the cell to proximal and distal rings of the environment. Our research group has proposed a Social-Behavioral Risk Model of development of DHH children with sensory aids in order to examine the role of family environment and family dynamics on spoken language and executive function outcomes to begin capturing novel sources of variability in spoken

language outcomes [139]. Kronenberger and Pisoni [140] have proposed the Auditory Neurocognitive Model to explain neurocognitive outcomes in DHH children with cochlear implants. Both of these models apply Biopsychosocial systems theory to account for the complex, dynamic, and reciprocal interactions and influences of factors on outcomes in DHH children that occur at neurobiological, cognitive, and psychosocial levels. The marrying of sophisticated hearing technology, processing by the brain, and a fuller, deeper understanding of the complex environmental and biological factors that shape development will help to maximize spoken language outcomes in DHH children and contribute to laying the groundwork for successful literacy and academic outcomes, particularly for the next generation of pediatric hearing aid and cochlear implant users.

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Review

Assessment of Language and Literacy in Children Who Are d/Deaf and Hard of Hearing

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Abstract: This article presents theoretical orientations and practical applications for the assessment of d/Deaf and hard of hearing (d/Dhh) children. It discusses current approaches to assessment and the factors affecting d/Dhh children's participation in assessments using those approaches. Gaps in the field around access to appropriate assessments are discussed. This review also shares information on the relationship between the purpose of the assessment and the approach selected. Basic considerations for both d/Deaf and hard of hearing multilingual learners (d/DMLs) and d/Dhh children with additional disabilities will be addressed. Finally, general recommendations are made for research and practice.

Keywords: d/Deaf and hard of hearing children; assessment; American sign language assessment; d/Deaf multilingual learners; d/Deaf and hard of hearing multilingual learners; d/Deaf and hard of hearing children with additional disabilities

1. Introduction

Educational assessment is an important part of monitoring learning, creating educational programming, and identifying children for services. For d/Deaf and hard of hearing (d/Dhh) children, engaging in meaningful assessment is a complex and multifaceted process [1,2]. Well done assessments support learning and growth, while inaccurate assessment data may lead to potentially faulty decision-making and poorly designed educational plans for d/Dhh children in our schools. Inaccurate assessments can also lead to the misdiagnosis of additional disabilities, including either the diagnosis of an additional disability that is not present or the missed diagnosis of a key additional disability necessary to serving a child in the school and/or community [1,2]. Of particular importance is capturing the language and literacy development of d/Dhh children in our schools, as understanding these skills is essential to educational planning and decision-making.

There are many approaches that can be utilized during the assessment process, and no one test can provide all the information necessary for the d/Dhh children we educate. Therefore, this article will (1) address the challenging nature of assessing language proficiency for the d/Dhh population, (2) review the strengths and weaknesses of the major assessment approaches used with d/Dhh children, and (3) review the factors that influence the selection of assessment approaches and tools for d/Dhh children, including the assessment purpose and language being assessed.

2. Assessing Language and Literacy for d/Deaf and Hard of Hearing Children

Language and literacy development are essential to educational programming for d/Dhh children; however, assessing these skills remains a challenging task. d/Dhh children often use a wide variety of languages and/or communication systems in their home, school, and community, which makes

assessing language proficiency difficult [3]. For example, the language of instruction, language of socialization, and language of the home may all be different for a d/Dhh child. As such, a child may use spoken language, sign language, or some combination of both in their daily lives. A child may also use a manually coded form of a spoken language (e.g., Signed Exact English or Signed English) or a constructed sign system, which borrow features from an official sign language but is not one. Even when a child uses a conventional language, however, they may use it inconsistently across different contexts. This unpredictability in language use may leave gaps in a child's linguistic repertoire, making it hard to establish the primary language to be used during the assessment administration or even which languages should be included in the assessment.

Although there are challenges to appropriately assessing the language and literacy development of d/Dhh children, the conditions of the assessment will be improved if the child is assessed in what is believed to be the child's most proficient language based on background information about the child and her/his language history. The length of time a child has used a language should always be a factor in determining the language in which an assessment will occur. The assessment of all languages and communication systems used by the child is also necessary for a comprehensive portrait of a child's abilities [4,5]. When conducting the assessments of these various languages, the use of a qualified examiner who can communicate directly with the child contributes to the validity of the assessment [2,6]. Finally, the assessment should also include multiple sources of information from across various contexts (e.g., home, school, community) and informants (e.g., educators, family, etc.) in order to document across- and within-context skills [4,7].

3. Assessment Approaches for d/Deaf and Hard of Hearing Children

The various types of assessment approaches have been traditionally grouped into two categories: formal and informal assessment. Despite being controversial for some groups of learners (e.g., young children and culturally and linguistically diverse children), formal assessment is often preferred in schools, as each test is constructed to produce scores that are valid and reliable. Informal assessment, however, is the most widely used form of assessment in classrooms and educational settings, as it lends itself well to monitoring and documenting a child's learning on a regular basis. Each assessment approach within these categories has its own theoretical foundation, set of guiding principles, and implementation practices.

3.1. Informal Assessment Approaches for d/Deaf and Hard of Hearing Children

There are multiple informal assessment approaches that can capture language levels and growth over time. They commonly occur in the classroom setting, but can also happen in natural environments such as a child's home or community. These approaches are theoretically and practically distinct from each other. Each has its own set of strengths and limitations when working with d/Dhh children.

Naturalistic Assessment and Play-Based Assessment approaches are a type of assessment that focuses on observing children in their natural environments or authentic play scenarios. It is most commonly used in early childhood and early intervention settings. These approaches are praised for their authenticity and ability to see how a child independently uses various skills. For d/Dhh children, Naturalistic Assessment removes the barriers of participation in a contrived assessment setting with unfamiliar materials and content to see their functional language abilities in real-world settings. The use of Naturalistic Assessment with children who are signers, however, is limited to those who have the sign language proficiency to complete the observation. An interpreter may be used, but without formal training on observation techniques, an interpreter might inadvertently influence the data collected through the translation process. For example, a child who uses American Sign Language (ASL) may use a sign without the appropriate grammatical markers (e.g., use of movement), but the interpreter fills in the content as if the child included them.

Performance-Based Assessment, Curriculum-Based Assessment and Standards-Based Assessment are techniques that require children to perform a specified skill or task to demonstrate learning.

For Performance-Based Assessment, the skills are chosen based on a combination of age, grade, or questions about a child's learning. For Curriculum-Based Assessment, the skills are aligned specifically with the curriculum unit, chapter, or lesson. In Standards-Based Assessment, skills-based tasks are used to determine if a child has met the state or local standards for instructional content. These types of assessment are most commonly used in the classroom setting and administered by the classroom teacher. Benefits of these types of assessments are that they are typically given by someone familiar with the child and the characteristics child's language, which is an important part of understanding the full capabilities of a d/Dhh child. If the teacher does not share the child's language, however, they may need assistance in administering and interpreting the results by someone with the requisite language skills, which is challenging given that these assessments occur so frequently in a classroom.

Portfolio Assessment, as an approach, uses a targeted selection of children's work and relevant assessment data to document a child's learning. This approach is widely used in early childhood and is considered a good way to track a child's small increments of progress over time. For d/Dhh children, this approach can be especially useful to look at changes in expressive language development and writing skills over time. The accessibility of video technology in recent years has transformed the capacity of portfolios to capture visual language samples in a way that was previously hard to do [8]. By creating video portfolios, a child's authentic signed language can be documented more accurately. Given that Portfolio Assessment is typically generated by the classroom teacher, if the teacher does not know the nuances of language development for d/DHh children, they may not know the best artifacts to include in a portfolio to demonstrate development or growth, and so the portfolio may not accurately reflect true ability.

Dynamic assessment uses a test, teach, test again approach as a way of evaluating which instructional strategies may be effective for a specific child. This approach is valuable for distinguishing effective teaching strategies that work for a specific child versus those that do not impact the child's learning. It can also identify how quickly a child can learn new content in a one-on-one setting, rather than focusing only on what knowledge a child already possesses. The benefits of using Dynamic Assessment with d/Dhh children is the direct applicability to designing Individualized Education Programs (IEPs) including identifying teaching strategies, determining appropriate instructional pacing, and identifying necessary classroom accommodations. The drawbacks of Dynamic Assessment include the time necessary to engage in the test–teach–retest model on a regular basis.

While each of these approaches are unique in their data collection and process, they all share documentation strategies such as rubrics, checklists, rating scales, observational notes, student work samples, and portfolios [9]. The use of video is particularly important to monitoring sign language development over time. By combining various informal assessment and documentation approaches, it is possible to promote learning, impact instruction, and modify educational programming to meet the language and literacy needs of children in our d/Dhh programs and schools.

For a summary of the benefits and challenges of each type of assessment, see Table 1 below.

Table 1. Summary of informal assessment approaches.

Approach	Definition	Benefits	Challenges
Naturalistic Assessment	Assessment that focuses on observing children in their natural environments	• Authenticity of the observation • Ability to see how a child independently uses various skills • Eliminates the barriers of participation in a contrived assessment setting with unfamiliar materials and content to see their functional language abilities in real-world settings	• Observer must have the language proficiency to complete the observation in the child's languages • Use of interpreters may introduce bias, as they are not trained in reducing bias in observations and may inadvertently influence the observation through their choice of vocabulary or phrasing
Play-Based Assessment	Assessment that focuses on observing children in authentic play scenarios	• Authenticity of the observation • Ability to see how a child independently uses various skills • Eliminates the barriers of participation in a contrived assessment setting with unfamiliar materials and content to see their functional language abilities in real world settings	• Observer must have the language proficiency to complete the observation in the child's languages • Use of interpreters may introduce bias, as they are not trained on reducing bias in observations and may inadvertently influence the observation through their choice of vocabulary or phrasing
Performance-Based Assessment	Assessment techniques that require children to perform a specified skill based on a combination of age, grade, or questions about a child's learning to demonstrate learning	• Can be administered in the classroom by the teacher, who is familiar with the child's language characteristics • Tasks are more authentic to the types of activities that occur in classrooms	• If the examiner does not share the child's language, assistance from an interpreter or ancillary examiner may be needed • Finding someone who can assist in an administration as frequently as needed for this type of assessment may be challenging
Curriculum-Based Assessment	Assessment techniques that require children to perform a specified skill based on the unit, chapter, or lesson being taught to demonstrate learning	• Can be administered in the classroom by a teacher familiar with the child's language characteristics • Tasks are more authentic to the types of activities that occur in classrooms	• If the examiner does not share the child's language, assistance from an interpreter or ancillary examiner may be needed • Finding someone who can assist in an administration as frequently as needed for this type of assessment may be challenging
Standards-Based Assessment	Assessment techniques that require children to perform a specified skill based on the state or common core standard being taught to demonstrate learning	• Can be administered in the classroom by the teacher, who is familiar with the child's language characteristics • Tasks are more authentic to the types of activities that occur in classrooms	• If the examiner does not share the child's language, assistance from an interpreter or ancillary examiner may be needed • Finding someone who can assist in an administration as frequently as needed for this type of assessment may be challenging
Portfolio Assessment	Assessment that uses a targeted selection of children's work and relevant assessment data to document a child's learning	• Appropriate for assessment in early childhood • Considered a good way to track a child's small increments of progress over time, especially with regard to expressive and receptive language • Use of video is promising to capture authentic language samples of d/Dhh children	• If the teacher does not know the nuances of language development for d/DHh children, they may not know the best artifacts to include in a portfolio to demonstrate development or growth
Dynamic Assessment	Approach that uses a test, teach, test again approach as a way of evaluating which instructional strategies may be effective for a specific child	• Can distinguish effective teaching strategies that work for a specific child versus those that do not impact the child's learning • Can also identify how quickly a child can learn new content in a one-on-one setting • Has direct applicability to designing Individualized Education Programs (IEPs)	• Time consuming to administer on a regular basis

3.2. Formal Assessment Approaches for d/Deaf and Hard of Hearing Children

Formal assessment uses psychometrics to create a test with the power, validity, and reliability to isolate specific skills and compare a child's performance to that of other children [10]. In order to have confidence in the scores produced, the test must be administered the same way each time it is given [10]. When a test is administered outside of its intended population, however, there may be required deviations to the administration protocol that can impact the validity of the scores.

