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Cued Speech: Evolving Evidence 1968–2018

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ABSTRACT
The mention of Cued Speech (CS) within the field of deaf education and deaf studies is sure to spark some strong opinions. In this systematic review of the literature, the existing evidence related to the use of CS is examined thematically. While several studies indicate differences between modalities, the purpose of this paper is not to refute any modality, but to give an historical understanding of the research related to CS. In addition, the authors provide a chronicle of the themes related to CS since its inception in the 1960s, illustrating a shift in use over time. Discussion and implications for future research is provided.

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Cued speech; language; deaf; research; historical perspectives

Background

Our field has long been caught in a polarised debate of communication and language practices, choices, and options. Historically, there have been two dominant schools of thought: those that follow the theories of Alexander Graham Bell (i.e. relying mostly on listening and spoken language), and those who follow Thomas Gallaudet (i.e. relying mostly on cultural representation and sign languages). However, an often-under-represented population falls somewhere in the middle, adhering to both, yet neither: those who follow the theories of Dr. Orin Cornett (i.e. relying on cued speech and cued language).

The purpose of this article is not to favour any mode or communication approach over another, nor is it designed to continue the debate on the uses of each. Rather, it is designed to recognise the value of the small population of CS users, examine what is known of their experiences, and evaluate how practices related to CS research have changed over time. While several of the studies examined compare modalities, the intent is not to create a hierarchical relationship among any, but to summarise, synthesise, and categorise what has been examined to move the field forward with a renewed purpose and direction.

As such, the following review examines peer-reviewed res in order to investigate changes in the use and research of CS since it was established in 1968 at Gallaudet University by Dr. Orin Cornett. Extensive background on the

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purpose and structure will not be provided but may be found through the National Cued Speech Association (NCSA) and affiliate organisations that promote cued speech.

Data collection methods

A search was conducted using the databases of ERIC/ProQuest, EBSCO, PsychINFO, and PubMed accessible through the University library faculty/student portal. Results were limited to those that were peer-reviewed, conducted in any language but available in English, and published between 1968 and 2019. Search terms included:

- "Cued Speech"
- "Cued American English"
- "Cued Language"
- "Cued Phonics"
- "Hand Cues and Speech Reading"

Additionally, a Boolean operator was added to include searches for truncated terms for individuals who are deaf or hard of hearing. To reflect the context of time, terms that are no longer considered proper terminology for medical or cultural reference were included:

- "Deaf"
- "Hard of Hearing"
- "Hearing Impaired"
- "Person* with Hearing Loss"
- "deaf and hard of hearing"
- "d/hh"
- "deaf-mute"

Duplicates were removed from the original database ($n = 649$). A title and journal review were conducted on each article for inclusion. If fit could not be determined, an abstract review was conducted. During this process, 35 manuscripts could not be obtained for review through inter-library loan.

Two researchers read the remaining articles to determine fit by inclusion criteria (see Table 1). For each article retained, extensive cross-checks were conducted using (a) reference lists and (b) Google Scholar "Related Articles" search. The inclusion criteria were re-applied, and hand-checks for additional references were repeated. This process identified an additional 11 articles, leaving a sum of 121 articles fully reviewed with 70 retained (see Figure 1).

Table 1. Inclusion and Exclusion Criteria.

Inclusion	Exclusion
• Any aspect of Cued Speech (CS) was considered including expressive and receptive language, achievement outcomes, use, translation and transcription, and access services	• Articles that focused only to describe the system of CS, including position papers and teacher practitioner articles
• The focus of the study must have been for d/Deaf users or of benefit to d/Deaf users (e.g. subjects are deaf, subjects are interpreters serving d/hh populations, teachers of the deaf)	• The focus of the study was to benefit hearing participants without the focus on d/Deaf supports
• Manuscript from peer reviewed sources that are written or translated to English	• Non-English materials; Texts without peer review, educational manuals, games
• Any geographic region, setting (educational, community)	• Case law
• Any methodology including qualitative, quantitative, experimental, mixed methods, and case studies.	• Articles not focused on cued speech (e.g. Cues of "*topic*", speech cues, language cues, social cues)
• Literature reviews including cued speech research	

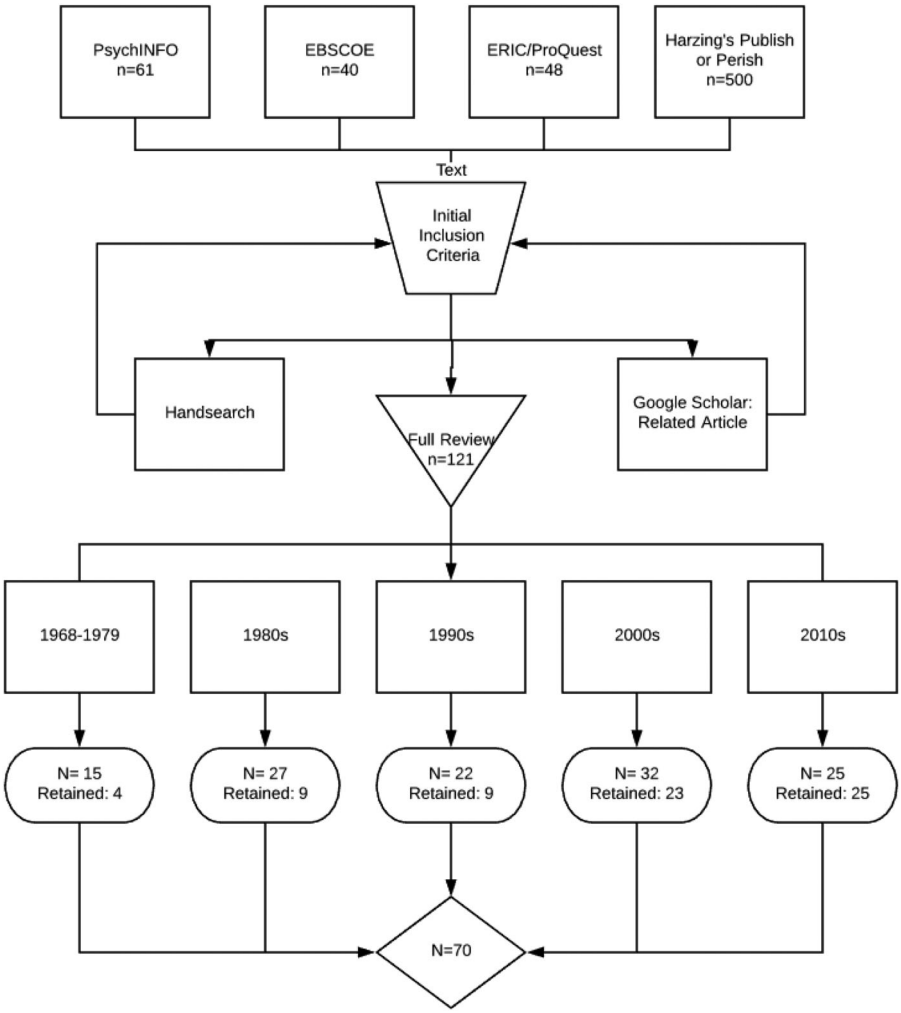


Figure 1. Literature Review Process.

Coding methods

Articles were thematically coded using an a priori framework (see Appendix). Five major categories (e.g. expressive language, receptive language, literacy, identity, and access) were included, each with subthemes more specific to the categories. Table 2 defines the specific themes and sub-themes identified in this review. Themes were based on the mission and vision statements of the NCSA, which promotes Cued Speech as a method to access language (expressive and receptive), increases access to literacy, supports accessibility – including with technology, and contributes to one's identity.

