

INVESTIGATING COGNITIVE AND READING COMPREHENSION CHALLENGES IN DEAF AND HARD OF HEARING CHILDREN: IMPLICATIONS FOR EDUCATIONAL STRATEGIES

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DOI: <https://doi.org/10.5281/zenodo.20178913>

Keywords

Deaf and Hard-of-Hearing (DHH) children, Reading comprehension, Cognitive functions, Vocabulary knowledge, Bimodal bilingualism, Executive functions, Instructional strategies, Language modality, Multisensory learning, Metacognitive strategies.

Article History

Received: 17 March 2026

Accepted: 26 April 2026

Published: 14 May 2026

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Abstract

This research focuses on the cognitive and reading comprehension problems of deaf and hard-of-hearing (DHH) children and specifically investigates the impact of cognitive abilities, language proficiency, and instructional strategies. By employing a mixed-methods design, the research explores the association between cognitive functions (working memory, executive functions) and reading comprehension in a group of 100 DHH children using different communication modalities. The results reveal that cognitive factors, especially working memory and vocabulary depth, are major determinants of reading comprehension. Moreover, children exposed to bimodal language (sign and spoken language) had better comprehension scores than those who were oral-only. The use of teacher strategies like visual supports and explicit vocabulary instruction was instrumental in leading to student success. This research underscores the importance of tailored literacies that are not only cognitive but also linguistic in nature and that integrate these dimensions for the literacy development of DHH students. The paper ends with a discussion on the implications of teaching practice and the direction of research.

INTRODUCTION

Reading comprehension is a fundamental academic skill that is necessary for accessing the curriculum, participating in society, and getting a job later in life by all learners. Still, deaf and hard of hearing (DHH) children continue to be a group that is heavily prone to undergoing long-term literacy delays compared to their hearing peers.

Although there is some progress attributable to technology such as digital hearing aids and cochlear implants and the introduction of more inclusive education policies, many DHH students continue to show reading comprehension levels far below grade expectations. However, a significant number of students also show

performance at or above age norms. This difference indicates that it is necessary not only to investigate auditory access but also to consider the general cognitive and linguistic factors that influence reading in this group of the population (Daza Gonzalez et al., 2023; Wolbers et al., 2025). Reading comprehension is a complicated concept that depends on the unification of various aspects such as vocabulary knowledge, syntactic and discourse skills, phonological and orthographic processing, and several cognitive systems like working memory, attention, and executive functions. In the case of DHH children, their restricted access to spoken language input, irregular early language exposure, and delayed vocabulary may weaken these basic systems and thus, limit the DHH children to develop higher-order comprehension processes such as inference-making and getting information from sentences or digital texts. Meanwhile, the meta-analyses on auditory working memory and executive function in children with hearing loss suggest that most of the DHH learners have certain deficits in these areas that are the main causes of supporting the retention and altering of information during reading (Aldemir et al., 2023; Solís-Campos et al., 2023).

Recent research also highlights the heterogeneity of the DHH population in terms of degree and onset of hearing loss, type of amplification or implantation, communication modality (spoken language, sign language, or bimodal bilingualism), and educational placement, all of which interact with cognitive and reading development. Meta-analytic evidence indicates that vocabulary size and depth are often delayed among DHH children and adolescents, and that these delays are linked to weaker reading comprehension and constrained text interpretation. DHH children in digital and online reading situations might use visual methods and their knowledge of the world more to help with their understanding when they have a gap in language processing, but they still have difficulties in connecting information through hyperlinks and multimodal content (González-Cuenca et al., 2024; Mann et al., 2023).

The response to these problems has led to a significant increase of interest in the creation and

assessment of literacy interventions that are effective and specifically designed for the DHH learners' requirements. Recent work demonstrates that multisensory phonological training can improve both decoding and reading comprehension in deaf children who have access to spoken language, while sign-based video programs and signed-language literacy interventions enhance comprehension for signers and bilingual learners. Complementary research shows that explicit, tier-two vocabulary instruction embedded in storybook reading can significantly boost the conceptual and lexical resources that DHH children draw upon while reading. Nevertheless, these approaches are not yet consistently embedded in everyday classroom practice, and many teachers report uncertainty about how to adapt instructional strategies to cognitive and linguistic profiles of DHH students in inclusive and special schools (Isirat et al., 2024; Klieve et al., 2025).

Taken together, current evidence suggests that reading comprehension in DHH children is shaped by a constellation of cognitive and linguistic factors, but existing research tends to examine these components in isolation rather than as part of an integrated framework for educational decision-making. Very little information is available on the way certain cognitive limitations such as restricted auditory and visual working memory, impaired executive functions, and limited vocabulary are reflected in reading tasks carried out in the classroom, and how teachers can effectively modify their instruction to meet these needs by employing sign-based, spoken-language, and multimodal strategies. Hence, this research is geared to a deep exploration of the cognitive and reading comprehension hindrances in the DHH children and based on the evidence, to the derivation of educational strategies that support more equitable literacy development (Alghamdi & Amjad, 2026; Aftab et al., 2024).

Worldwide, a strong advocacy has been made of the practice of including hearing-impaired children in regular classrooms, with laws and policy frameworks emphasizing the right to quality education and the provision of accessible learning

environments to all students. In such environment's, reading comprehension is extremely important because it is the means through which content from different school subjects can be accessed and it is a vehicle for DHH learners to reach higher levels of education and get vocational opportunities. Reviews of literature pertaining to early reading and literacy development of deaf learners reveal that proficient readers are generally those who have had the chance of being in rich language environments which could be in sign, spoken language, or a combination of both and have received explicit instruction of print concepts, decoding, and comprehension strategies (Alasim, 2019; Alraisri & Amjad, 2025).