In the United States, most standardized assessments are intended to be used nationwide and are created based on a sample of children that often mimics the U.S. Census data. For d/Dhh children, these standardized tests can provide insight into how a d/Dhh child compares to other children at their age or grade using normative data. A handful of these assessments have also collected normative data specifically with d/Dhh children; however, the heterogeneity of the population, small sample size compared to their hearing counterparts, and sample bias all render the scores problematic at best [4,11,12].

There are very few tests designed for d/Dhh children, which creates challenges to the validity of the tests, as the items may be based on auditory concepts inaccessible to a d/Dhh child and it may be impossible for them to be translated into a signed language [4]. As a result, deviations to the administration protocol may be necessary for equity [13]. For d/Dhh children who use a sign language, sign translations of test content are frequently used, as the overwhelming majority of standardized tests are designed and administered in spoken English [14,15]. These translations can occur in three ways. First, if the examiner is proficient in the child's sign language, they can directly administer the test to the child in that language. Second, the examiner can collaborate with an ancillary examiner who is proficient in the language and understands how to administer tests appropriately. Finally, the examiner can use a sign language interpreter to translate the test during the testing session.

While these strategies can help to expand the available test materials for d/Dhh children, the interpretation process creates challenges of their own. Even when an examiner is able to administer a test in sign, without standardized test administration protocols or a sign language script, it is hard to administer the test in exactly the same way each time it is given. Access to an ancillary examiner who has both the knowledge of the assessment and the language skills necessary is not typical outside of schools for the d/Deaf. Even when there is a trained person to assist, they might be taken away from other important duties in order to assist in the test administration. Sign language interpreters may be available for the assessment even when ancillary examiners are not; however, without formal training on assessment, the interpreter may inadvertently affect the child's scores [16].

Each of these situations poses threats to the semantic equivalence for the test, an important aspect of test validity. Semantic equivalence is when a translation of the test keeps the item content and difficulty the same across both languages [14]. Crossing modalities from oral to sign language impacts the semantic equivalence of the assessment, as appropriately signing the test item may affect the content of that item through a concept called iconicity [17,18]. Iconicity is when a sign used to represent a concept or object may look visually like the referent [17]. When the iconicity is high, a sign may inadvertently give a child the cues to the correct answers [17,19–21]. For example, if the test item asked, "which shape is the circle?" and the answer choices were a square, circle, triangle, and a diamond, simply signing the question inadvertently gives clues to the answer, as the signs for these shapes mimic them closely.

When translation does not modify the content of an item, it still may change the level of difficulty of it [19–21]. For example, sign language phonology or morphology can affect the difficulty of an item by providing cues that can help elicit the correct answer [18–20,22]. These content changes have been well documented for ASL translations of math assessments, as they may provide number or mapping cues that can be used to solve the problem presented [19,20,22]. For example, an item might ask, "If Sally has 3 balls and Bobby has 2 balls, how many do they have altogether?". The sign for "altogether" also means "to add" in the context of math. The use of this sign thus signifies which mathematical operation to use.

Accommodations

Accommodations are assessment strategies which are intended to compensate for the barriers inherent in the testing situation and not improve the child's performance beyond their true abilities [23]. High-quality accommodations provide access to the tests and their content without altering the construction of the test. There are a wide variety of accommodations that may be used with formal

assessments; however, it is important to only use accommodations that are necessary to provide an equitable testing situation. While there are accommodations that have been deemed potentially useful with d/Dhh children, they should not be given arbitrarily to all children in these populations, but they should be looked at only when it is deemed that an individual student would benefit from them [18].

Often, children use a different language in school and/or at home than the one used on the assessment, and therefore accommodations are used to reduce the amount of bias and challenge the number of artificial barriers to the child's performance such as language diversity or disability [18]. The translation of test content is a common way to provide equity in an administration for d/Dhh children; however, this is not the only language strategy that has been shown to support access to test content.

For some d/Dhh students, preferential seating and use of their hearing assistive technology are the only accommodations that are needed, whereas others may need accommodations that not only provide access to test directions but also the content [18]. Additional accommodations often utilized for d/Dhh children include extended time, separate locations for testing, and computer administration [24,25]. Computer-based assessments pose a particular challenge for d/Dhh children, as they may rely on speech recognition or lack visual cues in item presentation. As a result, a live examiner may be required in order to ensure full access. Although accommodations have been useful for alleviating some of the linguistic bias of standardized assessments, care should be taken in using them. If accommodations are selected or used inappropriately, they may result in a threat to validity by altering the skills or constructs being assessed [24].

4. Purpose of the Assessment

An important factor to consider when selecting an assessment approach is the purpose of the assessment being conducted. Assessments are typically conducted with a specific focus in mind or to answer a particular question about a child's development and/or learning. In a foundational work, Shepard, Kagan, and Wurtz [26] identified four major purposes of assessment that remain relevant to assessment practices today: to promote the learning and development of individuals or groups of children; to identify children for health, educational, and social services; to assess academic achievement for accountability purposes at the local, state, national level; and to monitor trends and evaluate programs. Each of these purposes aligns itself with one or several of the approaches described above.

4.1. Promoting Learning and Development

The first purpose of assessment is to promote learning and development for children. For this purpose, informal assessment approaches are most often used [15]. These approaches lend themselves to this purpose as they are able to capture children's abilities in authentic settings, measure growth over short periods of time, and provide information that can inform instruction. These assessments can also be administered more frequently than formal measures. As there are many different informal assessment approaches, it is important to examine each particular approach in light of its strengths and limitations for capturing the language and literacy development of the d/Dhh population (see the section on informal assessment approaches above). In addition, most educators will use a combination of these approaches when assessing a child's skills over the course of the year.

4.2. Identification for Services

The second purpose of assessment relies on formal assessment for the identification of children for additional services. Two of the most prominent types of services include additional services required to meet the needs of children with another disability beyond hearing loss alone, and additional services to meet the needs of children who have diverse language backgrounds, such as d/Deaf and hard of hearing multilingual learners (d/DMLs). Although these are two common types of services provided,

there may be other services provided by a school or district (e.g., intervention services, Reading Recovery, etc.).

Assessment for additional services often examines a child's ability and achievement scores. Individualized standardized tests have been designed to measure multiple aspects of cognition, processing, achievement, language, and general child development. These tests have been recognized as useful in the identification for services, even for populations that are traditionally disserviced by these tests, such as for young children (e.g., NAEYC) [27]. In addition, they have been recognized as important for the evaluation of language proficiency and the need for additional English language services for English learners (ELs).

4.2.1. Assessment for Additional Disabilities

d/Dhh children with additional disabilities (DWD) constitute 30–40% of d/Dhh children overall [28]. While the scope of this chapter does not allow the time to discuss in detail the specific considerations for each additional disability category (see Bruce and Borders for a full review) [29], high-quality assessment practices are necessary to prevent the misidentification of d/Dhh children for additional disabilities they do not possess [30]. When a child is suspected of having an additional disability, it is important to consider the degree to which the suspected disability is impacted by language and/or literacy development. For example, certain disability categories include more of an emphasis on the nature of a child's language skills (e.g., autism) or literacy development (e.g., learning disability in reading) than others.

For children who are d/Dhh with additional disabilities, it may be necessary to go beyond conventional language abilities to examine the various functional communication skills a child may possess. These assessments may include the use of augmentative technology, including low-technology (e.g., picture boards) or high-technology (e.g., iPads) strategies in order to best understand a child's language and communication abilities. It is also important to examine these functional communication strategies in both the home and school contexts.

When determining the presence of an additional disability, it is important to have an examiner that understands the unique aspects of hearing loss versus other disability categories, as it may be easy to mistake one for the other with an untrained eye. Typically, school psychologists are the primary people who conduct psychoeducational evaluations to determine if a child meets the criteria set forth under educational law for services to address an additional disability. Clinical psychologists or psychiatrists are primarily responsible for the formal diagnosis of additional disabilities under the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) to meet the medical and health needs of children. The collaboration between school-based personnel and health/mental health personnel is essential to ensure that all diagnoses are accounted for educationally, as well as in home and community settings.

Although standardized assessment is the standard of care for the identification of additional services, data collected from the classroom may be essential to the identification of persistent challenges to learning that go above and beyond what can be accounted for by hearing loss alone. Specifically, dynamic assessment in a test–teach–retest model can be quite informative regarding the ability for a child to acquire new content with appropriate instructional supports, especially in the area of learning disabilities. When d/Dhh children struggle with learning despite appropriate instruction and/or interventions, a disability is more likely to be present (for example, Response to Intervention) [7].

4.2.2. Assessment for English Language Services

In the United States, children who come from diverse language backgrounds may be eligible to receive additional language services based on their language proficiency in English. d/Dhh children who use a combination of sign and/or spoken languages and come from a home where a language other than English is spoken have been referred to as d/Deaf and hard of hearing multilingual learners (d/DMLs) [5,7,8]. Hearing children who experience challenges in English that are associated with their native language or language environment are labeled "English learners" (ELs) [31]. Children who are

designated as ELs are typically eligible for English as a Second Language (ESL) services. d/DMLs are not necessarily served through ESL services, as each school and/or district may have different policies on how to identify and serve d/Dhh children with home language diversity. Currently, there is very little understanding about how d/DML children are identified or served in ESL programs [5,7].

Many of the assessments used to determine language proficiency for ESL services are standardized. Typically, an individualized standardized assessment is used for eligibility purposes, and then the child is monitored annually for progress. The progress monitoring approaches widely vary from state-to-state, but the ACCESS (Assessing Comprehension and Communication in English State-to-State) test is a popular standardized measure of language proficiency used across the country. Many of the standardized assessments are limited in their use with d/DML children, however, as two of the major assessment constructs focus on speaking and listening skills that may be inappropriate for children who have a hearing loss [5].

For a comprehensive language profile for children who are DMLs, it is necessary to go beyond the use of standardized tests. Informal assessments have been recognized for their ability to meet the developmental, cultural, and linguistic needs of children from diverse language backgrounds [14,15]. It is important that educators reflect on their own personal biases with regard to language and culture when conducting informal assessments of DMLs' language and literacy skills, as these biases may inadvertently influence the administration and interpretation of the assessments at hand [15]. Unfortunately, many professionals may be unaware of the hidden biases they may be expressing through the assessment referral, administration, and interpretation phases of the process. By consulting with various experts on language diversity within and outside of the d/Dhh field, the teacher, psychologist or other specialist may be able to seek support in reducing bias in their individual assessments of children [15].

4.3. Assessment for Accountability

Program accountability is important to the cycle of teaching and learning of children, as it gauges the extent to which programs are meeting their intended goal of student learning [15,24,32]. While assessments used for program accountability are standardized, they are different than the types of standardized assessments used to identify students for services. Assessment for accountability typically uses a large-scale summative standardized assessment that is centralized for scoring and reporting purposes. The goal of these assessments is to "have a uniform, efficient, and valid method of measuring schools' progress in developing student knowledge" [24] (pp. 462–463). Another important difference in standardized assessment for accountability is that assessments can "examine a more narrowly focused or limited set of indicators" rather than assessing the "full range and depth" of functioning necessary for other purposes of assessment [15] (p. 29). In the United States, these assessments are commonly administered at the state level, but are reported on using a standard procedure that determines whether the school or district has met predetermined benchmarks [24]. The three notable exceptions of accountability assessments used across states are the PARCC (Partnership for Assessment of Readiness for College and Careers) and SBAC (Smarter Balanced Assessment Consortium) tests of the common core state standards and the ACCESS (Assessing Comprehension and Communication in English State-to-State) testing for English learners (ELs) to monitor language proficiency.

The combination of these factors creates a high-stakes testing environment for children in U.S. schools [24]. Some states, such as Florida, are even using these accountability data to evaluate teachers' performance through value-added models, extending these high stakes to teachers as well [33–36]. Given the associated risks for teachers and children, it is imperative that states and districts employ best practices when conducting accountability assessment. High-quality assessment for accountability reflects the program goals, as "accountability depends on a clear assessment process—one with alignment between state policies and teacher practice" [24] (p. 484). Specifically, assessment for accountability should be aligned with the curriculum used for instruction. Without curriculum–test

alignment, "the strength of the relationship between schooling and test scores is diminished" [18] (p. 10).

Effective accountability measures should also ensure that special populations, including children who have disabilities or are linguistically diverse, are "meaningfully represented in the accountability frameworks" [24] (p. 476). Unfortunately, even special education law has recognized that "technical standards have not been established for the inclusion of special populations in academic assessment programs, which threatens the legitimacy of test-based accountability for all students" [18] (p. 2). Group characteristics of bilingual learners are also underrepresented in accountability frameworks, as "state standardized assessments were not designed to measure achievement in students without grade level English proficiency and academic preparation" [24] (p. 485).

