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Use of elements from the *Visual Communication and Sign Language Checklist* to supplement language sampling analysis in assessing the language abilities of children who use signed and spoken communication

by

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Contents

List of Figures vi
List of Tables vii
Abstract viii
Introduction 1
Communication Modalities for DHH Children 2
  Multimodal Options 2
Complexities of Multimodal Language Development 4
  Form 4
  Content 6
  Use 6
Current Trends in Assessing DHH Children 8
Assessments 11
  Systematic Analysis of Language Transcripts 11
  Visual Communication and Sign Language Checklist 11
Purpose 15
Methods 15
  Participants 16
  Hearing Status 17
  Home Language 17
  Data Collection 17
  Identifying Applicability 17
  Finding Trends in Spoken and Visual Language Development 18
Results 19
  VCSL Tasks and Codes 19
  MLU 23
  Trends Across Home Languages 28
Discussion 29
  VCSL Applicability 29
  Multimodal and Multilingual Language Development 31
  Limitations 34
  Conclusions and Recommendations 35
References 37

List of Figures

Figure 1 VCSL-T Performance 19

Figure 2 Correlation between VCSL-T and VCSL-C in communication samples....................... 22

Figure 3 Trends in participant age, VCSL-C, and MLU-m 24

Figure 4 Comparative use of signed utterances, spoken utterances, and VCSL-C....................... 26

Figure 5 Trends in MLU-m and use of individual codes within VCSL-C 27

Figure 6 Trends in participant age, MLU-m, and level of hearing loss 27

List of Tables

Table 1 Common approaches to language for DHH individuals in the United States 2

Table 2 Developmental norms for MLU-m in English... 9

Table 3 Multi-sign utterance development, as per the VCSL.. 10

Table 4 VCSL Sources.. 12

Table 5 VCSL reference group participants by age... 12

Table 6 VCSL tasks by age range and domain.. 13

Table 7 Participant demographics.. 16

Table 8 Demonstration of VCSL tasks (VCSL-T) by each participant....................................... 20

Table 9 Analysis codes and descriptions.. 21

Table 10 Correlations between VCSL-T and VCSL-C during communication sample.............. 22

Table 11 Participant MLU-m compared to same-age peers 23

Table 12 Multi-sign utterances, by participant 25

Table 13 Trends VCSL-C, HL, and MLU-m.. 28

Table 14 Comparative MLU-m, use of signed utterances, and VCSL-C 29

Abstract

This study aimed to expand understanding of (1) language development in deaf/hard-of-hearing (DHH) children who use signed and spoken communication and (2) how speech-language pathologists (SLPs) can most appropriately assess language in this population. Communication samples from 12 DHH children who receive services in a Total Communication classroom were analyzed with additional analysis codes derived from the Visual Communication and Sign Language Checklist (VCSL). Results suggested increased spoken language skills and decreased visual language skills with age, with complex language development across modalities potentially being influenced by level of hearing loss and home language modality. VCSL Codes are indicated to be a viable option for SLPs assessing multimodal language abilities of children who use signed and spoken communication, and may be used (1) to provide a more comprehensive view of development, and/or (2) as a screener to determine if further evaluation by VCSL-trained clinician is warranted.

Key words: Hearing Loss, Total Communication, Bilingual, Bimodal, Language Development, Language Assessment

Use of elements from the Visual Communication and Sign Language Checklist to supplement language sampling analysis in assessing the language abilities of children who use signed and spoken communication

Thirty-four million children globally have a hearing loss (HL) of 35 dB or greater in their better hearing ear, which can limit access to language and significantly impact language development (World Health Organization [WHO], 2012). In the United States, 1.1 per 1000 infants present with neonatal HL (Mehra et al., 2009). Roughly 92% of deaf or hard-of-hearing (DHH) children[1] are born to parents who are hearing, with only 8% of all DHH children having at least one parent who is Deaf (WHO, 2012).

DHH children with Deaf parents outperform DHH children with hearing parents in terms of cognition, theory of mind, language, and academic achievement (Emmorey, 2002; Geeslin, 2007; Spencer & Marschark, 2010; Hrastinski & Wilbur, 2016). Challenges and outcomes in these areas are augmented for DHH children born to hearing parents, who have comparatively limited experience with HL or alternatives to verbally-presented language. A DHH child born to hearing parents may therefore experience a delay in language exposure while waiting to either obtain access though hearing amplification technology or for consistent access to a developed visual language (Bailes et al., 2009). This suggests a critical need to provide early assessment and intervention to prevent a further gap in language development, which can impede academic success as well as long-term social and vocational achievement (Paul et al., 2020).