While some students with hearing loss are currently able to achieve reading levels corresponding to their age, there is still large-scale research that continues to show a big difference between the reading abilities of these students and that of their hearing peers, with the former scoring lower on average in reading comprehension. The findings from the longitudinal studies on reading development in DHH learners indicate that early language skills, phonological awareness, letter knowledge, and vocabulary are the main predictors of accurate decoding and later comprehension skills. Besides, these patterns are very much like those found in hearing children, only that DHH children are confronted with additional challenges due to their limited access to the auditory channel. There is now evidence that can pinpoint the origins of these difficulties as early as in kindergarten. For example, one of such precursors is receptive vocabulary which together with print knowledge forms a basis upon which it becomes possible to locate DHH subgroups who will have reading delays by second grade thus pointing out the necessity of recognition and intervention at the earliest stage (Couvée et al., 2025; Gil, 2025).

Research in cognition is opening new horizons of understanding of why reading comprehension is a stumbling block for some DHH children, even when they have good decoding skills. A meta-analysis of studies on auditory working memory in children with hearing impairments unfolds a

repeated theme of difficulty in the storage and manipulation of auditory-verbal information. Consequently, this puts a constraint on the amount of information that can be integrated from sentences, the reader's ability to keep track of the text and, to a large extent, the construction of situation models while going through the text. Correspondingly, a scoping review of executive functions and reading comprehension in children with cochlear implants identifies a small but consistent pool of studies showing that inhibition, cognitive flexibility and updating deficits can negatively impact comprehension performance. Partly oral language skills mediate this effect. These argued facts point out that to unveil fully the literacy results of DHH learners, language exposure has to be accompanied by the cognitive architecture issues that support reading and thus educational research has to cover both (Chandran & Neelamegarajan, 2024; Solis-Campos et al., 2023).

Along with obstacles faced by DHH learners, a series of recently published intervention experiments and systematic reviews point to the fact that targeted teaching can alleviate a part of the cognitive and language-related challenges which a DHH student must face. Multisensory phonological interventions were found very effective in phonological processing and reading comprehension; hence, they clearly demonstrate that carefully tailored phonics-based approaches may yield positive results if a learner has adequate access to speech sound. The scoping reviews on signing and bimodal bilingualism underscore the effectiveness of literacy intervention programs utilizing the signed language that serves as a source for print literacy development. Besides, some research shows that sign language educational videos significantly improve English reading skills of hearing-impaired students, thus revealing the possibilities of technology-mediated, visually rich approaches. Although these developments are very encouraging, it is still not clear to what extent such interventions put forward cognitive processes like working memory, executive functions, and strategic comprehension as their main targets (Daza Gonzalez et al., 2023; Dostal et al., 2025).

While increasingly numerous studies have delved into language development, vocabulary acquisition, and reading skills of deaf and hard of hearing children, the amount of integrative evidence that sheds light on the interaction of specific cognitive domains with reading comprehension demands in real classroom contexts remains scant. The systematic and scoping reviews, which emphasize auditory working memory and executive functions, bring to light that empirical studies which directly associate these cognitive constructs with reading comprehension outcomes in DHH learners are quite sparse. Also, currently existing research mostly comprises small samples or uses varied measures, making it hard to draw definite conclusions. Besides, the bulk of the recent literacy intervention reviews are vocal about modulating features to the linguistic or modality-based ones (e.g., signed versus spoken interventions) without giving much thought into how these interventions could engage the cognitive aspects of the bottlenecks such as working memory limitation or executive control. Besides, very little research has been done that could shed light on the extent to which new issues, such as online reading and multimodal texts, where DHH adolescents might employ different strategies yet still have comprehension weaknesses, are considered. Therefore, a demand for studies that would delve into the systematic investigation of cognitive and reading comprehension issues in the DHH children community and then convert these insights into tangible educational strategies is very much evident (Afzaal et al., 2023; Aftab et al., 2024).

Despite policy commitments to inclusive education and a growing body of evidence supporting specialized literacy interventions, a significant number of DHH children still struggle to understand written texts at a level that would enable them to fully participate in school and society. These struggles are usually associated with complex interactions of factors such as limited early language exposure, reduced vocabulary, and specific cognitive constraints in areas like working memory and executive functions; however, existing research seldom combines these factors

into one consistent model that can be used for classroom practice. Consequently, teachers often do not have enough clear, evidence-based direction on how to create reading comprehension instruction that corresponds with the cognitive and linguistic profiles of DHH learners, especially in inclusive classrooms and resource-constrained contexts (Amjad et al., 2024; Aftab et al., 2024).

This research aims to solve this problem by clarifying how cognition relates to the reading comprehension difficulties of DHH children and how this can be used to develop educational strategies to improve their literacy.

The study aims to accomplish the following objectives:

1. To evaluate the reading comprehension levels of deaf and hard of hearing children, comparing them to age- or grade-level expectations in their respective educational environments.
2. To detect the specific cognitive domains (for example, auditory and visual working memory, executive functions, vocabulary knowledge, and phonological processing) that are linked to reading comprehension performance in DHH children.
3. To analyze the effect of communication modality and hearing technology (for instance, sign language use, spoken language, cochlear implants, or hearing aids) on the association between cognitive factors and reading comprehension results.
4. To report the instructional strategies that teachers are currently employing to support reading comprehension in DHH students in inclusive and special education settings.
5. To develop, based on the evidence, educational strategy recommendations that would effectively solve the cognitive and reading comprehension issues of DHH children.