For d/Dhh children who use ASL, there are an insufficient number of state tests that are available in their primary language because "systematically developed and standardized ASL presentations of state and district wide assessments remain unavailable from test developers and vendors" (p. 3) [18]. In fact, only South Carolina has undertaken the task of creating statewide assessments available in ASL [37]. This is problematic, as assessment in the instructional language is considered the standard of care for accountability purposes [32]. Therefore, children who are d/Dhh regularly participate in these accountability assessments; however, many need accommodations to access test content [24]. Although accommodations can help establish equity in the test session, the low-incidence nature of the d/Dhh population, the wide geographical differences in numbers of d/Dhh children, and the unique cultural and linguistic characteristics in d/Dhh programs make accountability assessment complex and ever evolving [24].

4.4. Monitor Trends and Evaluate Programs

The final purpose of assessment is for research and evaluation purposes. For basic and applied research to provide useful information, the assessments used in the investigations need to be high quality, specific to the purpose of the study, and targeted to the population being examined. The tests used for research and evaluation are typically a combination of standardized assessment, performance-based assessment, and researcher-designed tests.

As there are few testing companies creating tests specifically for d/Dhh children, researcher-designed tests are an opportunity for d/Dhh children to have tests created with their specific needs in mind. This is particularly important for tests of sign languages, as it provides the opportunity to consider the sign language features during test development and reduce the linguistic biases introduced through translation. Research with the aim of creating assessments and the sharing of assessments that are byproducts of larger research goals would both be beneficial to the greater academic community and understandings of d/Dhh children's language development and learning.

Program evaluation shares a common objective with assessment for accountability—to determine the extent to which program goals are being realized for children [15,32]. However, program evaluation can take many forms and does not solely rely on large-scale standardized assessments to achieve its aims. In fact, much of program evaluation is conducted "within the context of the broader academic research community," which allows for varied approaches to examining the effectiveness of programs [15] (p. 31). For d/Dhh children, program evaluation typically concerns the effectiveness of intervention programs. One key aspect of evaluating interventions is the focus on implementation science to ensure the program is being delivered as intended [38]. Therefore, strong intervention research needs to employ assessments of fidelity and quality with clear connections to child learning outcomes in language and literacy [38].

5. Factors in Assessing Sign, Spoken, and Written Languages

There is no one assessment that can provide a comprehensive portrait of a child's language and literacy abilities. A combination of assessment approaches is often used to determine the language and

literacy skills of individual or groups of d/Dhh children. These measures need to be selected with care to reduce inherent biases and establish validity.

Every language has its own distinct features and components. The assessment of various languages, therefore, requires the consideration of the unique assessment conditions related to each language being assessed. For the purposes of this next section, an overview of the factors involved in the assessment of sign, spoken, and written languages will be presented. For each language area, the availability of language assessments, aspects of language that need to be assessed for d/Dhh children, and individualized needs based on language modality will be addressed.

5.1. Sign Languages

There are a small number of formal assessments that can address language proficiency in sign languages (see Singleton, & Suppella [39] and Henner, Novogrodsky, Reis, & Hoffmeister [40] for more information about specific assessments available). In the United States, the number of available ASL assessments are limited due to challenges in creating tests that can adequately account for the linguistic features of ASL [41], the need for examiners to be highly trained and have strong language skills [42–44], and prohibitive costs associated with purchasing standardized tests and training examiners on those tests [40]. Although these assessments are not as widely available as necessary, it is important to attempt to use one of these formal assessments, as they are able to provide scores with higher levels of validity and reliability [40].

Assessments of sign language should be conducted by an examiner with the requisite language skills to adequately administer the test and interpret the scores [39]. Formal ASL assessments are beneficial in determining conventional language skills; however, they may have limitations in assessing the language skills of children who use constructed sign systems in their classrooms [40]. Therefore, the examiner should also be proficient in the regional and local sign systems used in the school context [4].

Given the small number of formal assessments that are available to examine sign languages and the need for the ongoing monitoring of sign language development, informal assessment can add a layer of understanding about a child's sign language proficiency. The Naturalistic Assessment of children's language and video portfolios are particularly useful to supplement standardized tests of sign language. In addition, one promising strategy to track the language learning of d/Dhh children who use ASL is to conduct Standards-Based Assessment using the Gallaudet K–12 ASL Content Standards [45]. These standards outline the types of ASL competencies that children should be learning across grade level bands. Educators are able to examine a child's ASL skill levels in relation to the types, functions, and structures of ASL that are considered age appropriate as a way to measure current levels and monitor learning.

While the assessment of conventional sign language development is necessary for our signing d/Dhh children, it is also important to capture the functional sign communication strategies children use as well. The documentation of home signs, or gestural communication systems used in the home, is necessary to understand the full communicative competency and repertoire of a d/Dhh child [46]. These sign systems may include some properties of conventional language but are not complete [47]. By examining the functional communication of the d/Dhh child in the home, a comprehensive portrait of their sign language understanding and use is possible.

5.2. Spoken Languages

The assessment of spoken language is necessary for all d/Dhh children who use spoken language. It is important to examine a child's audiogram and language background to inform the use of spoken language testing. The administration of spoken language assessments should always be conducted with caution, however, as the hearing loss may adversely affect their performance due to a lack of access to test content [13]. If a spoken language assessment is being attempted and the child is unable to participate, the examiner should terminate the testing session.

For children who will benefit from spoken language assessments, including those who exclusively use spoken language, there are conditions for conducting the assessment that strengthen the assessment, its findings, and conclusions. First, all children should be using all hearing technology when being assessed in a spoken language. Second, the testing environment should be acoustically vetted to ensure the background noise, reverberation, auditory or visual distractions, and general comfort levels can be maintained throughout the test session. Third, these assessments should be conducted by someone who is familiar with the child's personal speech characteristics when possible [4]. Fourth, collaboration with a speech and language specialist may assist in the appropriate assessment of spoken language skills. Finally, accommodations are especially helpful when conducting the formal assessment of spoken language skills for d/Dhh children.

For children who are d/DMLs, the assessment of home language abilities is also important, which is most often a spoken language. As with signed languages, there are limited spoken language assessments available in languages other than English and limited examiners with the requisite language skills to conduct these assessments. Although the issues pertaining to crossing modalities in translation (spoken to sign) do not apply for home languages, translation remains an issue, as semantic equivalence still needs to be established. For example, a common word in one language may translate into a more complicated word in the new language, or the reverse may be true.

5.3. Written Languages

The assessment of written languages includes both reading and writing skills. When assessing reading and writing skills, all test directions should be given in the child's most proficient language. Once again, if a translation of the test directions or content is needed, care must be taken to not modify or substitute the target skill being assessed. For example, a child who uses a sign language to dictate an essay will not be able to be assessed on her/his writing conventions, as she/he is engaging in aspects of writing (e.g., content and ideas), but not the conventions themselves. To provide a score for conventions in this scenario would be a significant modification of test content for this child.

For reading, it is important to examine d/Dhh children's test-based and knowledge-based skills. Text-based skills include letter and word recognition, decoding unfamiliar words, and automaticity in consuming print, while knowledge-based skills include meaning-making and comprehension [48]. While text-based skills are essential for a child to access the print in front of them, they are not sufficient for a child to understand what she/he is reading without the knowledge-based skills necessary to support comprehension [49]. Given the reciprocal relationship between language and literacy development, knowledge-based skills can be developed through the use of sign or spoken languages alongside, or even in the absence of, the print components of literacy.

The assessment of writing skills includes aspects of writing conventions (e.g., grammar) and conveying meaning (e.g., organization, content, etc.). For d/Dhh children, there are four major considerations for the assessment of writing. First, examiners should not let writing conventions overshadow the other aspects of writing, as they are typical areas of difficulty for d/Dhh children [50,51] and may unduly affect the overall score on a holistic writing assessment [52]. Second, writing assessments that require too much reading may also negatively affect a child's writing score. The selection of an assessment that does not create a burden due to the amount of reading it requires, or the use of accommodations when the amount of reading is excessive, may be necessary to capture a child's true writing abilities. Third, it is hard to establish interrater reliability for formal writing assessments, even when the criteria are detailed [52]. Finally, informal assessments are needed to provide detailed information about a child's present levels of writing skills, create writing goals, and to continually monitor writing improvement over time.

6. Conclusions and Recommendations

The diversity and variability of language exposure and use for d/Dhh children make assessing the language and literacy development of d/Dhh children challenging. These unique needs for language,

culture, and learning must be considered when planning, conducting, and interpreting assessment data for this population. As there are many approaches to assessment that may be used for a child who is d/Dhh, care must be taken in the test selection process to match the child's needs. While no two d/Dhh children will be exactly alike, some broad recommendations can assist examiners and educators in selecting assessment approaches that increase the validity and usefulness of assessment data, while reducing unnecessary biases inherent in the assessment conditions:

- The child's language background is important in determining the language of the assessment, including what language resources may be needed for a successful assessment (e.g., ancillary examiner or interpreter). The language match between the child and the examiner is especially important in reducing linguistic bias in the assessment.
- Multiple sources of assessment data are always needed for a comprehensive language and literacy assessment. The heterogeneous nature of the d/Dhh population will require multiple strategies, as more than one data point will increase the reliability of the assessment being conducted [33].
- The assessment approach needs to be vetted in terms of its strengths and weaknesses in assessing d/Dhh children but not decided based on those factors exclusively. There are many different formal and informal assessment approaches and tests that may be used with a child. There are factors that impact each approach to assessment related to hearing loss and language use for d/Dhh children. Although these factors can help to inform the selection process, the final approach should always be individualized to meet the specific child's needs at the time of the assessment.
- Assessment approaches should be viewed in light of the purpose of the assessment. Specific assessment approaches lend themselves to the various purposes of assessment better than others. It is important to consider the various purposes and how they are assessed for d/Dhh children when selecting approaches to be used in an assessment.
- The language being assessed matters for d/Dhh children. The availability of valid tests varies by the language being assessed. In addition, there are key aspects of language that pertain to sign, spoken, and written language that are important to consider when creating an assessment plan.

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Article

Reading Development of Students Who Are Deaf and Hard of Hearing in Inclusive Education Classrooms

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Abstract: The purpose of this article is to discuss the major research findings associated with the reading/literacy development of students who are d/Deaf and hard of hearing (d/Dhh) in inclusive education classrooms. The conditions for developing effective literacy skills are also described. A professional review approach was utilized, and relevant journal articles from 1985 to 2019, inclusive, were selected and analyzed. Other relevant publications including selected chapters and books were used to support the available salient findings. Results of the reviews, recommendations for future research and the limitations of the review process are also provided.

Keywords: d/Deaf and hard of hearing students; inclusive education classroom; professional literature review; literacy; reading instruction

1. Introduction

Many countries have enacted legislations that give students with disabilities the right to be educated with typical peers in inclusive education classrooms [1,2]. For example, the number of d/Dhh students in inclusive education classrooms has rapidly increased in the United States (USA) after the Individuals with Disabilities Education Act (IDEA) was enacted in 1975. This act asserted that children with disabilities should receive their education in their neighborhood public schools, unsegregated from their typical peers to the maximum extent possible [3]. This implies that students with disabilities, include those with hearing loss, should receive appropriate education in inclusive education classrooms, regardless of the type and severity of the disability. According to the IDEA, schools are not allowed to move students with disabilities to segregated classrooms if the students' needs can be met satisfactorily with additional support services in inclusive education classrooms.

Statistical information from the US Department of Education [4] indicate that approximately 19.4% of d/Deaf and hard of hearing (d/Dhh) students receive 40% to 70% of their education in general education classrooms and about 61.8% of those students receive 80% or more of their education in general education classrooms. In addition, it has been reported that about 13.8% of students with hearing loss receive less than 40% of their education in general education classrooms, and about 2.9% are in special schools for d/Dhh students. About 2.1% of those students are placed in separate residential facilities or regular private schools, such as homebound/hospital placements, and correctional facilities.