Two researchers coded 15 articles, three articles from each decade. Inter-rater agreement (IRA) was calculated within thematic units using accuracy estimates calculated as *points of agreement/points total*, with a goal of 85% IRA. Clarification was added to distinguish frequently confused codes (e.g. receptive parameters; spelling vs. writing; school services vs. preparation vs. transliteration; autocue vs. expressive/receptive language), and the fifteen articles were recoded using the clarified parameters. IRA (original/refined) was measured as: expressive language (80%/95.7%), receptive language (81.3%/98.6%), literacy (80.3%/94.3%), identity (88.9%/97.1%), and access (100%/100%). The entire set ($n = 121$) was then coded by the primary investigator, with 15 additional articles randomly cross-checked by another researcher to ensure constant IRA. Data from each summary sheet was entered in SPSS using dummy variables (i.e. 0=not present, 1= present) or numerical codes for categorical subsets (e.g. fluency subset speed=1, accuracy=2, prosody=3, co-articulation=4) and proofed for accuracy.

Table 2. Coding matrix summary.

Major Theme	Definition, including sub-theme
Expressive Language	Expressive language theme includes any research related to a cuer's use of (a) spoken language, (b) cued expression or production, (c) expressive grammatical structures, or (d) any other forms of expressive language.
Receptive Language	Expressive language theme includes any research related to a cuer's use of (a) audition or speech reading, (b) cued reception, (c) receptive grammatical or language, or (d) any other forms of receptive language.
Literacy	Literacy included any research related to reading or writing skills, including those research studies measuring expressive or receptive language through literacy means. Topics include (a) phonological awareness (through cues or audition), (b) word identification/decoding, (c) fluency, (d) vocabulary, (e) comprehension, (f) spelling, (g) composition
Identification, School, and Identity	This category included any research related to (a) identity as a d/hh person (and term used to describe d/hh person), (b) family (i.e. supports, decision of cued speech), (c) school services, (d) teacher preparation, (e) peers and siblings, and (f) age, onset, and duration of CS use
Access and accommodations	This category included any research related to access and accommodates related to cued speech including (a) interpreters/transliterators, (b) translation/ adaptation to other languages and transcription, (c) use as a support or supplement to technology (e.g. hearing aids, cochlear implants), (d) automatic generation or translation (i.e. autocuer technology)

Results and theme analysis

Decade analysis

The number of articles identified and retained increased over time (see Figure 1 and Figure 2). Most early manuscripts (1968-1979) were of descriptive nature; thus, only 4/15 articles were retained. In the 1980s, 9/27 articles were retained; similarly, the 1990s saw 9/22 manuscripts retained. This decade was saturated with articles that were not peer-reviewed. In the 2000s, 23/32 articles were retained, and in the 2010s 25/25articles were retained.

Themes changed significantly over time from receptive speech reading (1970s) to expressive and receptive language skills (1980s), followed by topics of literacy (1990s). More currently, since the turn of the twenty-first century, the topics have diversified, while also continuing themes of early research. These two decades (2000–2019) illustrate all five major themes. Except for written composition, all subtopics have been researched since 2000.

The variety of publication sources also diversified over time. While deafness and deaf education-focused journals remain central for CS research publication ($n = 24$), a variety of other journals including medical ($n = 2$), linguistic ($n = 3$), psychology ($n = 9$), speech and hearing ($n = 24$), and specialty journals (e.g. mechanical engineering) ($n = 9$) have also published CS research. Each decade has diversified the target audience for publication.

Expressive language

Thirty instances were identified that related to expressive language and CS (expressive speech=4, expressive cues=10, expressive language=10, and other expressive topics=6). Most research centralised in the 2000s ($n = 16$) and 2010s ($n = 6$). A detailed visual representation of themes can be found in Figure 3.

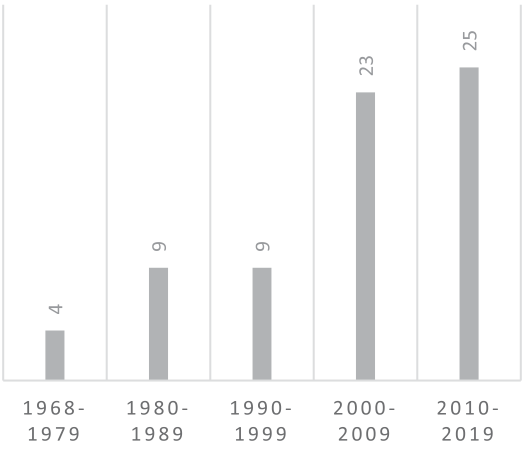


Figure 2. Total Number of Articles Retained by Decade.

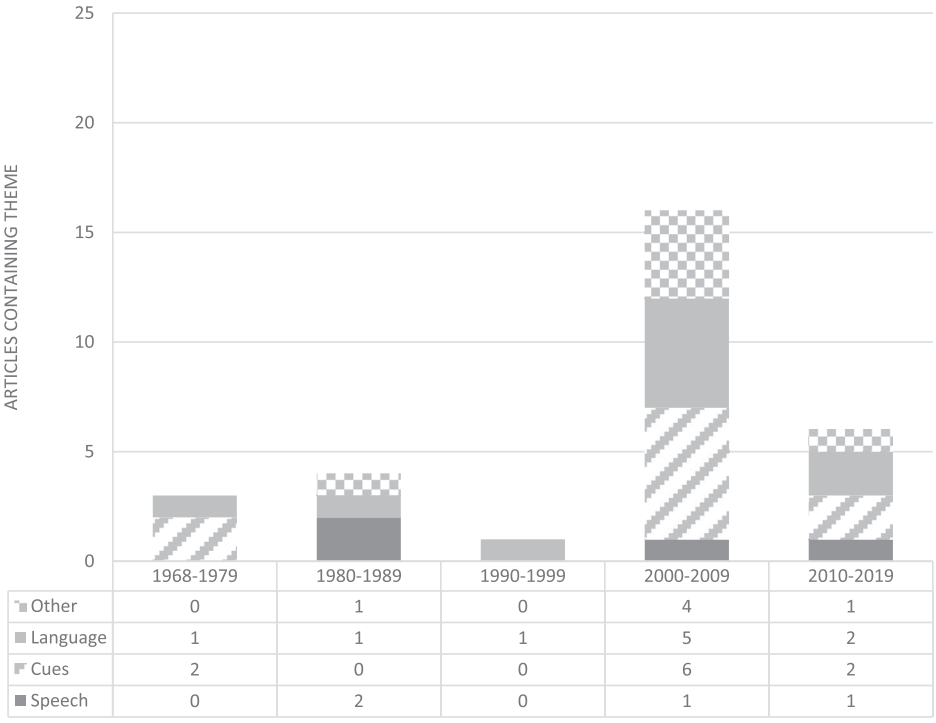


Figure 3. Expressive Language Themes by Decade.

Early research (Nash, 1973) that indicated a family and child's preference for expressively using American Sign Language (ASL) over CS was later rebutted (Cornett, 1973) over the flaws in study design. Other early research (Mohay, 1983) also criticised CS, as subjects changing from oral to CS programmes decreased gestural communication but did not increase spoken or cued language.