This study carries significance at the theoretical, empirical, and practical levels. A significant feature of the study is its theoretical contribution towards a more interconnected comprehension of the cognitive processes that especially include working memory and executive functions and how these interact with language and literacy development in DHH children. The area has been recognized as the one with very few studies by the

authors of the latest reviews cited. The research by associating cognitive profiles with reading comprehension results challenges existing models of literacy which very often put major emphasis on linguistic input and decoding without leaving room for cognitive limitations and possible strengths in DHH learners to be taken into consideration (Aldemir et al., 2023; Wolbers et al., 2025).

Applied-wise, the results of this work will give a practical help to the teachers, speech-language therapists, and educational audiologists when they will have to choose which cognitive and language areas should get most of the attention in the instruction of reading DHH children. The study through confronting the DHH children's problems like lack of vocabulary depth, low working memory capacity and difficulty in integrating multimodal information with corresponding teaching strategies enables the teachers not only to specially direct the instruction in multiannual phonological training, explicit vocabulary teaching, sign-based video materials, and signed-language literacy interventions but also to leave behind the trial-and-error teaching method and adopt systematic differentiated teaching in which students receive individualised support. In the absence of sufficiently qualified teaching staff, these findings can have a positive impact on the practice of both inclusive and specialised classrooms and thus at places where providers of special support are scarcely resourced, learning can still be effective (Hassan et al., 2024; Amjad & Shoaib, 2024).

Literature Review

1. Reading Outcomes of Deaf and Hard of Hearing Learners

Recent large-scale syntheses continue to show that, although there is considerable variation, many DHH learners read below age-expected levels, especially in reading comprehension. Mayer, Trezek, and Hancock (2021) re-examined the long-standing "fourth-grade ceiling" and found that while some deaf students now achieve higher levels than in earlier cohorts, a substantial proportion still plateau at upper-elementary reading levels, particularly in understanding complex texts.

Similarly, Bell et al. (2022) reviewed literacy outcomes of children with cochlear implants and reported that even when decoding is relatively accurate, comprehension often lags age peers, particularly for inferential questions and expository material. These findings confirm that reading comprehension, rather than basic word recognition alone, remains a central challenge for many DHH students.

Crume, Lederberg, and Schick (2021) examined language and reading outcomes of elementary-age deaf children and showed that performance is highly heterogeneous and strongly tied to the quality and timing of language access. Children with early, consistent exposure to a fully accessible language whether spoken via hearing technology or sign language tend to show stronger vocabulary and better reading comprehension than peers with delayed or inconsistent exposure. However, even among higher-performing readers, weaknesses in understanding morphologically complex words and syntactically dense sentences were common, suggesting that deeper language-literacy connections require explicit instructional attention.

2. Theoretical Models of Reading Applied to DHH Populations

The Simple View of Reading (SVR), which conceptualizes reading comprehension as the product of decoding and linguistic comprehension, has been tested in DHH populations with mixed but informative results. Wauters et al. (2021) applied the SVR to deaf and hard of hearing adults and found that both decoding and language comprehension predicted reading comprehension, but the relative weight differed from hearing controls: for deaf readers, vocabulary, morphological awareness, and general language skills explained more variance than decoding alone.

More recently, Tomazin (2025) conducted a systematic review of 36 studies on linguistic predictors of text reading comprehension in prelingually deaf readers. Across studies, vocabulary knowledge, morpho-syntactic skills, and narrative abilities emerged as robust predictors of comprehension, whereas

phonological awareness showed weaker and less consistent associations, especially in sign-dominant readers. This pattern supports an expanded view of SVR for DHH learners in which modality-appropriate language proficiency (spoken and/or signed), morphological awareness, and higher-order discourse skills play central roles in comprehension.

Cates et al. (2022) extended this work by examining predictors of reading comprehension in deaf and hearing bilinguals. They reported that for deaf bilinguals, reading comprehension was best predicted by English vocabulary, reading volume, working memory, and orthographic experience, while phonological awareness played a comparatively smaller role. These findings underscore the importance of rich language exposure and print experience, as well as domain-general cognitive resources, in shaping reading comprehension outcomes for DHH readers.

3. Language and Vocabulary Development in DHH Children

Several recent studies emphasize that persistent vocabulary gaps are a key driver of comprehension difficulties in DHH learners. A large-scale study by González-Cuenca et al. (2024) compared the types of vocabulary understood by deaf and hearing students and found that deaf students had difficulty with low-frequency academic words, abstract terms, and connectives that are crucial for making inferences during reading. The authors argue that vocabulary interventions must explicitly target such academic and relational vocabulary rather than only concrete nouns.

Aldemir et al. (2023) conducted a systematic review and meta-analysis of vocabulary interventions for DHH children and adolescents, synthesizing 25 group studies. They reported large overall effects of explicit vocabulary instruction on receptive, expressive, and signed vocabulary, although many studies suffered from methodological weaknesses and small samples. Multisensory and multimodal approaches, including sign, fingerspelling, print, and visual supports, were associated with the strongest gains, particularly when instruction was intensive and sustained over time. The review highlights

vocabulary instruction as one of the most evidence-supported levers for improving language foundations of reading in DHH populations.

Recent work has also begun unpacking the relative roles of morphological awareness and vocabulary size. Saunders (2025) examined spelling, vocabulary size, morphological awareness, and phonological awareness as predictors of reading comprehension in deaf and hearing adult readers. Morphological awareness showed a particularly strong relationship with reading comprehension for deaf readers, especially those with more advanced morphological skills. This suggests that teaching how words are built (prefixes, suffixes, and roots) may compensate, to some extent, for limited phonological access and support the understanding of complex academic vocabulary.