When language deficits and/or delays are a concern, DHH children often face an inadequate or unidimensional assessment of their communication abilities (e.g., English only). This is in part because language development and assessment in the United States tends to focus

[1] Use of identity-first language is most often preferred in the Deaf community and will therefore be used throughout this article. See American Psychological Association (2020), chapter 5.

on mastery of spoken and written English, to which DHH children do not have equal access (Bailes et al., 2009).

Communication Modalities for DHH Children

Parents of DHH children have a variety of communication modalities to implement for development of signed and/or spoken language (see Table 1).

Table 1

Common approaches to language for DHH individuals in the United States

Approach	Description
Listening and Spoken Language (LSL)	Use of amplified and/or residual hearing and spoken language.
Cued Speech (CS)	Spoken language with simultaneous use of gestures representing spoken language sounds.
Sign Language (SL)	Visual language distinct from spoken language. Includes American Sign language (ASL).
Simultaneous Communication (SimCom)	Signing while speaking; generally using the structure of spoken language in both modalities.
Manually Coded English (MCE)	A visual representation of English using signs and fingerspelling; includes Signed Exact English (SEE)
Bilingual-Bimodal (Bi-Bi)	Use of ASL and English, with ASL being considered the child's first language.
Total Communication (TC)	Use of all communication modalities, including spoken and signed language

Multimodal Options

Total communication (TC) is a communication ideology that emerged in the late 1960s and was designed to improve language acquisition and communication success in the DHH population through a comprehensive approach (Marschark & Spencer, 2015). It consists of using all available communication modalities to fit the needs of the child. This may include, but is not limited to, total or partial implementation of methods such as listening and spoken language (LSL), sign language (SL), cued speech (CS), fingerspelling, gestures, and writing. According to a 2017 survey of 321 families with children who were DHH and aged 2-6, approximately 46% of families report using a combination of modalities, such as TC (National Center for Hearing Assessment and Management [NCHAM], 2021). Specifically, 14% report using equal parts SL and spoken language, 17% report using mostly spoken language, supplemented by SL or CS, and 3% report using mostly SL, supplemented by spoken language or CS. According to the most recent *Annual Survey of Deaf and Hard of Hearing Children and Youth* conducted by Gallaudet University, 34.3% of schools and programs in the United States for DHH students regularly use American Sign Language (ASL), with regional use ranging from 19.6%-54.6% (Office of Research Support and International Affairs [RSIA], 2014).

Simultaneous Communication (SimCom) is a method of communication used often by educators of the deaf (Emmorey et al., 2008). It is a contact language aimed at facilitating communication without emphasis on adherence to the morphosyntactic rules of any related languages or modalities. It often presents as spoken English messages supplemented by simultaneous signed representations of the spoken message. The visual modality used typically reflects manually coded English (MCE) rather than ASL.

The Bilingual-Bimodal (Bi-Bi) approach was established in 1990 and is characterized by acquisition and use of both ASL and English as distinct languages and encourages inclusion in both the Deaf and hearing communities (Spencer & Marschark, 2010). In Bi-Bi, ASL is generally considered the primary language and supports English acquisition. Bi-Bi is reported to be the method used by 11%-13% of DHH children in the United States and Canada (Spencer & Marschark, 2010; Cannon & Luckner, 2016). It is important to note the similarities and overlap between TC and Bi-Bi. Some TC programs are implemented to mirror the Bi-Bi method, whereas others focus on English as a primary language, with gestures, writing, and functional sign language skills being used to support successful communication of spoken messages. These similarities, and variations in implementation, may influence patterns of language acquisition across DHH children (Spencer & Marschark, 2010; Cannon & Luckner, 2016).

Complexities of Multimodal Language Development

There are multiple characteristics that contribute to the complexity of language development in children who use TC. First, is the distinct language form, content, and use differences between English and ASL.

Form

One of the most notable differences between English and ASL is the domain of phonology, which concerns the smallest units of a language that can alter meaning. In spoken languages such as English, phonology describes the sounds used as well as the rules associated with how those sounds are structured in the language. ASL, which is not sound-dependent, is primarily comprised of five parameters within the domain of phonology. These parameters are handshape, location, movement, palm orientation, and non-manual markers. However, it is important to note that these parameters are also often classified as the foundation of morphology in some approaches to sign linguistics (Holcomb, 2013; Struxness & Marable, 2013).