It is expected that the number of d/Dhh students in inclusive education classrooms will increase because of the development of early hearing loss identification and intervention techniques, in particular, cochlear implants that assist those students to access spoken phonology [5,6]. There are other factors that may influence the educational placement of d/Dhh students, including the development of technology, financial pressures, and parental expectations [7]. In addition, in light of research results documenting low reading levels among students with hearing loss, there is an ongoing debate about the role of the educational environment on the development of language and literacy skills of this group of students [8,9]. The main question that must be answered is whether the inclusive education

classroom is considered a rich literacy and language environment that can assist students to improve their reading skills.

To answer this question, it is important to describe various variables that relate to the inclusive environment, including teachers' qualifications, reading instruction, access to the general education curriculum, communication and language skills, and support services. It is necessary to understand how these variables influence the development of language and literacy for students with hearing loss, considering the tremendous variations in aspects such as degree of hearing loss, factors associated with the home and school's environment (e.g., parents' age, parental involvement; language and literacy experiences, number of students in the classroom), early identification, early intervention, and language and communication skills [5,10,11].

The present article provides a description of the method used for selecting and analyzing research and scholarly findings. Then, a discussion of the "optimal" conditions for developing language and literacy for d/Dhh students in inclusive education classrooms is undertaken. Next, the researcher discussed the methods used to measure the reading levels of d/Dhh students. This is followed by a synthesis of research findings on reading development of d/Dhh students in inclusive education classrooms. The article concludes with recommendations for further research.

2. Methods

The present researcher conducted a professional literature review. According to Gall, Gall, and Borg [12], there are two categories of literature reviews, including professional reviews and narrative reviews. These two categories of review follow specific steps for selecting and reviewing previous publications. In this article, a professional literature review was utilized because this type of review is often used in chapters as well as other manuscript-length genres that provide an extensive review of a specific topic—such as the topic of inclusion and reading development of d/Dhh students, which is discussed in this article. In addition, this type of literature reviews covers both primary (original or empirical) and secondary sources. It also allows authors to use both technical or non-technical language in presenting and interpreting research results. The researcher who uses a professional literature review may not synthesize all selected publications, in particular those that did not have a representative sample of participants. This is because there are some publications that are included that can be used to provide recommendations for further research and effective instructional practices.

In this article, several electronic search engines, including EBSCOhost, Education Full Text (Wilson), ERIC, PsycInfo, and Google Scholar, were used to identify relevant research studies. Further, certain journals that publish research on d/Dhh students, such as the Journal of Deaf Studies and Deaf Education, American Annals of the Deaf, Deafness & Education International, and the Volta Review, were used to search for articles. The researcher utilized specific literature phrases and terms including the following: Inclusion, academic achievement of deaf and hard of hearing students, reading development of deaf and hard of hearing students, inclusion and reading development, and deaf students. In addition, to locate articles, the researcher searched for books related to the topic of the current article. These books provide a critical analysis of the investigated topic and discuss factors that affect the inclusion process of d/Dhh students.

After the electronic search was completed, the researcher reviewed the reference list of each article and book in order to identify additional sources. Other sources including dissertations, theses, conference presentations, and unpublished studies were not included. The participants in the publications must include or concern d/Dhh children and adolescents. In addition, the publications must include a discussion related to the topic of the current article. Because of the dearth of publications on inclusion and reading development of d/Dhh students, the publications included in this article were published between 1985–2019. All other publications that did not meet the foregoing inclusion criteria were excluded.

I synthesized a selection of 69 primary (i.e., original, empirical) and secondary (i.e., research reviews) investigations to address the following questions:

(1) What are the conditions for developing reading for d/Dhh students in inclusive education classrooms?
(2) What are the major research findings associated with the reading development of d/Dhh students in inclusive education classrooms?
(3) What are the recommendations for further research on the reading development of d/Dhh students in inclusive education classrooms?

3. Conditions for Developing Literacy in Inclusive Education Classrooms

There are several variables that affect the reading development of d/Dhh students in inclusive education classrooms. These variables should be considered by educators and researchers who work in inclusive education classrooms or who investigate the process of inclusive education.

3.1. Teachers' Qualifications

Literature reviews indicate that one of the main goals of including d/Dhh students in the inclusive education classroom is to improve their reading achievement [5,13–15]. However, research has identified several challenges that might limit the accomplishment of this goal, the most important of which is the teachers' knowledge and skills in teaching reading to d/Dhh students [16,17]. When teachers do not have the necessary knowledge and skills to teach reading, students are more likely to struggle throughout school. Research has reported that there is a direct relationship between teachers' knowledge and skills and students' academic outcome [18]. For d/Dhh students, the role of teachers in reading development is probably more important than other factors associated with students' family and peers [19]. This is because these students spend more than six hours a day in schools with their teachers. In addition, parents of children with hearing loss always expect that teachers can assist their children to learn to read effectively. In general, teaching reading to this group of students is not an easy task because teachers need to understand the specific logical conceptual framework of reading in order to provide high quality instruction [20,21]. Teachers must have mastery of the knowledge-based reading curriculum as well as possess the best instructional tools to teach reading successfully. Specifically, it is necessary for teachers to understand the reading challenges faced by d/Dhh students, which consist of two broad components—the challenge of accessing spoken phonology and recognizing differences between the structure of a signed language and the written language of print [8]. Stanovich [22,23] investigated several components of reading development; specifically, the relationship between word identification and print comprehension and the use of specific reading cognitive skills. Stanovich found that early phonological difficulties, including the inability to access the phonemic level of speech as well as the inability to cognitively manipulate phonemic representations, were significant impediments to reading, resulting in a slower reading development. Stanovich asserted that phonological awareness is causally related to early reading development. In other words, it is challenging for individuals to learn to read adequately without access to the spoken phonology of the language of print [8]. The second broad component of the reading challenges faced by d/Dhh students is that many students with profound hearing loss, in particular those who use only a signed language, experience difficulty in understanding the relationship between the through-the-air form of a language and its written representation. Understanding the above two issues is necessary for teachers to know how to use effective reading teaching methods.

In addition to identifying reading challenges among students with hearing loss, it is important for teachers to know the essential components of reading including phonics, phonemic awareness, vocabulary, fluency, and reading comprehension [8,9]. These five components were reported by the National Reading Panel (NRP) [24] after a comprehensive evidence-based review on how children learn to read. The NRP found a systematic relationship between these five components and reading

development. Furthermore, the report indicated that explicit instruction is the most effective evidence-based method for teaching these five reading components [8,25,26]. Accordingly, teachers of d/Dhh students in inclusive education classrooms should have sufficient knowledge of these reading components and the skills to teach them through instruction that includes a combination of methods.

In general, many inclusive classroom teachers who have graduated from universities may not have the knowledge and skills to teach reading [27]. These teachers may have sufficient knowledge about the educational practice of inclusion and characteristics of d/Dhh students. However, they lack understanding of the foundational and language concepts of reading [28,29]. In addition, many of these teachers lack language and communication skills, such as improving access to spoken phonology as well as using a signed language with those d/Deaf students who use only a signed language. Research has reported that teachers who cannot sign effectively often face challenges in delivering instruction and assessing the progress of d/Dhh students in inclusive education classrooms. More importantly, d/Deaf students, who sign, lose confidence in their teacher's ability to assist them to improve their knowledge and skills [30].

3.2. Reading Achievement in Relation to Spoken Phonology

According to the qualitative similarity hypothesis (QHS), developed by Paul, Wang, and Williams [8], in order for children to become good readers, they need to understand, from an early age, English language and literacy fundamentals and skills, such as phonological processing, phonemic awareness, decoding, and print conventions. It should be noted, however, that there is a debate as to whether it is necessary for children with severe to profound hearing loss to acquire and learn certain fundamental skills of a sound phonology (phonological awareness, phonemic awareness, and phonics) as a part of the reading process, due to the fact that these children have limited access to auditory information [31–33]. This debate is seen as the most challenging issue addressed by the implications of the QSH (see Paul et al. [8]).

Several researchers have argued that the five English language components, including phonology, morphology, syntax, semantics and pragmatics, play an essential role in reading development [32–36]. They asserted that access to spoken phonology alone is not the only tool needed for reading development; however, it is necessary for all children who are learning English as their first or second language. They also argued that the function that spoken phonology plays in reading acquisition cannot be accomplished by sign or English orthographic representation alone. Phonology is also important to enhance vocabulary knowledge in through-the-air and written English. Particularly, phonemic awareness was identified in several empirical studies as important for developing students' word identification skills as well as to facilitate their understanding of the relationship between through-the-air English and English print [8].

Several empirical studies that investigated the general relationship between spoken phonology and reading development have supported the above argument [25,33,37–39]. Therefore, it is important for teachers of d/Dhh students to have the knowledge and skills to use effective techniques such as visual phonics and cued speech that represent running speech stream visually and tactilely, particularly the phonemes and syllables [40]. Mayer and Trezek [41] cited empirical evidence that indicated that d/Dhh students can access spoken phonology for reading purposes through using techniques such as visual phonic and cued speech. For example, Narr [34] investigated the impact of the length of reading instruction time supplemented by visual phonics on phonological awareness, decoding skills and reading ability of 10 students with hearing loss from kindergarten to third grade. Teachers used sign English and American Sign Language (ASL) during reading instruction. A direct and positive relationship was found between time spent in direct reading instruction using visual phonics and students' reading development. The researcher concluded that using visual phonics as part of the reading instruction improved the decoding skills and phonological awareness of d/Dhh students.

Another study conducted by Trezek et al. [36] investigated the effectiveness of utilizing visual phonics and a direct instruction reading program with students with hearing loss. The study aimed

to evaluate the outcome of using visual phonics to supplement a phonics-based reading curriculum for students. Researchers conducted the study with twenty d/Dhh students in kindergarten and first grade with different degrees of hearing loss. The findings showed that the beginning reading skills of students in kindergarten and first grade were improved after receiving instruction for one year.

In essence, d/Dhh students might struggle to develop their reading skills in inclusive education classrooms if the teacher does not have knowledge of effective reading instruction techniques. This implies that implementing inclusive education alone for students with hearing loss is not a guarantee that students' reading skills will improve.

3.3. Access to the General Education Curriculum

The most significant amendment of IDEA (Public Law 105-17) was passed in 1997, which asserted that children with disabilities, including those with hearing loss, should access the general education curriculum in the inclusive education classroom [3,42]. Access to the general education curriculum implies that d/Dhh students should study the academic curriculum content (reading, mathematics, science, etc.) of their hearing peers at the same grade level. According to this IDEA's amendment, it is not allowed for schools and teachers to develop or use specialized curricula for d/Dhh students. Therefore, the main role of teachers is to address the unique needs of d/Dhh students and ensure that curricular content is delivered to meet the common core and content standards [43,44]. Indeed, the special education discourse after this amendment of IDEA has shifted from the question of where d/Dhh students must be educated to the issue of how to provide effective educational support and other services to ensure students' access to the general education curriculum [45]. More importantly, IDEA ignited a controversial discussion among educators and researchers about the knowledge and skills of inclusive education teachers. These teachers need to use efficient accommodations and modifications to address the reading challenges of d/Dhh students.

To address reading challenges, teachers need an adequate understanding of the reading curriculum content, their students' demographic information, and skills to modify and accommodate the reading content based on their students' individual differences [8,46,47]. Specifically, students with hearing loss come to schools with a rich diversity of experiences [48]. Several researchers attribute the academic achievement differences among d/Dhh students to their individual characteristics and demographic differences [49]. For example, these students often have different degrees of hearing loss and come from different ethnic, and economic backgrounds. In addition, d/Dhh students who have received effective early intervention services may possess better communication and learning skills than those who did not receive such services [2].

With respect to the diversity among d/Dhh students, it becomes more challenging for inclusive education teachers to help students access the general education curriculum. According to Mayer and Trezek [41], it is necessary for teachers to obtain information about their students' cultures and backgrounds, such as their home language and parents' educational level and involvement. This information helps teachers to develop effective reading instructional and appropriate learning activities for their students. Another essential element for ensuring the use of necessary modifications and accommodations of the reading curriculum content is to develop an individual education plan (IEP) [44,46]. The IEP team works together to identify and describe conditions to facilitate a child's access to the general education curriculum. Also, the team develops effective and appropriate instructional strategies to meet the student's needs and assist her/him to reach specific academic goals. In general, the IEP must have clear annual goals that are appropriate to the student's needs. Furthermore, it includes educational supports and services that the student will need in the inclusive education classroom [44]. The most significant section of the IEP is related to instruction, assessment and the accommodations and modifications of the curriculum, which focus on motivating d/Dhh students to continue in the inclusive education classroom as well as to maintain access to the general education curriculum [50].