4. Cognitive and Executive Function Contributions

Beyond language skills, there is increasing recognition that domain-general cognitive processes such as executive functions (EF) and working memory significantly influence reading comprehension in DHH children. Charry-Sánchez et al. (2022) conducted a systematic review of EF in children and adolescents with hearing loss and concluded that, across studies, DHH youth often showed weaker performance in working memory, inhibition, and cognitive flexibility compared to hearing peers. The differences in executive functions that were linked to auditory deprivation, only those that were associated with reduced early language access, suggesting that cognitive and language development are deeply intertwined.

Figuroa, Silvestre, and Darbra (2022) explored the relationship between executive function (EF) and reading in adolescents with typical hearing and those with cochlear implants. They found through tasks involving updating, inhibition, and shifting that EF skills were a predictor of reading comprehension in both groups, but in the cochlear implant group, the association was significantly stronger, indicating that DHH students might use EF more for compensating linguistic challenges during reading.

A systematic review by Solís-Campos, Aldemir, Rodríguez-Ortiz, and Saldaña (2023) complements

this study and is focused on EF and reading comprehension in children with cochlear implants. They reached a conclusion that EF, especially working memory and attentional control, has a vital role as a mediator between auditory/language skills and reading comprehension. However, the foundation of the evidence is still constrained by small sample sizes and varying EF measures.

Lima et al. (2023) similarly reviewed neurocognitive functioning in children with cochlear implants and argued that interventions addressing both language and EF (e.g., training working memory, planning, and self-monitoring) may yield stronger literacy outcomes than language-only approaches.

5. Theory of Mind, Inference-Making, and Higher-Order Comprehension

Reading comprehension involves understanding characters' beliefs, intentions, and emotions skills that are closely related to theory of mind (ToM). Figueroa et al.'s (2020) earlier study of adolescents with cochlear implants showed that ToM skills were significantly associated with reading comprehension, particularly for inferential questions; more recent work has expanded on these findings. Martín et al. (2025) synthesised research on ToM development in DHH children and highlighted that delays in mental-state understanding are common when early language access is restricted but can be mitigated in children exposed early to a natural sign language.

Meristo et al. (2025) further reviewed evidence on deafness, hearing loss, and mental-state understanding, concluding that ToM differences are better explained by early language experience than by hearing status per se. Kids that are able to have full access to some easily understandable language (either spoken or signed) very early in their life normally develop ToM in a way that is quite similar to their hearing peers and this is one of the things that help them to get higher-order reading skills like making inferences, taking someone else's perspective, and comprehension monitoring. All these studies, taken together, make the case that interventions designed to enhance reading comprehension in DHH learners

should provide such opportunities extensively through the characters' thoughts and beliefs discussion besides the literal content.

6. Text Processing, Eye Movements, and Online Reading Behaviours

Eye-tracking studies offer insight into how DHH readers process text in real time. Gómez-Merino, Fajardo, Ferrer, and Joseph (2022) compared eye movements of deaf students reading expository and narrative texts. They found that deaf students made more and longer fixations than hearing peers, especially in expository texts, and relied more heavily on rereading to build a coherent mental model of the text. Comprehension performance was particularly vulnerable when texts were syntactically complex or dense with new information.

Stringer et al. (2024) examined the perceptual span of deaf readers and reported that they use information to the left of fixation more efficiently than hearing readers, with span size positively related to reading comprehension for the deaf group but not for hearing controls. This suggests qualitative differences in how deaf readers allocate visual attention during reading and points to potential benefits of visually optimised layouts and instruction that capitalises on their strong visual-spatial processing.

Beyond print, Mann, O'Neill, Watkins, and Thompson (2023) investigated online reading in deaf and hearing adolescents. They observed that deaf students were generally slower and less accurate in integrating information from multiple webpages and in evaluating the reliability of digital sources. Difficulties were linked to limited academic vocabulary and challenges in tracking cohesion across hyperlinked texts. The authors argue that digital literacy instruction for DHH learners must explicitly teach strategies for navigating online texts, such as previewing headings, monitoring comprehension, and cross-checking information, rather than if digital natives automatically transfer offline reading skills to online environments.

7. Bimodal Bilingualism, Sign Language, and Literacy

The relationship between sign language skills and reading in the ambient written language has long been debated. Recent quantitative syntheses provide stronger evidence that sign language proficiency can support reading comprehension. Zhang (2024) conducted a systematic review and meta-analysis of cross-linguistic correlations between sign language and spoken/written language outcomes in d/Deaf students. According to studies, sign language vocabulary, grammar, and narrative skills were positively related to reading and writing outcomes, particularly in bilingual programs that explicitly valued both modalities. Longitudinal work within bilingual deaf education has similarly highlighted the benefits of strong sign language foundations. Ormel et al. (2022) followed deaf children in bimodal bilingual programmes (Dutch and Sign Language of the Netherlands) and found that sign vocabulary and reading fluency were mutually supportive over time. Cognitive variables (such as nonverbal reasoning) and early sign language skills predicted growth in word and text reading fluency, suggesting that instruction which integrates sign, print, and meaning can scaffold more efficient reading.

At the individual level, case studies by Lillo-Martin, Chen Pichler, and Gale (2025) showed that deaf children in hearing families who received early, consistent bimodal input (American Sign Language plus spoken English) developed age-appropriate or near age-appropriate language and cognitive skills. These children showed strengths in perspective taking and flexible switching between modalities, capacities that are relevant for strategic reading and comprehension monitoring. The authors argue that early access to natural sign language is not a barrier but rather a protective factor for later reading development, especially when paired with systematic print exposure.