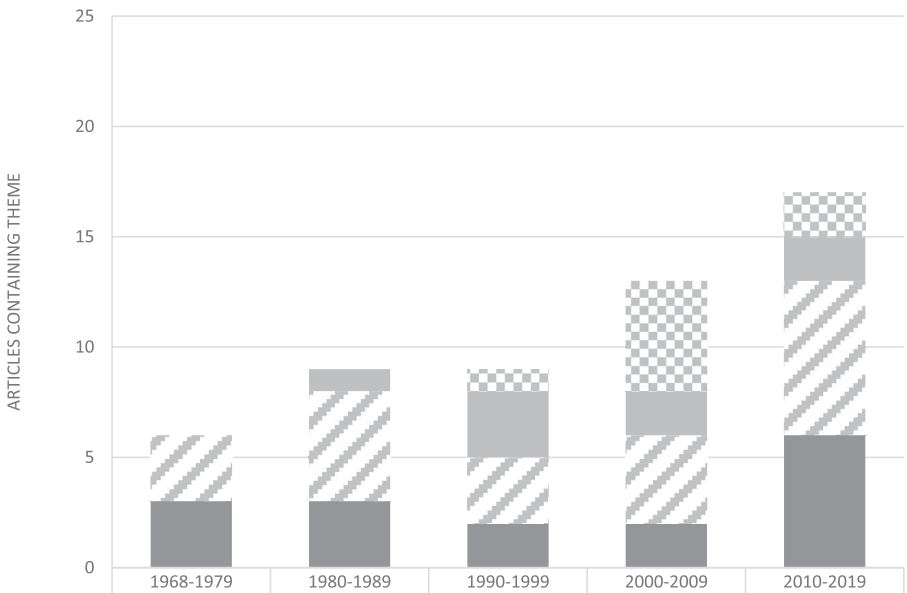
In 1986, Brentari and Wolk promoted the potential of CS by demonstrating that cueing can facilitate new vocal behaviours and clarify speech when unintelligible. In 1992, Charlier reviewed findings on French CS, indicating that French users of CS have been observed to have improved phonology, semantics, and syntax when combining CS with French Sign Language. Similar improvements in syntax specifically prepositions, for expressive Spanish cuers were reported (Hernández et al., 2003) and again for phonology and non-salient Spanish vocabulary (Moreno-Torres & Torres, 2008). Brain research indicated lateralisation of CS users during expressive language evaluations, and illustrated differences between deaf CS users and d/Deaf sign users when compared to hearing peers. CS users left hemispheric specialisation for processing language is more like their hearing peers than their signing peers (Leybaert & D'Hondt, 2003).

Several studies examined the expressive use of CS by hearing supports of D/hh cuers (e.g. transliterators, family members, teachers, service providers), which give an initial insight into the expressive behaviours of the surrounding

CS community. These studies identify that in the co-articulation of hand-mouth-sound, hand movements begin slightly before the sound or mouth movement, but desynchrony does not disrupt the message for experienced cuers (Attina et al., 2004). Expressive behaviours (e.g. intelligibility, voice-to-cue transliteration, speed, and accuracy) were central to the development of the Educational Interpreter Performance Assessment (EIPA) transliterator standards (Krause et al., 2007). Other research (Rees et al., 2017) indicated that the clarity of expressive behaviours of transliterators positively impacts the message received by users. One study (Torres et al., 2006) examined the use of CS in therapeutic settings by a mother and a speech therapist, resulting in an increase in quality of production over time in both length and syntactic complexity.

Receptive language

Fifty-four instances of receptive language topics were identified (receptive speech=16, receptive cues=22, receptive language=8, and other receptive topics=8). While the trend indicates an increasing number of articles with language topics (see Figure 4), receptive skills research decreased over time. Specifically, 75% of articles from 1968 to 1979 had themes of receptive language compared to 44% in 2010–2019.



	1968-1979	1980-1989	1990-1999	2000-2009	2010-2019
Other	0	0	1	5	2
Language	0	1	3	2	2
Cues	3	5	3	4	7
Speech	3	3	2	2	6

Figure 4. Receptive Language Themes by Decade.

Many articles highlighted the use of CS for receptive speechreading/lipreading. Cueing was supported early as a support to the perception of auditory information, especially when paired with speechreading (Gregory, 1987; Ling and Clark, 1975; Neef & Iwata, 1985). The benefit of congruent cues with speechreading continued to be a theme during the 2000s, diving more deeply into the impact of the McGurk paradigm (i.e. the interaction between hearing and vision for speech perception) (Alegria & Lechat, 2005; Bayard et al., 2013, 2014). Recent research indicates that even though CS users depend on both the speechreading and cues, native cuers (i.e. those who cue from a very young age) depend on cues more than speechreading (Aparicio et al., 2017). For those using cochlear implants, CS visually supports the reception of auditory information (Bayard et al., 2019; Rees & Bladel, 2013).

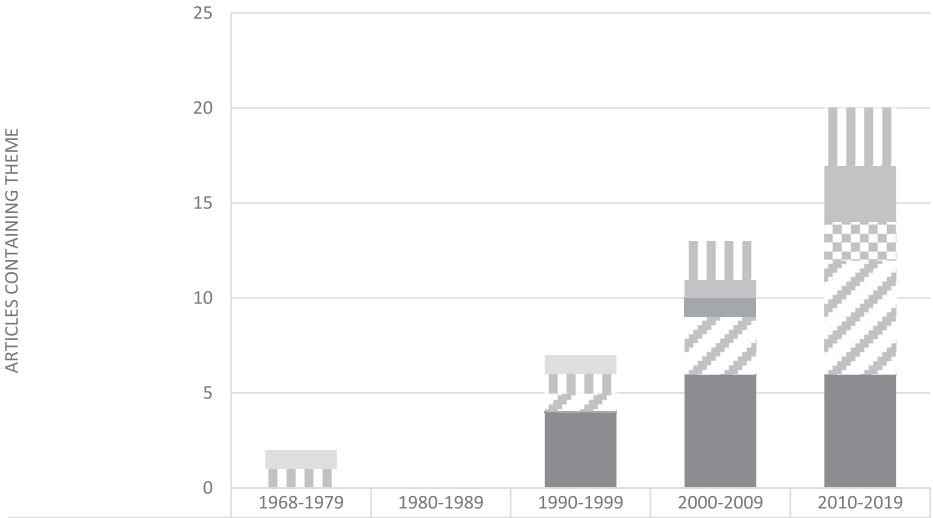
Research emerged in the early 1990s that indicated a potential for automatically generated cues (i.e. via computer software paired with glasses or monitors) to provide better access than speechreading alone (Uchanski et al., 1994). Automatically generated cues were further supported in 2000 when Duchnowski, Lim, Krause, Bratakos, and Braida demonstrated an improvement of receptive language with autocues (66% accuracy) compared to speechreading alone (35% accuracy).

Lastly, Leybaert and Charlier (1996) and Bouton et al. (2011) reported that CS users organise receptive cues using auditory practices, similarly to hearing peers. Such practices include recoding of messages into print phonetically (Alegria et al., 1999; Rees et al., 2017).

Literacy

Six major content areas were considered related to literacy: phonological awareness (PA), word identification (WID) /decoding, vocabulary, fluency, comprehension, and writing. Only one study was retained prior to the 1990s that used CS as a literacy support. Currently, literacy has become a focus in CS literature (see Figure 5).