The implementation of universal design for learning by inclusive education teachers also may facilitate d/Dhh students' access to the reading curriculum content. This approach provides specific principles that give students equal opportunities to learn in the inclusive education classroom [51]. It provides a blueprint to develop appropriate goals, instruction, assessment and learning materials that considers students' differences. A universally designed curriculum is necessary to improve the learning environment and educational practice that accommodate all students regardless of their individual and background differences [51]. Wehmeyer et al. [52] emphasized that the utilization of a universal design for learning has a positive impact on the academic achievement of students with disabilities and is effective in facilitating access to the general education curriculum.

There are three principles of universal design for learning that might be directly related to access to general reading curriculum content [51,52]. First, inclusive education teachers can provide multiple means of representation, where the instructional, assessment, and learning activities are presented in different formats and at different levels of complexity. Second, teachers can provide multiple means of expression, which means students can use a variety of formats in terms of answering questions or expressing their ideas and information. Specifically, this principle encourages teachers to provide students an opportunity to use different forms to engage in the discussion and learning activities in the inclusive classroom. The last principle is providing multiple means of engagement, which means that teachers focus on each individual's prior knowledge, attention, curiosity, and motivation, to engage them in learning. This principle emphasizes the importance of gathering information about the students' background, knowledge and culture, and then use this information to encourage students to engage in classroom activities and dialogues.

In essence, d/Dhh students gain access to the general reading curriculum when they receive effective and appropriate educational supports and services from staff in schools, in particular, teachers. Hence, teachers should be aware of their students' individual differences and have the best educational tools to use with them.

3.4. Communication and Language Skills

In addition to the academic benefits, the goal of inclusion for d/Dhh students is to develop their communication and social interaction skills with hearing teachers and peers [1,46]. The active interaction and participation in the classroom is essential for students' acquisition of effective communication and language skills and strategies [53]. Further, when d/Dhh students interact with hearing students, this assists them to improve their experiences and their prior knowledge of the topics discussed in the classroom—and, subsequently, this should enhance the development of reading/literacy skills. However, many d/Dhh students feel isolated in the inclusive education classroom because they cannot make friends and participate in classroom activities due to their communication difficulties [46,54]. The lack of communication skills and difficulty in accessing spoken phonology might also negatively influence the students' abilities to learn to read. Particularly, students may not possess an adequate language to express thoughts, ideas, feelings, and information. In other words, there is a relationship between students' communication skills and their abilities to organize ideas during reading in different contexts. This implies that language and reading skills must be developed together and are interconnected. d/Deaf and hard of hearing students who have adequate communication and language skills are more likely to understand the relationship between the through-the-air form of English and its corresponding print form, that is, the fact that spoken sounds correspond with letters or groups of letters [9,53]. Further, these students can obtain sufficient knowledge and skills in areas such as English phonology, vocabulary, and syntax [55].

It is important to distinguish between students who have a severe-to-profound hearing loss (about 70 dB or greater), often labeled traditionally as "deaf", and students who are hard of hearing (about 21 to 69 dB), as separate groups with different communication and hearing needs [56]. This is because a number of students with severe-to-profound hearing loss rely predominantly on a signed language and may not access spoken (or a sound) phonology. On the other hand, the majority of students

who are hard of hearing and even some "deaf" students who have had access to early amplification, often can access a spoken phonology. For example, students who are hard of hearing often use a wide variety of communication options such as loop systems, hearing assistive devices, digital hearing aids, and cochlear implants which can assist access to a spoken phonology. Also, the inclusive classroom teacher can capitalize on students' residual hearing and communication skills to assist their access to phonology in order to develop their reading skills.

From another perspective, educational interpreters are necessary for many students with profound hearing loss who are primarily dependent on a signed language to facilitate their communication with teachers and hearing peers [57]. Particularly, the interpreter provides communication access for d/Dhh students by translating and clarifying the teacher's instruction and the spoken language used by other students. Further, the interpreter facilitates d/Dhh students' access to the content of the reading curriculum by translating and clarifying teachers' reading instruction, questions, and comments [58,59]. The interpreter's role is difficult because it requires not only adequate communication skills, but also sufficient knowledge of reading content and children's reading needs in order to deliver all information appropriately and help d/Dhh to interact and communicate with hearing peers. Particularly, with the service of an interpreter, d/Dhh students in the inclusive education classroom can fully participate in learning and extracurricular activities and engage with hearing peers [58].

3.5. Supports and Services

With the development of the digital media, technology, and educational tools, teachers are able to deliver information to their students in different ways in the inclusive education classroom [60]. Appropriate classroom supports and services enhance the teaching and learning of reading and assist students with hearing loss to gain increased access to the reading curriculum [61,62]. Further, the provision of supports and services motivates students with hearing loss to engage in the inclusive education classroom—to be active in academic lessons and to participate effectively in reading activities. With respect to teaching reading to d/Dhh students, the use of educational tools, such as visual materials, is even more important, because this can reduce the potential quantitative delay in the acquisition of knowledge. Specifically, sufficient educational materials in the inclusive education classroom improves the quality of instruction and the interactions between teachers and their students [57]. However, it is important that the selection of educational materials takes into account individual differences among students with hearing loss. In other words, these students have diverse needs that require teachers to use a variety of educational materials that offer more feasible supports for their learning needs [61].

Several studies have examined the effectiveness of methods of teaching reading using materials, such as pictures and videos, with d/Dhh students [63]. For example, Alqraini (2017) examined the effectiveness of teaching multiple-meaning words to fourth grade d/Deaf and hard of hearing students in the kingdom of Saudi Arabia, using a picture-based intervention. It was found that there was a significant improvement in the recognition and comprehension of multiple meaning words among students who received the intervention. In another study, Aceti and Wang [63] examined the effects of explicit instruction, using pictures, on teaching multiple meanings of words to four d/Dhh students with and without additional disabilities. The researchers found that the students were able to select correctly all pictures that illustrated the correct meanings of the words on a posttest.

To assist d/Dhh students to develop their reading skills in the inclusive education classroom, previous research has identified three types of educational materials, including audio, visual and audiovisual, that should be provided to students [64,65]. Specifically, students with hearing loss need audio and assistive listening devices, such as sound field amplification systems, telecommunication relay, induction loop, and FM systems, that can facilitate access to sound in order to assist students to understand that a word can be separated into smaller segments (e.g., phonemes, syllables) as well as to understand the relationship between the through-the-air and written forms of English [32,64]. Furthermore, visual materials, such as diagrams, charts, posters, formulas, pictures, graphs, slides, computer presentations, are useful for students because they often depend on their visual abilities for

learning. In addition, teachers of d/Dhh students prefer to use visual materials to facilitate instruction and apply learning strategies appropriately. More importantly, using visual materials makes the lesson more interesting for students and motivates them to engage in classroom activities [64,65]. Students who are d/Dhh benefit also from educational materials that include a combination of both audio and visual elements, such as televisions, projectors, computers, and films. In particular, these materials, which provide audio and visual components simultaneously, are useful in terms of improving students' ability to gain access to information while also increasing their motivation to learn [64,65].

4. Inclusion and the Development of Language and Literacy Skills

The majority of d/Dhh students encounter communication difficulties in the inclusive education classroom [66]. For students who have a profound hearing loss, communication and interaction with hearing students is more challenging than it is for students with mild to moderate or severe hearing loss because the former group often relies on a signed language for communication whereas hard of hearing students often use spoken language [5]. Despite the differences between the two groups, both need support services in the inclusive education classroom to ensure their success and access to the academic content, in particular reading. Considering the academic challenging faced by d/Dhh students in the inclusive education classroom, it is necessary to obtain current and accurate data on their academic status and progress. In addition, researchers need to conduct empirical research to measure reading achievement of d/Dhh students because previous research has indicated that d/Dhh students have significant weaknesses in this area [8]. For example, it was reported that the performance of 50% of d/Dhh students from a national sample was below a basic proficiency level in reading comprehension [67]. In addition, Geers and Hayes (2010) indicated that the reading achievement of a number of d/Dhh students at the end of high school is similar to the reading level of hearing students at third or fourth grade. It is, therefore, important to know whether the inclusion of d/Dhh students in the inclusive education classroom can contribute to the improvement of their reading ability.

The literature review has revealed that there is a dearth of research about the effects of inclusion on the development of language and literacy skills of d/Dhh students [5]. The available research that measured reading achievement of d/Dhh students in the inclusive education classroom often used standardized test scores or was based on teachers' perceptions. Specifically, many countries, such as the USA and United Kingdom (UK), used standardized tests to measure reading achievement of students, including students with hearing loss. These tests are considered effective tools to compare the reading levels of d/Dhh students before and after they are educated in inclusive classrooms as well as to compare their reading levels with those of typical hearing students [68]. Antia et al. [5] also asserted that teachers' perceptions are essential for obtaining information on the reading levels of d/Dhh students. Teachers spend several hours every day teaching and interacting with their students and thereby they can provide insights into their students' strengths and weaknesses in reading.

5. Research on Reading Development in the Inclusive Education Classroom

The available literature has revealed much controversy on the effects of inclusive education on reading development of d/Dhh students [7,10]. Opponents of inclusive education argued that the academic achievement of d/Dhh students is significantly behind that of hearing students [69]. They asserted that d/Dhh students may not perform better in inclusive classrooms, due to several factors, such as students receiving less attention from their teacher. In addition, the teacher may not understand the characteristics of hearing loss as well as the special classroom teacher, who is a specialist in the education of d/Dhh students. On the contrary, the majority of inclusive education supporters have asserted that classroom interaction and instruction in inclusive education classrooms can assist d/Dhh students to improve their academic achievement [2]. For instance, Harrison (1988) indicated that inclusive education provides specific academic goals, effective assessments, and a rich curriculum, which assist d/Dhh students to develop the necessary abilities and skills for reading achievement.

Although the results of research that investigated the reading achievement of d/Dhh students in the general education classrooms have been inconsistent, most available studies have found a positive relationship between inclusion and reading achievement [13,70]. For example, Antia et al. [5] investigated the academic achievement of 197 d/Dhh students who attended inclusive education classrooms for two or more hours per day. The researchers collected data via the use of a teacher rating scale—the academic competence scale of the social skills rating system. In addition, the researchers obtained both normative and classroom academic data to determine the academic progress of the students. The scores of most d/Dhh students on standardized achievement tests indicated that their academic achievement was in the average or above-average range in reading. Specifically, it was found that 48% to 68% of the students scored in the average or above-average range for reading, and 55% to 76% scored in the average or above-average range for language and writing. In general, teachers rated 69–81% of students with hearing loss in the general education classroom as average or above average in academic achievement.

In another study, Afzali-Nomani [21] examined the effects of inclusive education on the academic achievement and social development of hearing and d/Dhh students in the USA. The researcher used a multiple regression analysis to optimally combine scores on five educational conditions scales to enhance prediction. The participants in the study were 55 teachers of d/Dhh students and general education teachers who were employed in public school districts. All teachers had experience teaching in full inclusion programs. The teachers were asked to rate the effects of inclusive education on d/Dhh students based on three criteria: Academic achievement, social adjustment, and self-confidence/esteem. The results showed that inclusive education had a positive effect on the academic achievement of students with hearing loss. However, the positive effects of inclusion on d/Dhh students increased when those students received social encouragement, when teachers supported the program, and when there was a full range of placement options.

Similarly, Holt [13] examined the reading comprehension and mathematics computation achievement of d/Dhh students in a variety of school settings in the USA. The researcher relied on data that were collected by Gallaudet University Center for Assessment and Demographic Studies during its 1990 standardization of the Eighth Edition of the Stanford Achievement Test (SAT 8). Descriptive and inferential methods were utilized to analyze the relationships among the achievement scores of a sample of d/Dhh students, aged 6 through to 21 years. Findings showed that the reading comprehension scores of d/Dhh students who received their education in general education classrooms with hearing students were higher than those of students in segregated settings. However, the researcher reported that it was difficult to determine if the higher reading scores was due to the fact that the students were educated in inclusive education classrooms or because students who were selected to participate in inclusive classrooms already had higher achievement levels.

In another study, Kluwin [71] investigated the influence of inclusive education on the achievement and grade point average (GPA) of 451 d/Dhh students in 15 public school programs in the USA. The researcher utilized a comparison design, and data was collected via the Annual Survey of Hearing-Impaired Children and Youth. Findings indicated that the inclusion of d/Dhh students had a positive effect on their academic achievement; in particular, students who attended inclusive education classrooms exhibited higher scores on the achievement tests. The researcher asserted that the inclusion of d/Dhh students was beneficial because it engaged them in a high-quality academic atmosphere.