Morphology focuses on the organization and use of morphemes, which are the smallest units in a language that carry meaning. It is often measured through mean length of utterance (MLU). In English, this includes root words and affixes. Morphology in ASL features both compounding (i.e., combining two or more free morphemes into a new word) and derivation (e.g., adding the AGENT marker to the end of "TEACH" to indicate "teacher") similarly to English. However, ASL does not generally use inflectional morphemes (e.g., past tense may be indicated by stating the time at the beginning of the sentence or adding the sign "FINISH" before or after the verb). ASL also allows for morphemes to be either sequential or simultaneous, whereas English morphemes must be produced sequentially (Emmorey et al., 2008; Baker et al., 2016). For example, simultaneous use of a facial or body posture may be used adverbially to describe an action. Altering the shape and pace of movement can differentiate between the use of a single sign WAIT to signify "waiting," "waiting for a while," "waiting for a long time," and so on. The opportunity for simultaneity presents unique opportunities where the complexity of a sentence in ASL may be increased without altering the number of signs or production time. This also implies that assessment of ASL development is most valid when considering both the utterance length as well as sign modifiers used.

Like all human languages, ASL features rule-governed syntax. Syntax in ASL is based on a topic-comment structure, wherein sentences generally follow an object-subject-verb (OSV) pattern (e.g., "SCHOOL+BOY+GO") which differs from the subject-verb-object (SVO) pattern generally used in English (e.g., "The boy goes to school") (Holcomb, 2013). ASL syntax also differs from English in that it is comprised of multiple subdomains, namely the structure of manual sign production and the simultaneous production of grammatical non-manual markers (Emmorey, 2002, Struxness & Marable, 2013). These include movements and postures of the mouth, eyes, eyebrows, and other body parts. Morphology and syntax both impact how sentences are formed and may therefore be referred to and measured as morphosyntax to reflect this interrelation.

Content

Semantics may be measured similarly in English and ASL in terms of lexical diversity, such as number of total words, number of different words, and type-token ratio (Baker et al., 2016). A unique characteristic of semantics in ASL and other signed languages is the high-iconicity of visual language, whereas the etymology of words in spoken languages is often opaque. This may be demonstrated in representations of the concept of "chocolate." The sounds comprising the word "chocolate" in English are not necessarily related to the item beyond relationships to other spoken words (as in other spoken languages), whereas the ASL representation incorporates the motion of grating chocolate in the production (Shaw & Delaporte, 2015). ASL also includes lexicalized structures, which are signs derived from the orthographic representation, as seen in the signs #JOB and #STYLE. Fingerspelling or lexicalization are indicated in gloss by an octothorpe (#). These may incorporate all or some of the handshapes used in the fingerspelled form of the concept. Semantics may also be adjusted through handshape changes (e.g., I handshape vs. G handshape to indicate thickness of an item), or location (producing a sign in neutral space vs. close to the body).

Use

Pragmatics in ASL and English may both be measured in various ways, including turn-taking, topic maintenance, transitions, and sense of politeness. Notable characteristics of ASL in comparison to English include increased eye contact, higher use of direct or blunt language, increased sharing of seemingly private or sensitive information, increased physical contact, and higher permissibility of walking between conversing individuals (Holcomb, 2013). Storytelling is also more likely to include use of classifiers, which are sets of handshapes used to represent classes of things based on attributes in a way that is overtly iconic. Classifiers present information spatially and visually in a way that may not directly translate to spoken language forms. They consist of three types of classifiers based on what they represent: body part (e.g., an inverted “3” to represent legs), whole entity (e.g., a “B” to represent papers or book covers), and handling classifiers (e.g., an “S” to represent holding and using a tool) (de Lint, 2020). Further, while English tends to follow a general-to-specific discourse style, where it is customary for conversation topics to be ambiguous upon initiation. In contrast, ASL follows a specific-to-general style, where topics are generally made clear at the beginning of discourse, and understanding is confirmed before discourse continues (Holcomb, 2013).

Because TC uses spoken and signed modalities, some who use TC may convey messages using both languages simultaneously, a phenomenon known as code-blending (Emmorey et al., 2008). This simultaneous use may present as periodic code-blending and code-switching, or a more constant blending that results in a production pattern similar to SimCom. As is true for all languages of any modality, SL structure may also differ greatly between subcultures and populations, and different ASL dialects are used throughout the United States, and an individual’s signed structure and vocabulary may further differ between communication partners or audiences. (Occhino et al., 2021). Further, few signers use formal ASL outside of an academic setting. It is more common for people to use a pidgin of ASL and MCE, also known as “contact signing” (Hardin et al., 2014).