Phonological awareness. Sixteen instances of research related to PA were identified: four in the 1990s and six each during the 2000s and 2010s. Charlier (1992) introduced the use of CS in France to English speaking audiences in a review of French Cue-Sign for literacy instruction. Leybaert and Charlier (1996) continued examining the benefit of CS for PA, specifically rhyme, and in spelling tasks, as did many others (Charlier & Leybaert, 2000; Colin et al., 2013; D'Hondt & Leybaert, 2003; LaSasso et al., 2003). These studies indicate the ability of CS users, specifically those using cued speech from early ages, to successfully use the phonological structures and skills associated with rhyme generation and manipulation. The use of phonological skills is applied to short term memory skills (Koo et al., 2008). Overall, the use of phonological structures, such as word comparison (e.g. Which words have the same first sound?) and rhyme (e.g. Which



	1968-1979	1980-1989	1990-1999	2000-2009	2010-2019
Writing	1	0	1	0	0
Spelling	1	0	1	2	3
Comprehension	0	0	0	1	3
Vocab	0	0	0	0	2
Fluency	0	0	0	1	0
Word ID	0	0	1	3	6
Phonological Awareness	0	0	4	6	6

Figure 5. Literacy Skills Themes by Decade.

words rhyme?) are indicators in predicting reading and writing levels of CS users (Colin et al., 2013, 2007).

Word Identification. Ten instances related to WID were identified; one in the 1990s, three during the 2000s, and six in the 2010s. LaSasso and Metzger (1998) describe how CS can be used as a decoding strategy, reducing the dependency on memorisation. Early use of CS aided in WID and spelling (Leybaert & Lechat, 2001b), phonological structure development (Charlier & Leybaert, 2000), and decoding (Bouton et al., 2011; Tucci et al., 2014). Wang et al. (2008) recommend using CS or visual phonics to integrate phonological skills, including both PA and WID, into literacy instruction.

Vocabulary and Fluency. Two instances of vocabulary research were identified, both during the 2010s. In a longitudinal study of literacy skills, Colin et al. (2013) found that early CS users have receptive vocabulary scores slightly lower than hearing children that were not significantly different. New and late CS users score below the confidence interval on the same tasks. Colin et al. (2017) later found that children with early cochlear implant (CI) usage and early CS usage show higher scores in all areas of literacy, but these results are mainly attributed to the CI.

One instance of fluency CS research was identified. This research examined the fluency skill of speed. Torres et al. (2008) found that children who used CS were able to read and identify congruencies and incongruences in the text

more quickly than peers with similar reading levels and chronological age, indicating CS impact on both reading fluency and comprehension.

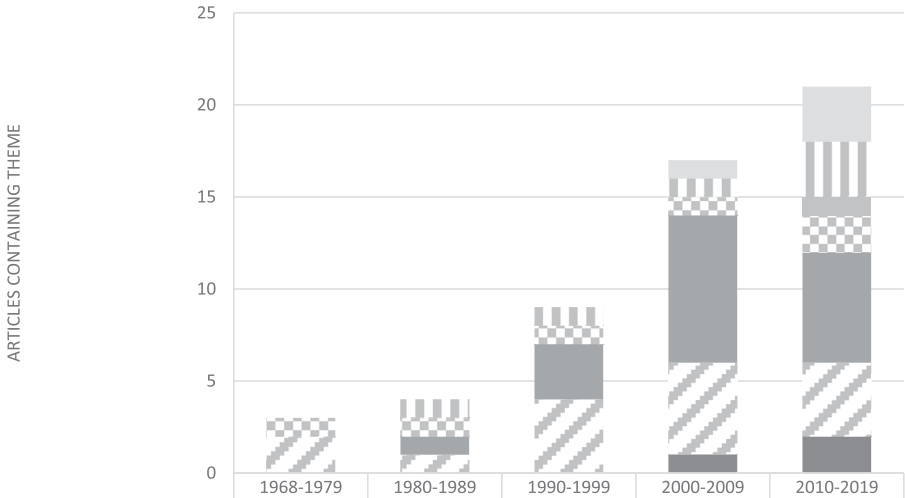
Comprehension. Four instances of comprehension literature were identified; one in 2008, and three with the same primary author in the 2010s. When exploring the ability of profoundly deaf cued speech users to use higher-level reading skills, Torres, et al., (2008) found that those using CS had the ability to inference to a greater extent than other peers who do not use CS. Supported by cochlear implants (CI) and CS, students using Modelo Oral Complementado (MOC, or cued-oral-model) had high overall expressive and receptive language levels, which likely contributed to higher comprehension scores. Colin et al. (2010, 2013, 2017) provide evidence that CS does support comprehension (2-3%), but that the CI is more critical.

Writing & Spelling. Nine instances related to written composition or spelling were identified. Leybaert (2000) and Leybaert and Lechat (2001a) illustrated that the spelling skills of early CS users are like those of hearing peers. Errors in spelling were more frequent, though not significantly; however, those students exposed to CS at a later age demonstrated significant differences in spelling errors, including a greater tendency to use non-phonological spelling errors. While Colin et al. (2010), provided evidence that CS only attributes to a 2-3% variance in spelling abilities of CI users, the earlier introduction of CS continues to be a factor in successful writing skills, longitudinally (Colin et al., 2013, 2007). For older children who are trained in CS, the reception of spoken language for closed sets of CVC words improves, indicating that a visual support for auditory information can be used for supporting spelling and writing (Rees et al., 2017).

Identification, school, and identity

Three instances, all written since 2000, touched on the theme of identity as a D/deaf person, 16 instances compared modalities, and 18 instances referenced the age of initiating the use of CS (see Figure 6). Seventeen articles compared outcomes between modalities (Aparicio et al., 2017, 2012; Bayard et al., 2014; Charlier, 1992; Charlier & Leybaert, 2000; Cornett, 1973; Hernández et al., 2003; Koo et al., 2008; LaSasso & Metzger, 1998; LaSasso & Crain, 2015; Leybaert & Charlier, 1996; Leybaert & D'Hondt, 2003; Leybaert & Lechat, 2001; Nash, 1973; Nicholls & Ling, 1982; Power et al., 1990). In many cases, the skills compared were phonologically based (e.g. PA, decoding, speechreading.) Multiple studies (described in prior sections) made the case that early exposure and constant use of CS in the home result in better outcomes than later use or use in school settings only.

In the first of three studies on identity, Portolano (2008) proposes that CS, particularly Cued American English (CAE), is a dialectical variety of English and that native-cuers have unique behaviours and language play that establish them as a community. This community may or may not be a part of Deaf community and



	1968-1979	1980-1989	1990-1999	2000-2009	2010-2019
Techer/Professional Prep	0	0	0	1	3
School Services	0	1	1	1	3
Peers	0	0	0	0	1
Family	1	1	1	1	2
Age of Starting CS	0	1	3	8	6
Compares Modality	2	1	4	5	4
Deaf Identity	0	0	0	1	2

Figure 6. Identification, School, and Identity Themes by Decade.

may be a Creole-like culture of Hearing and Deaf. The second study (Mirus, 2014) examines the use and play of language that is unique and defining to CAE users. The presence of articulatory play including rhyme, spoonerisms, portmanteaus, glossolalia, and crossing indicate a socio-cultural aspect of cueing users. The third study by Dupont et al. (2018) examines the perception of students and families on the use of CS in mainstream settings. Themes of code-switching, fitting into a hearing world, and supports and barriers for success emerged.