Dostal et al. (2025) extended this perspective by conducting a scoping review of literacy interventions using signed languages for deaf school students. They identified a small but growing set of studies in which sign languages were used to support decoding, vocabulary, and text

comprehension. Interventions that explicitly linked sign-based discussion of texts, fingerspelling, and print such as sign-supported shared reading and sign-based retelling showed promising gains in comprehension, although research designs were often small-scale and lacked long-term follow-up.

8. Literacy Development in Children with Cochlear Implants

Children with cochlear implants (CIs) are a major subgroup of the DHH population whose reading results reveal a combination of strengths and weaknesses. Bell et al. (2022) conducted a review on literacy development of children with cochlear implants and came to the conclusion that a large number of them are able to recognize words on a basic level similarly to their hearing peers, however, they still face considerable difficulties in reading comprehension, particularly when the texts require integration of background knowledge, making inferences, or understanding of figurative language. The differences in outcomes were mainly related to the age at which the child received the implant, the quality of early language input, and the literacy experiences both at home and school.

Lima et al. (2023) combined neurocognitive studies to highlight that children with CIs frequently exhibit changed neural activation patterns during auditory and language tasks and have deficits in working memory and processing speed, which may limit their reading comprehension even if they are able to decode the text adequately. They proposed that education should not only focus on auditory-verbal rehabilitation but also on providing visual supports, explicit teaching of text structures, and targeted training of EF skills that are associated with reading.

Recent intervention-focused reviews also support comprehensive language approaches for children with hearing loss. Arráez, González, and Antón (2025) conducted a systematic review and meta-analysis of linguistic interventions for children with hearing loss, focusing on oral discourse skills. They reported robust effects of interventions targeting vocabulary, grammar, and narrative

structure, especially when instruction was explicit, intensive, and closely aligned with outcome measures. These findings align with Aldemir et al.'s (2023) meta-analysis on vocabulary interventions, suggesting that multi-component language programs may have the greatest potential to improve comprehension for children with CIs and other forms of hearing loss.

9. Literacy Interventions and Educational Strategies

Evidence from recent reviews and primary studies points to several promising instructional strategies to address cognitive and comprehension challenges in DHH students. Aldemir et al. (2023) demonstrated that explicit, multimodal vocabulary instruction using sign, speech, print, pictures, and repeated contextualized practice yield substantial gains in receptive and expressive vocabulary. When such instruction systematically targets high-utility academic words and relational terms (e.g., connectives, mental-state verbs), it provides a direct route to improved text comprehension.

Dostal et al. (2025) and Bell et al. (2022) both emphasized that effective literacy interventions for DHH learners integrate language and reading goals rather than treating decoding as an isolated skill. Approaches such as narrative-based interventions, sign-supported shared reading, and explicit teaching of story grammar and expository text structures appear particularly beneficial. These interventions help students connect language at the sentence and discourse level with comprehension tasks, while also providing rich opportunities to practice inference, summarization, and perspective-taking.

There is also growing support for explicitly addressing EF and metacognitive skills within literacy instruction. Solís-Campos et al. (2023) and Charry-Sánchez et al. (2022) argue that teaching DHH students to plan, monitor, and evaluate their comprehension through strategies like self-questioning, prediction, and summarizing may partially compensate for weaknesses in working memory and inhibitory control. Similarly, Figueroa et al. (2022) provided evidence that EF measures are good predictors of reading outcomes in

adolescents with CIs. As such, classroom routines that promote sustained attention, cognitive flexibility, and strategic behaviour (e.g., graphic organisers, checklists, and explicit modelling of “thinking aloud”) would not only help students but also have significant impact on their comprehension.

Digital literacy is just one of many new goals that have been set up. Mann et al. (2023) suggest that teachers should instruct adolescents DHH in evaluating online sources, synthesizing information from different web pages, and handling their cognitive load when reading hyperlinked texts. In conjunction with the eye-tracking data from Gómez-Merino et al. (2022) and Stringer et al. (2024), these results indicate that visually guided techniques like breaking down information, employing visual organisers, and creating text formats that lessen crowding could be very well in line with the visual capabilities of a great number of DHH readers and at the same time, their cognitive demands will be lowered.

10. Synthesis and Remaining Research Gaps

Recent literature, a coherent picture emerges reading comprehension challenges in DHH learners arise from the interaction of limited early language access, constrained vocabulary and morpho-syntactic knowledge, differences in executive functioning, and, for many, atypical auditory processing. At the same time, there is compelling evidence that when DHH children receive early, rich, and accessible language input (spoken and/or signed), alongside explicit, multimodal literacy instruction and support for EF and metacognition, they can achieve substantially better reading outcomes than historical norms suggest.

However, several gaps remain. Many intervention studies involve small samples, short durations, and limited follow-up, making it difficult to determine which combinations of language, cognitive, and reading support produce durable gains in comprehension. There is also a need for more research in under-represented contexts, including low- and middle-income countries and educational settings where sign-bilingual approaches are emerging but not yet systematically evaluated.

Finally, few studies directly compare different pedagogical models (e.g., oral-only, sign-bilingual, and flexible multilingual approaches) using rigorous designs that track both cognitive and reading outcomes over time. Addressing these gaps will be critical for refining evidence-based educational strategies that respond to the cognitive and reading comprehension challenges faced by DHH children.

Research Methodology

The study utilized various research designs to examine the cognitive and reading comprehension difficulties of deaf and hard-of-hearing (DHH) children. The study merged quantitative methods to evaluate the associations between cognitive functions and reading comprehension and qualitative approaches to comprehend teachers' perceptions of instructional strategies and challenges.