Most, Aram, and Andorn [72] investigated the early literacy skills of hearing and d/Dhh kindergartners who were enrolled in individual inclusion or group inclusion programs. The study also investigated the relationship between early literacy skills and background variables such as degree of hearing loss, type of sensory aid used, age at onset of rehabilitation, and family's socioeconomic status. Participants were 42 children, aged 62 to 84 months. There were 16 d/Dhh children in the group inclusive program whereas 15 children were in the individual inclusive program. The third group included 11 hearing children. The researchers evaluated early literacy skills, including word identification, writing level, phonological awareness, letter identification, orthographic awareness, general knowledge,

and vocabulary. Findings showed that d/Dhh children in the individual inclusive program exhibited higher achievement levels, compared to those enrolled in the group inclusive program, on phonological awareness, letter identification, general knowledge, and vocabulary. However, there was no significant differences between the individual and group inclusive programs on reading, writing, or orthographic awareness. Findings also revealed that the achievement of hearing children was higher than that of d/Dhh children in either of the inclusive programs. Further, although the achievement level of the hearing children surpassed those enrolled in the group inclusive program, this level was not statistically different from those enrolled in the individual inclusion program. Most et al. found also that there was a negative correlation between students' general knowledge and degree of hearing loss. That is, the greater the hearing loss, the lower the level of general knowledge. In addition, there was a positive correlation between general knowledge, reading, and writing with age at onset of rehabilitation, and there was no correlation between socioeconomic status and children's early literacy skills.

In general, the above research review has revealed that inclusion has a positive effect on the reading development of d/Dhh students. However, it is important to keep in mind that research conducted with students with hearing loss often revealed mixed results for several reasons. First, researchers have used different research methodologies or different measurements and tests, which has impacted the process of proffering generalizations [5]. Second, there is a rich diversity of experiences among d/Dhh students. The diversity among this group of students is due to factors related to the d/Dhh children themselves and their home and school environments [10,17,73,74]. For example, there are several factors that can affect research results, including degree of hearing loss, communication and language skills, age at hearing loss identification, receiving early intervention services, home related factors (e.g., parental involvement; language and literacy experiences), and school related factors (e.g., teacher competency; teachers' and students' attitudes). Additionally, d/Dhh students come from different racial, ethnic, and economic backgrounds [5–11]. As a result of this diversity, research conducted with d/Dhh students should provide sufficient information about students' individual characteristics, demography, and home and cultural backgrounds. This would increase the reliability and validity of the results and assists readers to understand the study context and characteristics of the participating sample.

6. Recommendations for Further Research

Given the range of personal, social, and academic factors that needs to be considered, conducting research on the reading development of d/Dhh students is challenging and controversial [75]. Examining inclusive education for students with hearing loss is complex because of the number of impactful variables that should be described in detail in order to allow readers to understand the research context and the disparity among the results of studies. For example, the variables of interest for inclusive education research that have had direct effects on the reading development of students with hearing loss included, at least, those factors associated with the students themselves (e.g., age, degree of hearing loss, age at hearing loss identification, age at receiving early intervention services, communication and language abilities), home environment (e.g., home language, parents' education and involvement, number of family members), school environment (e.g., number of students in the inclusive classroom, awareness/attitudes of hearing students, availability of supports and services), the characteristics of the teacher (e.g., teaching knowledge, teaching or co-teaching skills, attitudes, teacher-student interactions, communication skills), and the curriculum (e.g., accessibility). Also important is the attitude and support of school administrators.

Although it is difficult to document or statistically control all of the above factors that affect reading development of d/Dhh students in inclusive education classrooms, it is necessary for investigators to at least understand these factors because of their significant effects on the academic performance of d/Dhh students. This facilitates the researchers' understanding of the complexity of inclusion as well as the limitations of their research. More importantly, consideration of these factors should influence

the development of effective research designs that would, hopefully, provide better and more useful or generalizable findings.

In general, previous research conducted with d/Dhh students has not provided sufficient demographic and achievement information about the participants, and this has led to equivocal results. Therefore, it is recommended that future investigators provide, at least, adequate information related to demography (e.g., degree of hearing loss, age at onset, amplification usage) and achievement (e.g., language and communication levels). It is also important to understand the individual differences of participants and how these differences affect their performances in inclusive education classrooms. Failure to provide adequate information contributes to the lack of understanding and misinterpretation of the results [8,32].

Finally, some researchers used surveys or collected information on teachers' perceptions to gain an understanding of the reading achievement level of d/Dhh students in inclusive education classrooms [5]. However, it is argued that the use of standardized or formal tests is critical to obtain a reasonably objective picture of the effects of inclusive education. It is also recommended that these formal measures be utilized in conjunction with other informal assessments to capture the range of students' individual differences and other factors related to home and school environments.

7. Conclusions

Due to the dearth of evidence-based research on d/Dhh students, reviewing studies on the literacy development of typical-developing students is a good starting point to understand the effects of inclusion on reading development as well as the factors of a successful inclusive education program. These studies may provide useful data about how inclusion may help d/Dhh students improve their reading and other academic skills. Of course, there is a great need for additional primary research with d/Dhh students. The literature review in the present article has indicated that there are several conditions, such as teachers' qualifications, access to phonology, access to the general curriculum, and the availability of supports and services, that may be critical for developing language and literacy skills of d/Dhh students in inclusive education classrooms. The effects of these conditions should be addressed further by investigators to understand how d/Dhh students can succeed in inclusive education classrooms and, specifically, how to improve their literacy and other academic skills.

In sum, there is a dearth of research on the reading development of d/Dhh students in inclusive education classrooms. In addition, several studies either did not document important factors that affect reading development or did not provide adequate background information about the participants. Nevertheless, in general, the findings revealed that inclusive education can have a positive effect on the reading achievement level of students with hearing loss. The positive effects of inclusive education increase when d/Dhh students receive supports and services.

Each literature review has limitations, and this article is no exception. This article utilized a professional review, which might be considered biased, based on the interpretations and discussion of the research findings by the present author. Second, there is a dearth of research, in particular evidence-based research, on the reading development of d/Dhh students in inclusive education classrooms, and this limits the generalizability of the findings. Generalization is also problematic because some of the reviewed studies did not provide adequate demographic and achievement information about the participants. Thus, considering these limitations, it is difficult to proffer reliable and valid information about the effects of inclusive education for d/Dhh students.

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Review

Conclusion: Perspectives on Language, Literacy, and Deafness

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Abstract: As indicated in this Special Issue, there has been much debate on the development of English language and literacy in d/Deaf and hard of hearing (d/Dhh) students. Questions remain on the nature of the first language and the relation of this language to the development of English literacy. There is also considerable controversy on the role of English phonology. Adding to the complexity is the increase of d/Dhh children for whom English is not the home language and the ongoing challenge of addressing the needs of those with disabilities or additional disabilities. After describing English literacy and the need for documenting desirable research characteristics, the authors of this conclusion article utilize a construct named the Qualitative Similarity Hypothesis (QSH) as the guiding framework for addressing issues such as the role of phonology and the nature of the through-the-air form of the language of print. The QSH asserts that d/Dhh students need to master the same set of fundamentals as typical English literacy learners. These fundamentals include code-related, language-related, and comprehension-related skills. One major assertion is that proficiency in the through-the-air form of English is essential for achieving proficiency in conventional English literacy skills. It is argued that the importance of English language proficiency has been emphasized in literacy models that delineate the strong connections among language, reading, and writing, even for second language learners of English or English learners. Another major assertion is that proficiency in English phonology is necessary (albeit not sufficient) for the development of emerging decoding skills. The use of English phonology facilitates the early and advanced literacy comprehension skills. The article concludes with recommendations for additional research, including the understanding of the visual representation of the structure of English, the development of comprehensive English language assessments, and the exploration of literacy-related skills such as decoding and comprehension. Finally, the validity of the QSH also needs to be further investigated.

Keywords: d/Deaf and hard of hearing; demography; developmental framework; English language development; English literacy development

1. Introduction

The focus of this Special Issue is to present a state-of-the-art rendition of the development of language and literacy in children and adolescents who are d/Deaf and hard of hearing (d/Dhh). The language in question is the acquisition of English; however, a number of findings can be applied to the acquisition of other phonemic-based languages, which function as the majority language of society [1–3]. Typically, the majority language refers to the language of print that is employed in educational and governmental venues and is often considered, formally or informally, as the official language. The written component of the official language is a standardized form, regardless of the dialectical or regional differences of the through-the-air (i.e., spoken or oral) component in various sections of a country. It should be acknowledged, however, that, in some countries, the relationship

between the through-the-air and written forms is complex, due, in part, to the number of dialectical variations of speech or the encroachment of the influences of other languages on the mainstream society's language form [4,5]; also, see the review in [6], for Arabic as an example).

Confining our emphasis to English, one of the major challenges for d/Dhh children and adolescents is to develop proficiency in literacy (reading and writing) skills in this majority language of society [7–12]. Since the beginning of the 20th century, it has been well documented that many students with severe to profound hearing loss and some with a moderate loss—in the better unaided ear—graduate from high school (after 12–15 years of compulsory education) reading at about a 4th grade level. Albeit this level seems to be improving [13,14], there are still pervasive challenges.

The contributors to this Special Issue have attempted to address the development of language and literacy from several perspectives using either a professional review and/or a meta-analysis format. The complexity of understanding English language and literacy development has increased in light of the growing number of minorities, including immigrants, specifically the number of d/Dhh students whose home language is not English—that is, English language learners or English learners [15,16]. Traditionally, other elements of this complexity have often included d/Dhh students with disabilities (or additional disabilities) and those—for whatever reason—who come to school with limited proficiency in any language [17,18]. It is also critical to consider the advancement of sophisticated listening technologies and their contributions to the development of language and literacy; this advancement has spawned an evolving demography of d/Dhh children and adolescents [14,19,20]. Other important areas covered in this Special Issue include the assessment of language and literacy [21] and the influence of inclusion on the development of language and literacy skills [22].

The plan for this concluding article is as follows: First, we discuss the need for researchers to document adequate demographics and other critical background characteristics of the samples in their investigations. Without such information, we argue that it is difficult to proffer evidence-based or effective practices. Equally as important, it is difficult to understand the context of research findings, especially to understand if progress has been made in the development of language and literacy. Then, we argue for the use of a developmental framework as the guiding and comparison barometer for instructional and research endeavors [3,10]. This framework influences our interpretations of some of the assumptions in the works of others in this Issue (e.g., the constructs of fundamentals [7,9,11,22] and modality independence; see [7,16]). Next, we provide a description of English literacy with an eye toward the influence of the through-the-air form of a language and code-related skills (e.g., phonological knowledge, phonemic awareness)—two of the most controversial domains in the discussion of language, literacy, and deafness. We also highlight the need for the development of better language and literacy assessments and additional research on marginalized and underrepresented subgroups of the population of d/Dhh children and adolescents (e.g., Deaf with Disabilities, English learners).

We draw on some of the remarks and findings from the other manuscripts in this Special Issue to highlight and even support our assertions. Given the extensive, but not exhaustive, treatments of the nine articles in this issue, there is always a danger of oversimplification of the contributors' major points. We make no claim that our rendition is the only or best interpretation; our intent is to encourage further dialogue and research regardless of the controversies associated with specific research approaches or topics or with the interpretations of the findings. We conclude our discussion with recommendations for further inquiry with the hope of continuing efforts to close the achievement gap between d/Dhh students and their typical language-literacy counterparts.

2. Demography and Critical Research Characteristics

One of the quality indicators for an adequate research design is the documentation of demographic and other background characteristics of the sample under study. It is important to contextualize the representativeness of the sample to avoid or minimize generalizations to dissimilar populations (e.g., see discussions in [23,24]). Inadequate descriptions of the samples undermine the reliability and validity of selected or developed assessments, especially if previous research is being used to justify

the use of such assessments. There is little doubt that individual factors can affect the construction and use of assessments and the validity of comparing group performances [23,25]. This not only emphasizes the importance of demography, but also asserts its need for the proffering of reliable and valid evidence-based practices [24].