In the seven instances of the theme of relationships, only one article focused on the relationships between differing hearing statuses. Dupont et al. (2018) documented the negative perceived impact of facilitated communication triads (i.e. cuer, transliterators, and hearing peers). High school cuers reported issues of communication barriers, including the presence of a transliterator in peer conversation and an isolating effect for friendships and social learning. The other articles targeting relationships focus on those between children and their caregivers. In 1973, Nash reported that families were ultimately the deciding factor in modality. Cornett (1985) advocated that families should be one of the central considerations when deciding modality, as they will be the primary language models. LaSasso and Metzger (1998) theorised that the home language should be a child's first language (L1) and that CS allows for facilitation of that language. While they do not denounce the use of signed languages, they each emphasise that the home language should be the primary modelled

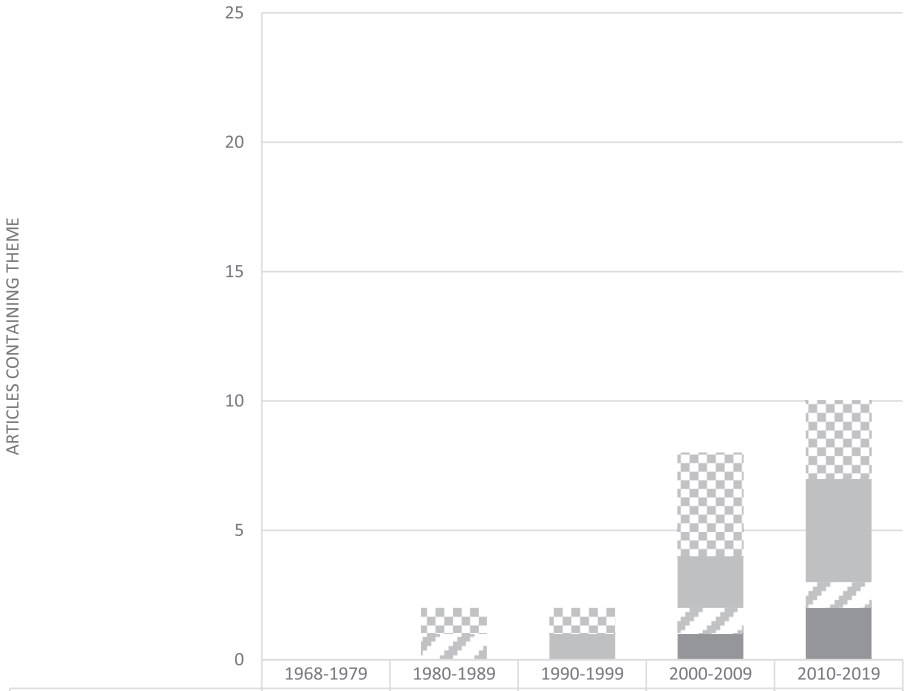
language. Torres et al. (2006) were the first to examine the use of CS as a language model by family members. In this case study, they found that a parent who was cueing with her child increased syntactic complexity, sentence length, and the natural gesture with cues, increasing child attention.

Movallali and Sajedi (2014) provided an analysis of CS outreach websites applied to the development of a new Persian Cued Speech outreach website. While this study was not directly related to the use of CS, it was demonstrative of the information parents receive in the process following diagnosis and prior to selecting a communication modality or approach. Dupont et al. (2018) later reported that for some families, the use of CS was chosen because of the proximity to deaf education programmes using CS, a need to support listening and spoken language (LSL), and/or not wanting to use signed languages. Families in this study used CS for supplementing LSL, clarifying speech, full communication, and as a support paired with signed languages. Some families continued to use CS long term, while others dropped cueing over time, as their child developed independent language processing skills. Many families also reported using combination approaches over time, varying between CS, signing, and spoken language.

Ten instances of educational topics, including professional preparation and school services were identified. Beaupre (1985) described the integration of CS into a college-level phonetics class as a support for a student with hearing loss. Assessed content was cued and presented auditorily for all students and assessments were modified for hearing status. Performance errors were similar, regardless of hearing status. The next study to identify school services (Power et al., 1990) compared teacher repair strategies by communication approach. Results indicate that teachers do not differ in conversational repair strategies used by their modality. Torres et al. (2006) illustrated the importance of skilled CS language models for child attention. Tucci et al. (2014) identified CS as one of six literacy strategies related to decoding but caution that the lack of intervention studies weakens the case for defining CS as an evidence-based practice. Lastly, two descriptive studies serve as models for supporting CS in practice. LeBlanc (2004) described the integration of CS, speech, language, listening, auditory development, early literacy, academics, and mainstream practices for the development of a successful programme in Louisiana. Movallali and Sajedi's (2014) development of a Persian Cued Speech website for parent education supported the inclusion of resources for supports and outreach centres, such as schools specialising in providing CS instruction.

Access and accommodations

The theme of access and accommodations included four subgroups: adaptation of CS to world languages, transliteration and transliterators, automatic generation, and technology support (see Figure 7). The number of times these



	1968-1979	1980-1989	1990-1999	2000-2009	2010-2019
Autocue	0	1	1	4	3
Technology Support	0	0	1	2	4
World Languages Adaptation	0	1	0	1	1
Transliteration	0	0	0	1	2

Figure 7. Access and Accommodations Themes by Decade.

themes have appeared within the literature has increased over time but remains limited in documentation.

The NCSA lists 66 translated languages and dialects on its website, with 19 available PDF cue charts, and 30 available as audiotape lessons. Despite this diversity in translation, only three instances of the adaptation process were found in peer-reviewed literature: a proposed Japanese Q-code, which resembles the CS system, (Hiki & Fukuda, 1981), as well as an adaptation of CS for Welsh (Ball et al., 2009) and Mandarin (Liu & Feng, 2018). All three have cue charts available within the manuscript. Two articles (Krause et al., 2011) documented a transcription process for researching CS. The method of transcription was included under this subtopic as a potential way to document the dimensions of CS. Krause and Lopez (2017) also illustrated the use of transcription methods to determine factors which affect reception by consumers.

Three manuscripts, all since 2007, focused on transliteration. Krause et al. (2007) described the piloting of the Educational Interpreter Proficiency Assessment (EIPA), helping to establish the validity and reliability of transliterator evaluation for the educational setting in the U.S. Krause and Lopez (2017) continued work on the impact of transliterator performance, reporting that accuracy

accounts for 26% of the variance of intelligibility. Additionally, they reported that on average a 0.6–1.8 s lag time is ideal for transliterated messages. Third, Dupont et al. (2018) reported that parents and students view the roles of personnel, social context of transliteration, and availability of services as impacting factors when describing the benefit of CS in a mainstream educational setting. Students reported that transliterators who step out of their professional role create barriers socially, especially for teenagers. Parents report that the difficulty into obtaining quality service providers also negatively impacts student outcomes.

Six studies examined the potential for automatically generated CS using computer software programmes. Uchanski et al. (1994) spearheaded work on translating speech sounds into CS automatically using speech spectrograms to identify phonemes. Support from this system proved more effective than speech reading alone. Further work by Duchnowski et al. (2000) indicated that while manual CS is superior to automatically generated CS, automatically generated CS enhances a cuer's ability to perceive spoken language better than speechreading alone. Bailly et al. (2006) used automatically generated CS to create a watermark onto a television, illustrating the potential for generated CS as a means of providing access to transliteration.

The process of recording the parameters of CS automatically for analysis was first explored by Attina et al. (2004), who used a specialised glove to record hand movements. Results indicate hand movements beginning 239ms before speech sound/mouth movement are initiated. Gibert et al. (2005) furthered this work documenting coarticulation parameters of hand, face, and sound. Heracleous et al. (2010) demonstrated the potential for automatic recognition of French CS using hidden Markov models. Using a combination of hand and lip shape, participants showed improved identification of vowel and consonant sounds over speechreading alone.

Within the sub-theme of technology support, seven instances of CS supporting hearing technology were identified. Descourtieux et al. (1999) established a benefit of watching spoken language through CS prior to CI implantation, specifically due to phonological mapping for (re)habilitation. Moreno-Torres and Torres (2008) supported using CS for the reception of non-salient words, supplementing the development of language through a CI. Bayard et al. (2013, 2019) illustrated that users of CIs using CS were able to reduce the ambiguity of speechreading and audition because of cues. As described earlier, multiple studies show literacy benefits when CS accompanies CIs, though again, the CI is the primary benefactor (Colin et al., 2010, 2017; Torres et al., 2008).