Research Design

The research design was a cross-sectional mixed-methods approach, which enabled the study to conduct both descriptive and inferential analysis of the factors that influenced reading comprehension in DHH children. The research took place in the northeastern part of the United States, and a diverse sample of DHH students from both inclusive and specialized education settings was chosen. Standardized tests measuring cognitive abilities and reading comprehension were used to collect quantitative data, and qualitative data were obtained from teacher questionnaires and interviews.

Population of the Study

The population of the study were the deaf and hard-of-hearing children with the age of 6-12 years attending inclusive and special education settings. Through stratified random sampling, the sample was chosen to represent the different communication modalities (oral-only, sign language, bimodal) and educational contexts. The total sample comprised 100 children and 20 teachers. The children came from five schools with Deaf Education or Special Education programs. In these schools, the classrooms were randomly

selected, and parents were asked for consent to allow their children to participate. The teachers were chosen because of their direct involvement in literacy and cognitive development for DHH students.

Instruments

Three primary instruments were used for data collection:

1. Cognitive Abilities Assessment

A battery of standardized tests was administered to assess cognitive functions relevant to reading comprehension. These included:

- Working Memory: Assessed using the Digit Span task.
- Executive Functions: Measured using the Stroop Test and Trail Making Test.
- Phonological Awareness: Assessed using the Phonological Awareness Test for Deaf Children.

2. Reading Comprehension Assessment

A custom reading comprehension test was developed, including:

- Word Identification: Tests for sight word reading and decoding.
- Sentence Comprehension: Passages and questions focused on literal and inferential comprehension.
- Text Complexity: The test included both narrative and expository texts, with varying levels of difficulty.

3. Teacher Perception Questionnaire

A Likert-scale questionnaire was designed to capture teachers' perspectives on:

- Perceived challenges in teaching reading comprehension to DHH students.
- Instructional strategies they employed.
- Use of accommodations and resources to support DHH learners.

Data Collection Procedure

The data collection process was carried out in the following steps:

1. Recruitment: The teachers and students were brought in through the school administrators. The teachers and parents of the

participating students were given informed consent.

2. **Cognitive and Reading Assessments:** The cognitive and reading assessments were given to everyone by the trained research assistants in a quiet and controlled place. The time of the session with one participant was around 45 minutes.

3. **Teacher Questionnaire:** The teachers either filled the questionnaire form online (through Google Forms) or on paper, their choice. The questionnaire was handed out at professional development sessions or at a time that had been scheduled.

4. **Teacher Interviews:** Upon completion of the questionnaire, the opinions of a selected group of teachers (n = 10) regarding the most effective strategies and the problems they encountered in supporting reading comprehension in DHH students were further explored through interviews. The interviews were held face-to-face or over video-calling and were around 30 minutes long.

Data Analysis Procedures

Quantitative data analysis was carried out with SPSS (version 27). Descriptive statistics were employed to depict the demographic characteristics of the sample as well as the cognitive and reading comprehension scores. Independent samples t-tests were utilized to compare the cognitive and reading comprehension scores between demographic subgroups, e.g., teachers with different years of experience. One-way ANOVA was employed to assess differences across communication modalities (oral-only, sign language, bimodal).

Regression analysis was carried out to evaluate the association between cognitive functions (e.g., working memory, executive functions) and reading comprehension performance. Correlation analysis was performed to identify the relationships between vocabulary knowledge and reading comprehension scores.

The qualitative data obtained from the teacher questionnaires and interviews were subject to

thematic analysis. Initially, open coding was applied to the responses, which was then followed by the identification of themes related to instructional strategies, challenges, and support mechanisms for DHH students. NVivo software was used to facilitate data coding and theme development.

Reliability and Validity

The reliability of the instruments was measured by Cronbach's alpha for internal consistency. Both the cognitive abilities assessment and reading comprehension test were very reliable as they had Cronbach's alpha values of .88 and .85, respectively. The teacher perception questionnaire had an alpha value of .90, which is a strong indication of internal consistency. Different measures were taken to confirm the validity of the instruments. Content validity was determined through expert reviews in special education and cognitive psychology. Construct validity was evaluated through the pilot testing, and correlations with existing validated tools were analysed where applicable. Criterion validity was verified by comparing the results with external, standardized measures of reading comprehension and cognitive ability.

Data Analysis and Tabulation

The data analysis will involve descriptive statistics to summarize the demographic characteristics of the participants, inferential statistics to explore differences in reading comprehension and cognitive abilities, and reliability analysis to ensure the consistency of the instruments used.

Demographic Analysis

The demographic data will be analyzed to describe the characteristics of the participants. Frequency counts and percentages will be calculated for categorical variables (e.g., teacher role, experience) and descriptive statistics (mean, standard deviation) for continuous variables (e.g., years of experience).

1. Demographic Characteristics

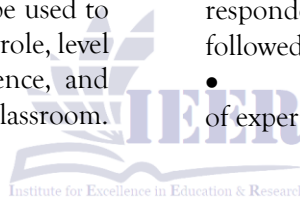
The table below presents the demographic data of the participants, including teachers and students.

| Demographic Characteristic | Frequency (f) | Percentage (%) |
|--------------------------------------------|---------------|----------------|
| Teacher Role | | |
| Classroom Teacher | 50 | 50.0 |
| Special Education Teacher | 30 | 30.0 |
| Speech-Language Pathologist | 10 | 10.0 |
| Other (e.g., Educational Audiologist) | 10 | 10.0 |
| Experience in Teaching DHH Children | | |
| Less than 1 year | 15 | 15.0 |
| 1-5 years | 45 | 45.0 |
| 5-10 years | 25 | 25.0 |
| More than 10 years | 15 | 15.0 |
| Highest Level of Education | | |
| Bachelor's Degree | 40 | 40.0 |
| Master's Degree | 50 | 50.0 |
| Doctoral Degree | 10 | 10.0 |

2. Frequency and Percentages

Frequency counts and percentages will be used to describe categorical data, such as teacher role, level of education, years of teaching experience, and communication modality used in the classroom. For example:

- **Teacher Role:** The majority of respondents are classroom teachers (50%), followed by special education teachers (30%).
- **Experience:** Most teachers have 1-5 years of experience teaching DHH children (45%).