Given some of the specific differences between English and ASL, assessment of DHH children that does not consider both languages may limit the validity of the assessment process and impact the child’s ability to receive appropriate services. Establishing developmental norms and assessing the language abilities of DHH children who use TC is challenging due to various child-internal factors and child-external factors that may influence language acquisition patterns.

Internal factors include degree of HL, age of HL diagnosis, age when intervention was initiated, age when fitted with hearing technology (if performed), and presence of other disabilities. External factors include language use in the educational setting, languages used in the home, and early intervention services accessed. External factors also include the quantity and quality of language exposure. They may be introduced to SL first, spoken language first, or both simultaneously. They may also be introduced to SL and spoken language as complete languages, as in Bi-Bi, use select SL skills as supports for spoken messages, or use spoken language skills as supports for signed messages.

Current Trends in Assessing DHH Children

The Individuals with Disabilities Education Act (IDEA) is a law in the United States that ensures free and appropriate education services are provided to children who have, or are suspected to have, a disability or condition that may negatively impact their access to education. This includes providing appropriate identification and intervention that reflect the unique needs of each child, as stated in Part B (Individuals with Disabilities Education Act [IDEA], 2004). The correlation between language abilities and academic/vocational success warrants comprehensive and appropriate language evaluation. In order to avoid overidentification of language disorders in children with language differences, they must be evaluated by a speech-language pathologist (SLP) in all languages that the child accesses and uses (IDEA, 2004; American Speech-Language Hearing Association [ASHA], 2010). This is commonly done with children who use multiple spoken languages to accurately identify children with language disorders and provide appropriate intervention. However, due to a paucity of research regarding overall language development in children who use multiple language modalities, there is limited guidance for SLPs on best practices for assessment and treatment of children who use TC.

When compared to their hearing peers, DHH children tend to demonstrate lower expressive spoken language abilities in terms of MLU, number of different words, and use of Brown's grammatical morphemes (Werfel & Douglas, 2017). These skills vary between children as a result of language exposure and access. Simultaneous bilingual preschool children demonstrate morphosyntactic development that mirrors that of typically-developing monolingual peers (Nicoladis & Genesee, 1997). This suggests that DHH children who simultaneously have full and appropriate access to ASL and a spoken language would also demonstrate morphosyntactic development, including MLU, that reflects developmental norms for typically-developing children who are monolingual in either English or ASL. Further, MLU is considered a reliable and valid element for measuring language acquisition and identifying language impairments in English (Rice et al., 2010). Table 2 indicates the developmental norms for mean MLU and standard deviation (SD) defined in morphemes (MLU-m) for preschool and early school-age children in English as described in 2010 by Rice et al., which were used to compare the participants to same-age peers.

Table 2

Developmental norms for MLU-m in English

Age Range	**3;6-3;11**	**4;0-4;5**	**4;6-4;11**	**5;0-5;5**	**5;6-5;11**	**6;0-6;5**
MLU-m	4.09	4.57	4.75	4.88	4.96	5.07
SD	0.67	0.76	0.79	0.72	0.70	0.75

Note. Information retrieved from Rice et al. (2010)

Because the structure of ASL differs greatly from English and inherently is demonstrated with a smaller MLU, comparison to development of signed MLU will also be made, in consideration of visual language morphosyntactic development. Table 3 describes the signed MLU milestones indicated in the VCSL for comparison.

Table 3

Multi-sign utterance development, as per the VCSL

ASL MLU Milestone	25% Mastered	50% Mastered	75% Mastered
Forms two-sign sentences	1;3	1;7	1;8
Forms three/four-sign sentences	2;1	2;6	2;8

Note. Information retrieved from Simms et al. (2013)