Future directions

Expressive language

While research trends positively for expressive language benefits of CS, large gaps of knowledge remain. No research was identified that indicates the

developmental order of expressive cues. Based on the knowledge of cheremes in sign language, cues have a physical developmental order (Mayberry & Squires, 2006; Schick et al., 2013). It is safe to assume that the handshapes of CS will also be dictated by fine motor skill development. No research indicates whether approximations or substitutions are intelligible, much the same way as approximations in ASL (i.e. Flat O for O) or in spoken language (i.e. /w/ for /r/) are intelligible. No research was located indicating if native CS users develop language along typical language trajectories. Limited research was found to document the development of CS when changing modalities (i.e. visual to auditory or vice versa) or integrating bi-modal methods. Minimal research was located to evaluate the development of expressive CS by families, professionals, or peers.

Receptive language

The benefit of CS to support speechreading/lipreading is a well-established. The sheer volume of research relying on speechreading/ lipreading as a requirement may contribute to the perception that CS is an "audist" method. While research hinted at the presence of multimodal (sign language and CS) users (Dupont et al., 2018), no research could be found indicating when users preferred one visual mode over the other. As hearing technology has changed, the benefit of CS for receptive auditory and/or visual information continues to evolve. Only one article (Krause et al., 2007) examined how hearing users of CS receptively process cues produced by cuers who are D/hh. Additional research should be conducted to determine the typical development of receptive processing in native cuers (early users) and immigrating cuers (late users), as well as to determine best practices within transliterated communication in the classroom.

Literacy

It is well established that CS can be used to develop PA, specifically in rhyme. CS may also be used to support decoding/recoding. Limited research exists to describe the impact of CS on phonological skills such as segmentation, blending, and general phoneme manipulation. The link between decoding and comprehension of vocabulary has not been studied. Fluency was only found to be present in one study focused on speed, with no research describing the accuracy, prosody, or impact of co-articulation of CS during assessment of reading skills. An evaluation matrix like that designed for the evaluation of fluency in Deaf ASL users (Easterbrooks & Huston, 2007) would be beneficial for equitable evaluation. Limited studies exist that demonstrate the development of comprehension skills among CS users. Comprehension studies examining the ability of CS users to recall, sequence, identify the main idea, predict, value, and problem solve are still needed. Finally, written language studies have only focused on spelling and recall of modelled sentences. No research identified indicated the use of CS as a means to support written composition. Finally, more research is

needed to establish how and when CS can serve as an evidence-based practice in literacy acquisition.

Identification, school, and identity

Research related to identification, services, and identity is still in emergent stages. Little is known about peer interaction, social-emotional well-being, or teacher preparation as related to CS. Resources are available to identify teacher preparation programmes that include CS, but no research has been conducted to examine the skill level of teachers needed at initial certification. Transliteration is an important need for CS users in mainstream settings, yet transliterator preparation programmes are limited, and not studied, unlike signed language interpreting. Limited formal data is available to help determine how many people use CS as a primary mode for communication, and therefore how much of a demand exists for such services. Lastly, little is known about the decision-making process for families who choose to use CS. Overall, this theme has large gaps in knowledge, which ultimately influence the inclusion or exclusion of cuers.

Access and accommodations

When considering the themes of access and accommodations, more recent research is focused on the use of CS to supplement CI use and subsequent listening skill development. The body of research available shows that a CI can be supported before and after implantation with a visual mode and that users may continue to use CS to support language access as deemed necessary or discontinue use. A moderate body of research indicates that automatic transliteration may be a potential to help solve the shortage of transliterators, but transliterators still play a crucial role in accessibility. Several studies have documented the adaptation of CS to world languages; however, the availability process of adaptations is poorly documented, and adaptations need to be easily accessible.

Conclusion

Over the past 50 years since the inception of Cued Speech, there has been a shift in the focus of the available research. The early research shows the focus of CS was originally on speech and lipreading. While some of the more recent research does highlight the support that CS lends to speech/lipreading, other recent research looks at using CS to fill in gaps that the CI cannot fully perceive. In the recent two decades, research has shifted to a focus on the benefits of CS and literacy, specifically spelling, comprehension, vocabulary, WID, and phonological awareness (PA). PA has been determined by the U. S. National Reading Panel to be one of several key components of developing strong literacy skills. Given that the process of developing PA of a spoken language is through the

air (audition), this emerging initial research lends support to the use of CS as a visual mode to access the phonemes of spoken languages, allowing for a medium to transfer from the spoken word to print.

In short, while the use of CS as a means of access to a spoken language and the resulting research is not prevalent in the U.S., several European countries have shown promising results in using CS to support both expressive and receptive language, as well literacy development. Research would benefit from exploring the transferability of study results between languages. Lastly, there need to be gains worldwide in the areas of identification, services, and identity to ensure equity for CS users.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Alegria, J., Charlier, B. L., & Mattys, S. (1999). The role of lip-reading and cued speech in the processing of phonological information in French-educated deaf children. *European Journal of Cognitive Psychology*, *11*(4), 451–472. https://doi.org/10.1080/095414499382255

Alegria, J., & Lechat, J. (2005). Phonological processing in deaf children: When lipreading and cues are incongruent. *Journal of Deaf Studies and Deaf Education*, *10*(2), 122–133. https://doi.org/10.1093/deafed/eni013

Aparicio, M., Peigneux, P., Charlier, B., Balériaux, D., Kavec, M., & Leybaert, J. (2017). The neural basis of speech perception through lipreading and manual cues: Evidence from deaf native users of cued speech. *Frontiers in Psychology*, *8*, 426. https://doi.org/10.3389/fpsyg.2017.00426

Aparicio, M., Peigneux, P., Charlier, B., Neyrat, C., & Leybaert, J. (2012). Early experience of cued speech enhances speechreading performance in deaf. *Scandinavian Journal of Psychology*, *53*(1), 41–46. https://doi.org/10.1111/j.1467-9450.2011.00919.x

Attina, V., Beautemps, D., Cathiard, M.-A., & Odisio, M. (2004). A pilot study of temporal organization in cued speechproduction of French syllables: Rules for a cued speechsynthesizer. *Speech Communication*, *44*(1–4), 197–214. https://doi.org/10.1016/j.specom.2004.10.013

Bailly, A., Attina, V., & Baras, C. B. (2006). ARTUS: Synthesis and audiovisual watermarking of the movements of a virtual agent interpreting subtitling using cued speech for deaf televiewers. *Modelling, Measurement and Control-C*, *67*(2, supplement:handicapt), 177–187. hal-00157826, version 1.

Ball, M. J., Dixon-Millar, J., & Crain, K. (2009). Adapting cued speech for Welsh. *International Journal of Speech-Language Pathology*, *11*(3), 234–243. https://doi.org/10.1080/17549500802624370

Bayard, C., Colin, C., & Leybaert, J. (2013). *Impact of cued speech on audio-visual speech integration in deaf and hearing adults*. Paper presented at the Auditory-Visual Speech Processing (AVSP). https://www.isca-speech.org/iscaweb/index.php/archive/online-archive.

Bayard, C., Colin, C., & Leybaert, J. (2014). How is the McGurk effect modulated by cued speech in deaf and hearing adults? *Frontiers in Psychology*, *5*, 416. https://doi.org/10.3389/fpsyg.2014.0041610.3389. eCollection 2014.