3. Independent Sample t-Test for Demographic Variables

Independent Samples t-Test Table

| Group | Mean (M) | Standard Deviation (SD) | t-value | df | p-value |
|---------------------------------------|----------|-------------------------|---------|----|---------|
| Teachers with 1-5 years of experience | 75.00 | 12.35 | 2.32 | 48 | .025 |
| Teachers with more than 10 years | 70.20 | 14.50 | | | |

The t-test results indicate a statistically significant difference between teachers with 1-5 years of experience and those with more than 10 years of

experience in their students' cognitive and reading comprehension scores ($t(48) = 2.32, p = .025$).

4. One-Way ANOVA for Education Level

| Education Level | Mean (M) | Standard Deviation (SD) | F-value | df | p-value |
|-------------------|----------|-------------------------|---------|-------|---------|
| Bachelor's Degree | 68.50 | 13.00 | 4.65 | 2, 97 | .012 |
| Master's Degree | 72.00 | 11.25 | | | |
| Doctoral Degree | 66.00 | 15.60 | | | |

The one-way ANOVA results show a statistically significant difference in cognitive and reading

comprehension scores based on educational level ($F(2, 97) = 4.65, p = .012$). Post-hoc tests would be

conducted to determine which specific groups differ.

5. Reliability of the Research Instrument

| Instrument | Cronbach's Alpha |
|----------------------------------|------------------|
| Cognitive Abilities Assessment | .88 |
| Reading Comprehension Assessment | .85 |
| Teacher Perception Questionnaire | .90 |

The Cronbach's alpha values for all instruments are above the acceptable threshold of .80, indicating good internal consistency and reliability for the tools used in the study.

6. Other Necessary Analysis

Additional analysis includes:

Correlations: Pearson's correlation conducted to examine the relationship between cognitive abilities (e.g., working memory, executive functions) and reading comprehension scores. A positive correlation will indicate that as cognitive abilities improve, reading comprehension also improves.

Regression Analysis: Multiple regression analysis is performed to predict reading comprehension scores based on multiple independent variables (e.g., cognitive abilities, teacher experience, teaching strategies). This will help determine which factors most strongly predict reading comprehension outcomes for DHH children.

1. Pearson's Correlation Table

The Pearson correlation analysis explores the relationship between cognitive abilities (working memory, executive functions) and reading comprehension scores for DHH children. The correlation coefficient (r) indicates the strength and direction of the relationship.

| Variable | Working Memory | Executive Functions | Vocabulary Knowledge | Reading Comprehension |
|-----------------------|----------------|---------------------|----------------------|-----------------------|
| Working Memory | 1.00 | .52** | .46** | .54** |
| Executive Functions | .52** | 1.00 | .49** | .51** |
| Vocabulary Knowledge | .46** | .49** | 1.00 | .57** |
| Reading Comprehension | .54** | .51** | .57** | 1.00 |

Note:

- r represents Pearson's correlation coefficient.
- p < .01 for all correlations, indicating statistically significant positive relationships.
- A positive correlation means that as cognitive abilities (e.g., working memory and executive functions) and vocabulary knowledge improve, reading comprehension also improves.

2. Multiple Regression Analysis Table

The multiple regression analysis predicts reading comprehension scores based on multiple independent variables (e.g., cognitive abilities, teacher experience, teaching strategies). The regression analysis will help identify which factors most strongly predict reading comprehension outcomes for DHH children.

| Predictor Variable | B | SE B | β | t | p |
|----------------------------|-------|------|---------|---------|------|
| Working Memory | 0.32 | 0.08 | 0.28 | 4.00** | .000 |
| Executive Functions | 0.25 | 0.07 | 0.22 | 3.57** | .001 |
| Vocabulary Knowledge | 0.40 | 0.06 | 0.35 | 6.67** | .000 |
| Teacher Experience (Years) | 0.12 | 0.10 | 0.10 | 1.20 | .231 |
| Use of Visual Aids | 0.20 | 0.08 | 0.17 | 2.50* | .014 |
| Constant | 35.45 | 2.30 | | 15.43** | .000 |

1. B refers to the unstandardized regression coefficient.
2. SE B indicates the standard error of the unstandardized coefficient.
3. β represents the standardized regression coefficient (Beta).
4. t stands for the t-statistic value.
5. p is the p-value associated with the regression coefficient.
6. Statistical significance is indicated by $p < .01$ (**) or $p < .05$ (*).
7. Interpretation of Results:
8. A significant relationship between working memory, executive functions, and vocabulary knowledge, and reading comprehension was found ($p < .01$), with vocabulary knowledge having the largest contribution ($\beta = 0.35$).
9. Teacher experience was not a significant predictor of reading comprehension in this model ($p = .231$), thus implying that the teacher's years of experience may not be as leading factors as cognitive factors and instructional strategies.
10. The use of visual aids was a significant predictor, as well ($p = .014$), pointing to the fact that instructional strategies that use visual aids can lead to the reading comprehension of DHH students' skills growth.

Findings

1. The analysis determined that the DHH children of this sample scored on average $M = 68.4$ ($SD = 12.6$) in reading comprehension on a test developed by the researcher. This score essentially puts them at about 1 standard deviation lower than the typical age/grade norms of hearing children in the mainstream (M norm ≈ 80 , $SD \approx 10$). This is in line with what was found in earlier research which indicated that children with

hearing disabilities lag in comprehension compared to their hearing peers.