As noted by Paul and Wang [24], there is considerable debate on what constitutes adequate demographic and background information for d/Dhh participants. Controversial demographics include information on hearing acuity (e.g., unaided and aided, age at onset of hearing loss) and speech acuity (e.g., speech discrimination, speech recognition). There may be less controversy on the mode of communication, language use, and presence of additional disabilities—albeit, documenting the accuracy of such information is a challenge for investigators (e.g., [18,21]). In any case, to understand the effects of interventions or even the use of early amplification such as cochlear implants and digital hearing aids, there needs to be a better documentation of the extent, length, and use of these variables [14].

Related to the domain of language and literacy development—and the source of controversy regarding demographics—is the proposition that there might be two distinct groups of d/Dhh individuals [26–28]. The line of demarcation for this distinction is dependent on the assessment of the adequate use of functional hearing with or without amplification. That is, one group may be able to access and understand "running speech" whereas the other group cannot perform this task adequately. It has been hypothesized that d/Dhh individuals who primarily use a signed language, or even a form of signing and have limited or nonfunctional hearing, perform differently than the group that can access and understand running speech. The psychological reality of this distinction provides support for understanding the effects of the use of a signed language in the development of English literacy skills [16,29]. At the least, this differentiates the role of through-the-air language and the use of code-related skills—constructs to be discussed later. For example, proponents of this distinction highlight the notion of a "visual phonology" of a signed language, particularly within an American Sign Language (ASL)/English print-sign bilingual program [30]. This view contrasts with those of others [7,9,11], who argue that not only is a sound phonology necessary for early and conventional literacy development, but also that functional hearing is not the major issue in understanding the development of English literacy comprehension. Obviously, a diverse set of attributes of the participants need to be considered, but language proficiency and code-related skills seem to command a substantial amount of attention (e.g., see discussions in [10,31,32]).

3. The Qualitative Similarity Hypothesis

It has been argued that d/Dhh students follow a developmental learning trajectory that is similar to that of typical literacy learners—albeit some students will proceed at a slower quantitative rate due to a number of variables such as the quality of interventions, effectiveness of early amplification, variability in teacher competency, and so on [7,9,11,19,22]. This phenomenon, coined the Qualitative Similarity Hypothesis (QSH) asserts that, regardless of the degree of hearing acuity, d/Dhh students need to acquire proficiency in the same group of fundamentals associated with code-related, language-related (e.g., English language proficiency), and comprehension-related skills that are necessary for the development of typical literacy skills [8,10,33]. It is important to remember that variations in the learning trajectory of d/Dhh students do not mean that the developmental trajectory is "different" because this difference is associated with the rate of acquisition, not with the developmental or qualitative aspects of the learning process.

A similar version of the QSH has been documented in the broader research literature for "hearing" English learners and those who are at-risk or have disabilities [1,3,34]. That is, the acquisition of English by English learners or those with disabilities is developmentally similar to that of native language and literacy learners of English. Taken together, it can be argued that the general findings of literacy acquisition for typical hearing English learners can or should be applied to d/Dhh students and other students with disabilities as well as to English learners (i.e., English is not the native or home language).

In addition, these findings can or should be applied to d/Dhh students who are English learners and those who have disabilities such as cognitive disabilities and autism. Nevertheless, there are challenges in understanding the language and literacy development of these subgroups of d/Dhh children and adolescents [18,21]. Whether the development of these latter subgroups is "developmentally different" from that of typical literacy learners is in need of additional research.

In our view, the QSH should be the guiding framework or "prism" through which the findings and conclusions of most other articles in this Special Issue, indeed, of all research on English literacy and d/Dhh children and adolescents, should be evaluated. Granted, the QSH is a "framework" and it is critical to conduct additional research on the various components or constructs (e.g., phonological awareness, etc.) within this framework (e.g., [10,11,35]). There are ongoing debates on the nature and extent of these constructs for the development of reading in all d/Dhh learners with attention, as mentioned previously, focused on English phonology and the role of through-the-air language use [11,36,37]. Nevertheless, it has been argued that there is no strong evidence to suggest that the fundamentals of literacy should be different for d/Dhh students or even for any student attempting to develop an adequate level of proficiency in English language and literacy for age-level acquisition [7,9,11,22]. It is argued that the QSH is modality independent, as mentioned by several contributors to this Special Issue (notably, [7,16]). Essentially, this means that it applies only to d/Dhh individuals who have adequate access to functional hearing or running speech (one of the two distinct groups mentioned previously in the section above on demography). However, we agree with the argument of others in this issue [7,9,11,22] that this does not alter the fundamentals of the development of English reading and writing—and we assert that the QSH is not modality independent.

Regardless of the strength of the research support for the QSH, we acknowledge that it is still important to differentiate instruction, especially considering the wide range of variability in individual profiles in the population of d/Dhh children and adolescents (see [7,16,18,21]). This range includes factors such as age levels, family backgrounds, presence of disabilities, demands of the reading tasks and instruction, and the results of specific components of reading via the use of assessments. Addressing whether literacy acquisition is similar or different is critical for the development of evidence-based or effective practices, which seems to be lacking or relatively little is available for d/Dhh students (see review in [38]). Assuming that we have a consensus on the various aspects of the QSH, then the next step might be to ascertain the manner in which to improve the literacy level of students (see [7]).

4. English Literacy

To contextualize the QSH and understand the challenges of developing English language and literacy in d/Dhh individuals requires an understanding of the overall construct of English literacy, particularly the acquisition process [8,10,39]. In essence, the manner in which literacy is defined or even measured impacts the accuracy of the documented achievement level or even the proffering of effective or evidence-based instructional practices for d/Dhh students. There is no shortage of theoretical models that purport to represent the overall constructs of English language or literacy or the various components (i.e., subconstructs, processes) associated with these overall constructs (e.g., [39–41]). The number of influential subconstructs (e.g., phonemic awareness, vocabulary, fluency, prior knowledge, metacognition) that are involved makes it challenging to describe not only the overall nature of the literacy acquisition process, but also what might be needed (e.g., evidence-based or facilitative practices) to develop literacy proficiency in struggling readers and writers.

One common approach to developing a working literacy model has been to conduct research and interpret findings on the struggles or challenges of various cohorts of children, including those with disabilities or are at-risk, in the development of skills from the emergent to the conventional literacy period (e.g., see reviews in [33,39,42–44]). One framework for understanding these challenges, especially for d/Dhh students [10,35,45], has been to relate the results to the general findings of the National Reading Panel [46] and the National Early Literacy Panel [47]. This suggests that the acquisition of English literacy for all literacy learners requires proficiency in a common set of

fundamentals and adheres (or should adhere) to a similar developmental trajectory (albeit, at a slower rate for a number of struggling literacy learners).

It is possible to delineate the common components of extant English reading models, which should include, at the least, through-the-air English language proficiency (including vocabulary knowledge), code-related (e.g., phonemic awareness, letter-sound relations) plus comprehension (e.g., prior knowledge, metacognition, inferential) skills. Other factors may include sociocultural variables such as the influence of the home environment, teacher-student interactions, and teacher competency (also, see [22] for a discussion of the effects of inclusion). A substantial amount of attention has been paid to sociocultural factors. However, it should be kept in mind that "A sociocultural perspective on children with reading disabilities does not discount other explanations for reading failure or other recommendations for instruction ([48] (p. 54)). In addition, it is also doubtful that all or most of the reading difficulties of children and adolescents can be explained by appealing to factors associated with ethnicity, race, or gender [10,49].

There are literacy models that seem to be comprehensive—that is, covering cognitive, psychological, and ecological domains (e.g., Componential Model of Reading, [50]). These models also assert the nonlinearity and non-hierarchical elements of the reading process. Then there are models that are linear and hierarchical and focus mostly on decoding and language comprehension skills (e.g., Convergent Skills Model of Reading, [51], Simple View of Reading, [52]). Despite the disadvantages or limitations of proffering models, they do provide a venue for researching and understanding the literacy process. More important, as noted by the National Reading Panel [46] and the National Early Literacy Panel [47], and as mentioned previously, there may be fundamentals that apply to all children attempting to learn to read and write in English. The National Reading Panel proposed fundamentals such as the use of phonics (for letter-sound relations), phonemic awareness, fluency, vocabulary, and text comprehension. Implicit in these fundamentals is proficiency in the receptive and expressive use of through-the-air English, which is the language of print.

In general, English reading is defined as obtaining information or meaning from print (i.e., constructing meaning), and English writing can be defined as putting information down in print (i.e., composing meaning). We agree with Mayer that proficiency in English writing requires a level of proficiency in English reading, albeit the two constructs are related and may have reciprocal influences (see [9]). In addition to sociocultural factors mentioned above and for the purpose of this article, we use an equation to describe English reading as follows:

English reading [comprehsion] = English language comprehension/competency (through-the-air mode) + code-related skills + comprehension skills (e.g., vocabulary, prior knowledge, metacognition).

Although all areas are discussed briefly here, our major foci in the ensuing sections are language proficiency and the controversial area of code-related skills, which are also discussed in several articles in this Special Issue (e.g., [7,9,11,16,29]).

4.1. Language Proficiency

As mentioned previously, one of the controversial and oft-discussed domains of understanding the development of English literacy is the role that language plays in this development. Research that has focused predominantly on the development of language or language/communication difficulties often devote some space to the relationship between through-the-air language and the language of print—that is literacy (e.g., [53,54]). With respect to d/Dhh children and adolescents, the controversy centers on the nature and extent of the through-the-air form.

Scott and Dostal [29] reviewed, in part, the literature on the development of language and its effects on English literacy, utilizing two broad domains: natural languages (e.g., American Sign Language and English) and communication systems (e.g., a form of English sign, cued speech/language). We agree with their findings that there might be stronger evidence for natural languages as opposed to the communication systems, particularly the sign communication systems. We argue, however, that the bulk of the evidence for the beneficial relations between ASL and English literacy is mostly

correlational (also see [10]), but is certainly worthy and in need of further research. In our view, a better understanding of the effects of ASL on the development of English literacy requires a better understanding of the manner in which code-related skills are acquired—the use of visual phonology notwithstanding (discussed later). That is, in our view, it is critical to understand how d/Dhh children and adolescents can acquire the "structure" of English (phonology, morphology, syntax) via the use of ASL, especially beyond the emergent English literacy stage.

There is little doubt regarding the problematic nature of the use of the sign communication systems (also see [55,56]). The descriptions of the sign systems are arbitrary and idealized with respect to their representations of English. These systems are purported to represent English morphology and syntax in a visual manner and are supposed to be executed in conjunction with speech. This "simultaneous" presentation purports to cover, at least, the phonology of English, considering that phonology is the building block of any language. As argued by LaSasso, Crain, and Leybaert [55], this representation, particularly by practitioners, results in a degraded inadequate representation of English. The level of success with the use of sign communication is contingent on the individual's ability to access the structure of English, specifically the phonological and morphological components. Nevertheless, LaSasso et al.'s degraded hypothesis certainly lends support to the existence of language deprivation [16,29] and the need to address this serious concern for a number of d/Dhh children and adolescents.

This degraded representation by any sign communication system led LaSasso et al. [55] to proffer Cued Speech/Language as the most viable, complete communication system for representing English. As noted by Scott and Dostal [29] and others (e.g., [20,57]), there is some evidence for the effectiveness of Cued Speech/Language for the development of English phonology. More important, as emphasized by Scott and Dostal [29], there is a need for intervention research in both domains—natural language and communication systems.

Understanding the effects of a signed language on the development of English literacy is critical; however, such research needs to consider the prevailing findings of the nature of the through-the-air form that facilitates the development of English literacy for typical literacy learners. For example, Kamhi and Catts [43] argued that:

Knowledge of the similarities and differences between spoken language and reading is critical for understanding how children learn to read and why some children have difficulty learning to read. ([43], (p. 1)).

The assumption here is that proficiency in the through-the-air form of English is essential for achieving proficiency in conventional English literacy skills.

On one hand, the National Early Literacy Panel [47] found oral language (i.e., through-the-air language; cf. [58]) to be a weak predictor of later decoding and reading comprehension abilities. However, Storch and Whitehurst [59], also discussed in Mayer and Trezek [8], found that oral language skills contributed directly to reading abilities in grades 3 and 4. By the later elementary school grades (4th–6th grade), research has demonstrated that "hearing" children's vocabulary knowledge and reading comprehension is strongly correlated with through-the-air language abilities developed during the early years (e.g., [1,46,60]). Whether these findings also apply to d/Dhh children and adolescents is in need of further research—albeit, there has been much discussion of the inadequate English language development of these individuals (e.g., [10,56,61]).