Bayard, C., Machart, L., Strauß, A., Gerber, S., Aubanel, V., & Schwartz, J.-L. (2019). Cued speech enhances speech-in-noise perception. *The Journal of Deaf Studies and Deaf Education*, https://doi.org/10.1093/deafed/enz003

Beaupre, W. (1985). Phonetics for the hearing-impaired university student: An alternate strategy. *The Volta Review*, *87*(7), 345–348.

Bouton, S., Bertoncini, J., Serniclaes, W., & Cole, P. (2011). Reading and reading-related skills in children using cochlear implants: Prospects for the influence of cued speech. *Journal of Deaf Studies and Deaf Education*, *16*(4), 458–473. https://doi.org/10.1093/deafed/enr014

Brentari, D., & Wolk, S. (1986). The relative effects of three expressive methods upon the speech intelligibility of profoundly deaf speakers. *Journal of Communication Disorders*, *19*(3), 209–218. https://doi.org/10.1016/0021-9924(86)90010-9

Charlier, B. L. (1992). Complete signed and cued French. An original signed language-cued speech combination. *American Annals of the Deaf*, *137*(4), 331–337. https://doi.org/10.1353/aad.2012.0441

Charlier, B. L., & Leybaert, J. (2000). The rhyming skills of deaf children educated with phonetically augmented speechreading. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, *53*(2), 349–375. https://doi.org/10.1080/027249800390529

Colin, S., Ecalle, J., Truy, E., Lina-Granade, G., & Magnan, A. (2017). Effect of age at cochlear implantation and at exposure to cued speech on literacy skills in deaf children. *Research in Developmental Disabilities*, *71*, 61–69. https://doi.org/10.1016/j.ridd.2017.09.014

Colin, S., Leybaert, J., Ecalle, J., & Magnan, A. (2013). The development of word recognition, sentence comprehension, word spelling, and vocabulary in children with deafness: A longitudinal study. *Research in Developmental Disabilities*, *34*(5), 1781–1793. https://doi.org/10.1016/j.ridd.2013.02.001

Colin, S., Lina-Granade, G., Truy, E., Ecalle, J., Penillard, A., & Magnan, A. (2010). Reading abilities in deaf children: Respective and/or combined contribution of early age of cochlear

implantation and exposition to cued speech. *Cochlear Implants International*, *11*(*Suppl 1*), 278–281. https://doi.org/10.1179/1467010101267117798919 2

Colin, S., Magnan, A., Ecalle, J., & Leybaert, J. (2007). Relation between deaf children's phonological skills in kindergarten and word recognition performance in first grade. *Journal of Child Psychology and Psychiatry*, *48*(2), 139–146. https://doi.org/10.1111/j.1469-7610.2006.01700.x

Cornett, R. O. (1973). Comments on the Nash case study. *Sign Language Studies*, *1003*(1), 93–98. https://doi.org/10.1353/sls.1973.0004

Cornett, R. O. (1985). Diagnostic factors bearing on the use of cued speech with hearing-impaired children. *Ear and Hearing*, *6*(1), 33–35. https://doi.org/10.1097/00003446-198501000-00009

Descourtieux, C., Groh, V., Rusterholtz, A., Simoulin, I., & Busquet, D. (1999). Cued speech in the stimulation of communication: An advantage in cochlear implantation. *International Journal of Pediatric Otorhinolaryngology*, *47*(2), 205–207. https://doi.org/10.1016/S0165-5876(98)00145-1

D'Hondt, M., & Leybaert, J. (2003). Lateralization effects during semantic and rhyme judgement tasks in deaf and hearing subjects. *Brain and Language*, *87*(2), 227–240. https://doi.org/10.1016/S0093-934X(03)00104-4

Duchnowski, P., Lum, D. S., Krause, J. C., Sexton, M. G., Bratakos, M. S., & Braida, L. D. (2000). Development of speechreading supplements based on automatic speech recognition. *IEEE Transactions on Biomedical Engineering*, *47*(4), 487–496. https://doi.org/10.1109/10.828148

Dupont, A., Beauregard, F., & Makdissi, H. (2018). Perceptions of the use of cued speech in an inclusive high school context in Quebec. *Exceptionality Education International*, *28*(1), 100–120. https://ir.lib.uwo.ca/eei/vol28/iss1/6.

Easterbrooks, S. R., & Huston, S. G. (2007). The signed reading fluency of students who are deaf/hard of hearing. *Journal of Deaf Studies and Deaf Education*, *13*(1), 37–54. https://doi.org/10.1093/deafed/enm030

Gibert, G., Bailly, G., Beautemps, D., Elisei, F., & Brun, R. (2005). Analysis and synthesis of the three-dimensional movements of the head, face, and hand of a speaker using cued speech. *The Journal of the Acoustical Society of America*, *118*(2), 1144–1153. https://doi.org/10.1121/1.1944587

Gregory, J. F. (1987). An investigation of speechreading with and without cued speech. *American Annals of the Deaf*, *132*(6), 393–398. https://doi.org/10.1353/aad.2012.1466

Heracleous, P., Beautemps, D., & Aboutabit, N. (2010). Cued speech automatic recognition in normal-hearing and deaf subjects. *Speech Communication*, *52*(6), 504–512. https://doi.org/10.1016/j.specom.2010.03.001

Hernández, R. S., Monreal, S. T., & Orza, J. G. (2003). The role of cued speech in the development of Spanish prepositions. *American Annals of the Deaf*, *148*(4), 323–332. https://doi.org/10.1353/aad.2003.0026

Hiki, S., & Fukuda, Y. (1981). Proposal of a system of manual signs as an aid for Japanese lip-reading. *Journal of the Acoustical Society of Japan (E)*, *2*(2), 127–129. https://doi.org/10.1250/ast.2.127

Koo, D., Crain, K., LaSasso, C., & Eden, G. F. (2008). Phonological awareness and short-term memory in hearing and deaf individuals of different communication backgrounds. *Annals of the New York Academy of Sciences*, *1145*(1), 83–99. https://doi.org/10.1196/annals.1416.025

Krause, J. C., Kegl, J. A., & Schick, B. (2007). Toward extending the educational interpreter performance assessment to cued speech. *Journal of Deaf Studies and Deaf Education*, *13*(3), 432–450. https://doi.org/10.1093/deafed/enm059

Krause, J. C., & Lopez, K. A. (2017). Cued speech transliteration: Effects of accuracy and lag time on message intelligibility. *The Journal of Deaf Studies and Deaf Education*, *22*(4), 378–392. https://doi.org/10.1093/deafed/enx024

Krause, J. C., Pelley-Lopez, K. A., & Tessler, M. P. (2011). A method for transcribing the manual components of cued speech. *Speech Communication*, *53*(3), 379–389. https://doi.org/10.1016/j.specom.2010.11.001

LaSasso, C. J., & Crain, K. L. (2015). Reading for deaf and hearing readers: Qualitatively and/or quantitatively similar or different? A nature versus nurture issue. *American Annals of the Deaf*, *159*(5), 447–467. https://doi.org/10.1353/aad.2015.0004

LaSasso, C., Crain, K., & Leybaert, J. (2003). Rhyme generation in deaf students: The effect of exposure to cued speech. *Journal of Deaf Studies and Deaf Education*, *8*(3), 250–270. https://doi.org/10.1093/deafed/eng014

LaSasso, C., & Metzger, M. (1998). An alternate route for preparing deaf children for BiBi programs: The home language as L1 and cued speech for conveying traditionally spoken languages. *Journal of Deaf Studies and Deaf Education*, *3*(4), 265–289. https://doi.org/10.1093/oxfordjournals.deafed.a014356

LeBlanc, B. M. (2004). A public school cued speech program for children with hearing loss and special learning needs. *The Volta Review*, *104*(4), 327–338.