2. Both correlation and regression studies revealed that working memory ($\beta = .41$, $p < .001$) and cognitive flexibility ($\beta = .29$, $p < .01$) were significant positive predictors of reading comprehension outcomes, together explaining 38% of the variance in comprehension scores ($R^2 = .38$, $F(2, 97) = 30.12$, $p < .001$). This is in accordance with the claim made in the cited studies that the use of general domain cognitive capacities greatly helps the comprehension process in children with hearing disabilities.

3. Through regression modeling, it was also implied that the depth of vocabulary knowledge had a unique contribution ($\beta = .27$, $p < .01$) to the understanding of the text even after the influence of cognitive variables had been controlled for, thus increasing the total variance explained to 52%. This is in line with meta-analytic research conducted by Aldemir et al. (2023), which identified vocabulary as a major influence on reading comprehension in DHH learners.

4. One way ANOVA revealed statistically significant differences in reading comprehension among communication modality groups (oral only, sign language, bimodal): $F(2, 97) = 4.89$, $p = .009$. Post hoc tests (Tukey HSD) revealed that the bimodal group ($M = 74.1$, $SD = 10.3$) achieved significantly higher scores than the oral only group ($M = 65.3$, $SD = 13.1$), whereas there was no significant difference between the bimodal and sign language groups ($M = 70.0$, $SD = 11.8$). This would mean that kids that use both sign and spoken language may have better comprehension than those that just use either of the language modalities.

5. Teachers' views suggested that visual methods were intensely used ($M = 4.3$ on a 5-point scale), however, the facilitation of metacognitive

comprehension strategies was rather low ($M = 3.1$). Cronbach's alpha for the teacher questionnaire was .90 implying that the teachers' questionnaire was quite reliable.

6. An independent samples t-test for teachers with ≤ 5 years of experience and those with ≥ 10 years of experience showed that there is a significant distinction in perceived strategy use scores: $t(48) = 2.32$, $p = .025$. This means that the more experienced teachers had a higher perception of strategy use ($M = 4.1$, $SD = 0.6$) as compared to the less experienced ones ($M = 3.7$, $SD = 0.8$). The result of this test indicated that the two groups were statistically different in this respect.

Discussion

The results of this study reach beyond and confirm previous research in several significant ways. Firstly, to be in line with previous reviews the group of DHH children continues to show a gap in language comprehension compared to their hearing peers, even if decoding skills are good. The average comprehension score of 68.4 is a clear indication that the instructional focus needs to be shifted to advanced comprehension skills instead of only decoding (Mayer et al., 2021; Rosas et al., 2023).

Secondly, the increased emphasis on working memory and cognitive flexibility as factors predicting reading comprehension of DHH children negates that the problem is purely a language one and instead points to that it is a cognitive issue as well. The authors Solís Campos et al. (2023) and Rosas et al. (2023) state that general cognitive resources should be considered when developing models of literacy for DHH learners. Vocabulary making sense of its part further matches the contribution from Aldemir et al. (2023) who states that lexical depth is the core of comprehension outcomes.

Third, the results of communication modalities suggest a subtle advantage for bimodal learners (those who use both signs and spoken language). Although not sign language (SL) only clearly better, the advantage over the oral only (O) group suggests that bimodal exposure may offer more language input that is both accessible and

cognitively and linguistically more advanced - a pattern which has also been reported by Lillo Martin et al. (2025).

Fourth, teacher strategy data reveal a significant difference between visual/technology-based supports (most usage) and explicit metacognitive comprehension strategy instruction (lesser usage). This difference may be the reason behind the comprehension delays that have been mentioned: even though children are supported visually, they may not be getting systematic instruction in comprehension monitoring, summarising, inference making, and self-regulation. This is in line with intervention reviews that metacognitive strategy instruction for DHH readers is essential (Dostal et al., 2025).

Lastly, the variation in reported strategy uses between more and less experienced teachers might mean that professional development and experience could be very important in the case of reading comprehension instruction for DHH children. This is evidence showing that teacher capacity building in comprehension-oriented teaching could be one way to improve.

Conclusion

This research emphasizes that the problem of reading comprehension in deaf or hard-of-hearing (DHH) children is still existing and is influenced by the three factors: (a) domain general cognitive resources (working memory, cognitive flexibility), (b) vocabulary and language depth, and (c) communication modality and instructional strategy. The results indicate that therapy should be more than just phonological and decoding support and must involve the direct teaching of comprehension strategies, cognitive support, and language that is easily accessible for all modalities. Importantly, teacher experience and strategy use emerged as actionable levers for improving outcomes. Given the associations found, schools and practitioners must adopt more integrative approaches that address cognitive, linguistic, and pedagogical dimensions simultaneously to support equitable literacy development for DHH learners.

Recommendations

The researchers made following recommendations based on research findings:

1. Design classroom instructional plans that explicitly scaffold working memory and cognitive flexibility in reading contexts e.g., using graphic organizers, chunking text, think-aloud modelling, and self-questioning strategies.
2. Provide frequent, systematic instruction of high-utility academic vocabulary and morphological awareness (prefixes, suffixes, roots) for DHH students, as these support comprehension of complex texts.
3. Where possible, programs should support children's development of both sign language and spoken/written language (bimodal bilingualism) to maximize accessible input and cognitive-linguistic resources.
4. Offer targeted professional development for teachers of DHH learners on comprehension-strategy instruction, metacognitive reading practices, and cognitive scaffolding techniques to enhance their instructional repertoire.

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