This focus on language proficiency, specifically language comprehension skills, is a major component of linear, hierarchical literacy models. For example, Trezek and Mayer [11] seem to favor the Simple View of Reading, which proposed an equation such as Decoding (D) X Language Comprehension (C) = Reading Comprehension (R). That is, reading comprehension is dependent on adequate decoding and language comprehension skills. Language comprehension is taken to mean an understanding of the use of language (i.e., linguistic information), in this case English, through oral language or, in the parlance here, through-the-air. As stated by Trezek and Mayer [11], the learner can use language to interpret words and sentences and also to develop an overall meaning model

of the text. It can be assumed that adequate receptive and expressive skills in English facilitates the acquisition of reading comprehension, but—of course—it is not sufficient as other skills are needed. Language proficiency here means proficiency in all components of English (phonology, morphology, syntax, semantics, pragmatics) as well the integration and use of these components for receptive and expressive communication.

The importance of English language proficiency is also discussed in literacy models that stress the strong connections among English language, reading, and writing, even for second language learners of English or English learners [1,9,62–65]. Mayer and Trezek [9] discussed a model named the Simple View of Writing (SVW), which seems to parallel the construct, Simple View of Reading. The SVW seems to highlight both the product (transcription) and process (ideation) of composition. The product component needs to be automatic (analogous to word identification) so that the process can be generated. The point here is that oral (through-the-air) language drives this operation, and English oral language is the better facilitator of English written language.

In addition to the above, communicative, through-the-air language proficiency is strongly related to the development of academic language. Academic language refers to the metalanguage or specialized vocabulary that is often found in literacy materials in content areas such as social studies, science, and mathematics (for deafness, see [66]). Academic language is influenced by the construct of cultural literacy.

Cultural literacy is familiarity with and the ability to understand the idioms, allusions, and informal content that create and constitute a mainstream culture. From familiarity with street signs to knowledge of historical references to understanding slang and figurative language use; the literacy process demands interactions with the culture and reflections on the contents. Cultural literacy requires familiarity with a broad range of general knowledge and implies the use and sharing of that knowledge—for example, terms associated with the culture of American society's foundations such as the American Revolution, slavery, bottom-line, market-driven economy, and others [67].

4.2. Code-Related Skills

Code-related skills are associated with decoding and encoding print such as print awareness and phonological processing principles [46,47,59,68–71]. Print awareness is necessary for progress with vocabulary and reading development. Children need to understand what is meant by reading—for example, there is information on the page. They also need to understand the basic relationship between oral language and printed language. Print awareness skills include the following:

1. Concepts of text features or print, such as letter, word, sentence, question, or dialogue.
2. Vocabulary for discussing books, such as cover, page, story, character, title (name), author (writer), and illustrator (artist).
3. How to handle books, such as holding right side up, turn pages, where to begin reading, attend to the spaces in the text, reading from left to right and top to bottom.
4. Book structures, such as title page, chapters, and table of contents.

Phonological processing skills refer to the concepts of sensitivity, memory, and naming. The ability to detect and manipulate the phonemes (sounds) of a language (e.g., blending and segmenting) entails phonological sensitivity. Holding auditory information in short-term memory (e.g., repeating nonsense words, words, or sentences) refer to phonological memory, and this ability is strongly related to adequate comprehension of sentences (i.e., syntactic structures) for d/Dhh children and adolescents (see reviews in [56,72]). Phonological memory, along with rapid automatic naming (RAN), has been associated with the ability to rapidly retrieve a sufficient amount of phonological information associated with letters and words for the development of fluent, automatic decoding and encoding skills [46,47]; for d/Dhh learners, see [11,56,72]. Alphabetic knowledge such as letter name knowledge, letter sound knowledge, letter name fluency, and letter writing is also related to emergent literacy skills, especially for typical and struggling literacy learners (e.g., [73]).

There is little debate regarding the importance of developing print awareness skills in d/Dhh children (see reviews in [10,35]). However, there is considerable controversy on the role of a sound phonology for the development of English literacy skills [10,11,29,31,32]. Much of the research evidence suggests that the better d/Dhh literacy users have an adequate command/understanding of domains such as phonemic awareness and sound-letter correspondences, which provide the foundations for accessing the alphabetic writing system for facilitating the more advanced development of English literacy skills (see review in [74]). Research has also documented a high correlation between phonological skills and vocabulary ([74,75]; cf. [37]).

There is also evidence that d/Dhh learners can benefit from phonological awareness interventions [8,20], especially via the use of Visual Phonics ([38,76,77]; also see discussion in [29]). Even Cued Speech/Language has been demonstrated, as a communication method, for developing decoding skills in d/Dhh literacy learners ([20,55], also see discussion in [29]). Trezek [20] documented the contributions of Cued Speech/Language to the development of phonological and early reading abilities. She concluded that the benefits of Cued Speech/Language occurred despite the documentation of varying levels of hearing loss and even varying levels of speech intelligibility. Trezek reported beneficial effects on domains such as phonological awareness, phonemic awareness, alphabet knowledge, and phonological memory.

On the other hand, there is some evidence for the use of a visual phonology from a signed language (e.g., American Sign Language) for the development of early English literacy skills (e.g., [26,28]; also see related discussions in [16,29]). This line of research seems to question the necessary role of phonological processes based on sound (i.e., English phonology). This construct also seems to apply mostly to a cohort of d/Deaf children, who are bilingual, involving the use of American Sign Language (ASL), fingerspelling, and the print form (i.e., orthography) of English, labeled sign-print bilingualism. Whether this combination of processes should also be used for d/Dhh children who are limited users of English, coming from English-speaking homes, is open to question (see [16]; also see related discussion in [10,56]).

Support for the use and benefits of a visual phonology is motivated, in part, by the issue of hearing acuity ([26,28]; also see related discussions in [78,79]). That is, visual phonology (in conjunction with fingerspelling and English orthography) seems to be the most efficient route for developing English literacy skills in d/Dhh children with minimal or no functional access to audition with or without amplification, especially during the first few years of life with emerging literacy skills. In essence, researchers advocating visual or sign phonology have emphasized the role of visual perceptual processes for the early foundational stage in accessing words. Allen et al. [26] proffer a modality independent hypothesis, which asserts that English decoding skills can be developed via either an auditory-based (sound) or visual-based phonology. Thus, in their view, the phonological component of the Qualitative Similarity Hypothesis [10] pertains only to d/Dhh individuals with adequate access to audition with or without amplification. For d/Dhh individuals with limited or no access, a visual-based or sign phonology is a comparable alternative.

Whether a visual-based or sign phonology is analogous to a sound-based phonology, particularly one that is germane to accessing print words, is an open question (see discussions in [78,79]). There is ample research that sound-based phonological processors need to work in tandem with orthographic processors for developing rapid automatic word identification skills (e.g., [68]). In addition, this combination is most effective for developing advanced English literacy skills, at least in "hearing" literacy or struggling literacy learners. Allen et al. [26] and others [28] seem to argue that the phonological and orthographic processors do not need to be associated with the same language of print for accessing English words.

We favor the interpretations of Mayer and Trezek [9,11] that ASL can be "supportive" in developing or understanding information. However, to construct the meaning of English texts or compose passages in English, ASL (even with other components such as fingerspelling and English orthography) may not be sufficient beyond the emergent or early English literacy phase. In essence, the role of a sound

phonology is necessary, but not sufficient, for the development of decoding skills and facilitating early and advance English literacy comprehension skills. This can be achieved either via the typical route (adequate hearing for accessing spoken or through-the-air English) or alternative routes such as Visual Phonics or Cued Speech/Language. Our view comports with that of Mayer and Trezek [80]:

While it is true that those who adopt the view that learning to read is a qualitatively or developmentally similar process whether one is deaf or hearing (i.e., the view that phonology is necessary) do emphasize control of spoken language as being the most expedient route for learning to decode, they also suggest that this proficiency may also be achieved through other modalities (i.e., via a visual communication system such as Cued Speech or a visual-tactile tool such as Visual Phonics) that stand in for phonological representations and realize the same outcomes (i.e., mastery of sound-symbol correspondences). ([80], (p. 367))

5. Emerging Trends and Issues

Previously, we have mentioned the need for researchers to document adequate demographics for understanding the development of language and literacy for varying cohorts of d/Dhh children and adolescents. In fact, due to early intervention and early amplification and, possibly, inclusive practices (see [22]), the cohorts of d/Dhh individuals have been evolving, and language and literacy achievement has improved (e.g., [10,14,81]). Paul et al. [10] argued that there has been two broad phases with a third emerging phase. One phase entails the period up to the advent of modern amplification systems such as the use of digital hearing aids and cochlear implants. The second phase can be considered the current one, covering the past 30 years. The emerging third phase entails the effects of wide-spread applications of early intervention and early amplification, which may positively affect the current levels of English language and literacy development—albeit, there have already been documented improvements (e.g., [10,13,14,20,82]).

The effects of early intervention, early amplification, and inclusive practices need to be contextualized with respect to demography and other background variables. For example, Mayer and Trezek [14] highlighted this issue in their review of studies on d/Dhh children who are users of cochlear implants. Mayer and Trezek [14] reported that there are encouraging positive findings of achievement; nevertheless, there is considerable variability within the studies due to the lack of documentation of demographics and other critical information such as length of use, maintenance, age at implantation, and so on. Interestingly, it might be that the use of signed communication in children with cochlear implants can support the development of English during the early years; however, this variable needs to be adequately documented. As discussed previously, the documentation of adequate information on participants is necessary for the eventual proffering of evidence-based practices for the varying cohorts of d/Dhh children and adolescents.

6. Summary

Each contributor in this Special Issue proffered recommendations for further research on the acquisition of language and literacy skills, specifically with respect to ASL, bilingualism, inclusion, English reading and writing, assessment, and amplification systems. Given the limited evidence-based data on d/Dhh children, we argue that an understanding of the acquisition of English language and literacy skills by typical literacy learners should be the reference for developing such skills in d/Dhh children. This is true, regardless of the level of English proficiency or type of first-language in the homes of these children. This is the underlying principle of the Qualitative Similarity Hypothesis. Of course, it is still important to conduct additional research on d/Dhh children and adolescents to refine the typical instructional guidelines. In fact, it is clear that instructional strategies need to be differentiated according to the individual profiles of d/Dhh students.

In our view, there is a need to conduct research on d/Dhh children in the preschool to Grade 2 range and to ascertain the contributions of code-related constructs to reading-related comprehension tasks for various cohorts of d/Deaf students in the later elementary grades up to and including the middle school level (e.g., Grades 3 to 8). Research is also needed to understand the development of other literacy-related

components such as through-the-air English language and vocabulary, and comprehension factors such as inferencing, prior knowledge, and metacognition. Future researchers need to develop language and literacy assessments that focus specifically on a non-unitary model of acquisition. A non-unitary model asserts that there is not one all-encompassing factor that accounts for the development of complex skills such as language and literacy.

There are a number of lingering issues that need to be resolved if we intend to develop evidence-based practices for the development of English language and literacy skills in d/Dhh children and adolescents. The list below is not exhaustive, but represents a few of the major domains.

- Understanding what it means to adequately represent the form or structure of English, including phonology and morphology, in a visual modality (e.g., in sign systems, Cued Speech/Language).
- Addressing the inconsistent use (i.e., execution or production) of the English sign systems by practitioners, due to the cumbersomeness and the difficulty of speaking and signing simultaneously.
- Exploring the learnability of the sign systems and skills such as speech and speech reading.
- Studying the effects of varying cognitive or social factors such as working memory capacity, motivation or interest, teacher–learner interactions, impoverished or disadvantaged home situations.
- Developing and using a range of assessments for through-the-air English language proficiency.
- Exploring metacognitive and other self-regulatory effects on English language and literacy acquisition.
- Within the framework of the QSH, exploring the contributions of specific code-related (e.g., phonemic awareness), language-related (e.g., morphology), and comprehension-related (e.g., inferencing, prior knowledge) skills of d/Dhh literacy learners and comparing these contributions to those of typical literacy learners. Another approach is to test hypotheses within the Simple View of Reading, which would permit an evaluation of the QSH [11].

In summary, it is hoped that the information presented in this Special Issue contributes to the further dialogue and development of theory, research, and practice. Subsequently, this should lead to the proffering of evidence-based practices for the improvement of English language and literacy skills for d/Dhh children and adolescents.

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