Leybaert, J. (2000). Phonology acquired through the eyes and spelling in deaf children. *Journal of Experimental Child Psychology*, *75*(4), 291–318. https://doi.org/10.1006/jecp.1999.2539

Leybaert, J., & Charlier, B. (1996). Visual speech in the head: The effect of cued-speech on rhyming, remembering, and spelling. *Journal of Deaf Studies and Deaf Education*, *1*(4), 234–248. https://doi.org/10.1093/oxfordjournals.deafed.a014299

Leybaert, J., & D'Hondt, M. (2003). Neurolinguistic development in deaf children: The effect of early language experience. *International Journal of Audiology*, *42*(*Suppl 1*), 34–40. https://doi.org/10.3109/14992020309074622

Leybaert, J., & Lechat, J. (2001a). Phonological similarity effects in memory for serial order of cued speech. *Journal of Speech, Language, and Hearing Research*, *44*(5), 949–963. https://doi.org/10.1044/1092-4388(2001/074)

Leybaert, J., & Lechat, J. (2001b). Variability in deaf children's spelling: The effect of language experience. *Journal of Educational Psychology*, *93*(3), 554–562. https://doi.org/10.1037/0022-0663.93.3.554

Ling, D., & Clarke, B. R. (1975). Cued speech: An evaluative study. *American Annals of the Deaf*, *120*(5), 480–488. https://www.jstor.org/stable/44388067.

Liu, L., & Feng, G. (2018). *A pilot study on Mandarin Cued Speech*. ⟨hal-01845295v2⟩.

Mayberry, R. I., & Squires, B. (2006). Sign language acquisition. In K. Brown (Ed.), *Encyclopedia of language and Linguistics* (pp. 11–739). Elsevier.

Mirus, G. (2014). Articulatory play among American cuers. *Sign Language Studies*, *14*(3), 382–401. https://doi.org/10.1353/sls.2014.0005

Mohay, H. (1983). The effects of cued speech on the language development of three deaf children. *Sign Language Studies*, *1038*(1), 25–49. https://doi.org/10.1353/sls.1983.0001

Moreno-Torres, I., & Torres, S. (2008). From 1-word to 2-words with cochlear implant and cued speech: A case study. *Clinical Linguistics and Phonetics*, *22*(7), 491–508. https://doi.org/10.1080/02699200801899145

Movallali, G., & Sajedi, F. (2014). Developing a bilingual "Persian cued speech" website for parents and professionals of children with hearing impairment. *Iranian Journal of Public Health*, *43*(3), 367–371. PMC4419176. http://irj.uswr.ac.ir/article-1-353-en.html.

Nash, J. E. (1973). Cues or signs: A case study in language acquisition. *Sign Language Studies*, *1003*(1), 79–92. https://doi.org/10.1353/sls.1973.0001

Neef, N. A., & Iwata, B. A. (1985). The development of generative lipreading skills in deaf persons using cued speech training. *Analysis and Intervention in Developmental Disabilities*, *5*(4), 289–305. https://doi.org/10.1016/0270-4684(85)90001-1

Nicholls, G. H., & Ling, D. (1982). Cued speech and the reception of spoken language. *Journal of Speech, Language, and Hearing Research*, *25*(2), 262–269. https://doi.org/10.1044/jshr.2502.262

Portolano, M. (2008). Cued American English: A variety in the visual mode. *World Englishes*, *27*(2), 196–216. https://doi.org/10.1111/j.1467-971x.2008.00552.x

Power, D. J., Wood, D. J., & Wood, H. A. (1990). Conversational strategies of teachers using three methods of communication with deaf children. *American Annals of the Deaf*, *135*(1), 9–13. https://doi.org/10.1353/aad.2012.0439

Rees, R., & Bladel, J. (2013). Effects of English cued speech on speech perception, phonological awareness and literacy: A case study of a 9-year-old deaf boy using a cochlear implant. *Deafness & Education International*, *15*(4), 182–200. https://doi.org/10.1179/1557069X13Y.0000000025

Rees, R., Fitzpatrick, C., Foulkes, J., Peterson, H., & Newton, C. (2017). Can explicit training in cued speech improve phoneme identification? *Deafness & Education International*, *19*(1), 13–21. https://doi.org/10.1080/14643154.2017.1281595

Schick, B., Skalicky, A., Edwards, T., Kushalnagar, P., Topolski, T., & Patrick, D. (2013). School placement and perceived quality of life in youth who are deaf or hard of hearing. *Journal of Deaf Studies and Deaf Education*, *18*(1), 47–61. https://doi.org/10.1093/deafed/ens039

Torres, S., Moreno-Torres, I., & Santana, R. (2006). Quantitative and qualitative evaluation of linguistic input support to a prelingually deaf child with cued speech: A case study. *Journal of Deaf Studies and Deaf Education*, *11*(4), 438–448. https://doi.org/10.1093/deafed/enl006

Torres, S., Rodriguez, J.-M., Garcia-Orza, J., & Calleja, M. (2008). Reading comprehension of an inferential text by deaf students with cochlear implants using cued speech. *The Volta Review*, *108*(1), 37–59. https://doi.org/10.17955/tvr.108.1.600

Tucci, S. L., Trussell, J. W., & Easterbrooks, S. R. (2014). A review of the evidence on strategies for teaching children who are DHH grapheme–phoneme correspondence. *Communication Disorders Quarterly*, *35*(4), 191–203. https://doi.org/10.1177/1525740114523776

Uchanski, R. M., Delhorne, L. A., Dix, A. K., Braida, L. D., Reed, C. M., & Durlach, N. I. (1994). Automatic speech recognition to aid the hearing impaired: Prospects for the automatic generation of cued speech. *Journal of Rehabililitation Research and Development*, *31*(1), 20–41.

Wang, Y., Trezek, B. J., Luckner, J. L., & Paul, P. V. (2008). The role of phonology and phonologically related skills in reading instruction for students who are deaf or hard of hearing. *American Annals of the Deaf*, *1*. https://www.jstor.org/stable/26234536.

Appendix: Data Collection Tool.

Expressive Language ☐Expressive Speech: ☐Expressive Cues ☐Expressive Language ☐Other: Click here to enter text. **Receptive Language** ☐Receptive Speech: *speechread, lipread, audition, coarticulation* ☐Receptive Cues ☐Receptive Language ☐Other: _____ **Literacy** ☐Phonological Awareness: *word comparison, rhyme, sentence segmentation, onset/rime, blend/segment phonemes, phoneme deletion, phoneme manipulation* ☐Decoding/ Word Identification ☐Fluency: *speed, accuracy, prosody, co-articulation(in reading)* ☐Vocabulary ☐Comprehension*: ID/Recall, sequence, cause/effect/inference, main idea, prediction, value, problem solve* ☐Spelling ☐Written Language **Identification, School, and Identity** ☐Identity as a D/deaf Person ☐Peers ☐Family ☐Age/Onset/Duration of CS use ☐School/Services ☐Teacher Prep ☐Compares Modality **Access** ☐Interpreter/ Transliterators ☐Technology Support (*CI, HA*, etc) ☐Translation to other Languages: _____ ☐Transcription ☐Automatic generation: *expressive, receptive*	**Expressive Language (Clarification)** Speech- speech production, verbally Cues—production of cues Language- semantic or syntactic properties **Receptive Language (Clarification)** Speech- speech reception, auditory or visual Cues—reception of cues Language- semantic or syntactic reception **Notes:**