Many norm-referenced language assessments demonstrate inadequate applicability for DHH children, due to factors including the languages and modalities considered in both administration and the references used in scoring. Because of this, many SLPs and educators of DHH children consider language sample analysis (LSA) to be a more appropriate method for evaluating language abilities of DHH children (e.g., Blaiser & Shannahan, 2018; Werfel & Douglas, 2017). Further, the American Speech-Language-Hearing Association (ASHA) also requires SLPs to possess competency in the use and analysis of non-standardized measures, such as LSA, and indicates LSA is a valid information source for a culturally competent and comprehensive assessment (ASHA, 2010). Despite this consensus, a study by Pavelko et al. (2016) revealed that roughly only two-thirds of school-based SLPs had used LSA in the past year. Norm-referenced and static assessments are used more frequently and widely compared to LSA, and in some cases LSA is not used when determining a child's diagnosis or eligibility for intervention (Blaiser & Shannahan, 2018). This is further compounded by the trend, contrary to IDEA, in which scores on norm-referenced tests determine eligibility for services in many settings (IDEA, 2004). Unfortunately, very few assessments designed to evaluate language acquisition in DHH children have been widely available to SLPs for use. The language of DHH children is therefore often evaluated using assessments normed on monolingual children who are hearing and use a spoken language (Simms at al., 2013). This can result in many DHH children being evaluated for a language delay or disorder without considering the child as potentially being multilingual with limited English proficiency. This approach is inconsistent with comprehensive and appropriate assessment processes required by IDEA for children who are exposed to multiple languages, and may lead to inaccurate diagnoses for DHH children, which may subsequently lead to them receiving either inappropriate intervention or being barred from receiving needed intervention. A considerable portion of DHH children use TC (RSIA, 2014; NCHAM, 2021), which warrants a systematic and holistic way of capturing the skills in both spoken and visual communication.

Assessments

Systematic Analysis of Language Transcripts

Systematic Analysis of Language Transcripts (SALT) is a software program designed to operationalize the process of LSA (Miller & Iglesias, 2019). It allows clinicians to input codes for linguistic features to analyze transcriptions of communication samples. Its use is widely endorsed for analysis both in clinical and research settings (Heilmann et al., 2010; Pezold et al., 2020). Although there is no established gold standard for language assessment in identification of language impairment, use of LSA through SALT is considered an appropriate basis of, or supplement to, assessment. This is especially true for nonmainstream populations who often face bias in standardized assessments (Heilmann et al., 2010).

Visual Communication and Sign Language Checklist

The Visual Communication and Sign Language Checklist (VCSL) was designed in 2013 to address the limitations of existing ASL assessments (Simms et al., 2013). Its development began with a synthesis of eight sets of previously-established developmental norms already in use (Gallaudet, 2017). Table 4 describes the sources referenced in development of the VCSL.

Table 4

VCSL Sources

Assessment/Checklist	Author
Signed Language Developmental Checklist	Mounty, 1994
Language Checklist	revised; Evans, Zimmer, and Murray, 1994
ASL Development Observation Record	California School for the Deaf – Fremont, n.d.
ASL Developmental Milestones	Philip, 2003
ASL Developmental Checklist	Laurent Clerc Center, 2010
ASL Developmental States	Ohio School for the Deaf, n.d.
ASL Linguistic/Cultural Behaviors	Kansas School for the Deaf, n.d.
Milestones of Language Development	Andrews, Logan, & Phelan, 2008

Note. Information retrieved from Simms et al. (2013)

During development, the VCSL was tested in three phases with three different groups. In the final phase, it was normed on 83 typically-developing DHH children aged 0;1 to 5;11 whose primary language was ASL. Age distribution varied, with each 12-month interval being represented by 6 to 25 children. Table 5 details the number of children in each age group.

Table 5

VCSL reference group participants by age

Age	0;1-0;11	1;0-1;11	2;0-2;11	3;0-3;11	4;0-4;11	5;0-5;11
n	6	8	11	11	25	25

Note. Information retrieved from Simms et al. (2013)

At time of assessment, 79 of the 83 children were enrolled in bilingual ASL/English school programs. Performance by this group on each VCSL task was used to assess the validity of the assessment as well as determine the quartiles for the developmental norms reference table range (Simms et al., 2013).

The VCSL provides information on ASL language development and may be completed by an SLP or educator who is familiar with the child's language abilities, fluent in ASL, and formally trained in VCSL administration and scoring (Simms et al., 2013; Gallaudet, 2017). The checklist features 114 tasks that are presented with four response options: not yet emerging, emerging, inconsistent use, and mastered. Scoring is based on the number of mastered tasks in each section. For further analysis and intervention guidance, each task is given an age range of when 25%, 50%, and 75% of typically-developing children have mastered the skill. Completion of the VCSL provides the examiner with a developmental age equivalency. Table 6 summarizes the target milestones, organized by age range and domain.

Table 6

VCSL tasks by age range and domain

Age	Form	Content	Use
0-12 months	- Hand babbling - Attends to signed motherese	- Distinguishes facial expressions	- Follows pointing, eye gaze - Waves bye-bye - Copies movements - Joint reference - Communicative play - Attentive to environment, faces - Responds to attention-getting - Emotion expression
1-2 years	- Gestures - Finger babbling - Negative headshake - Simple handshapes - Two-sign sentences	- Recognizes and uses name signs - Identifies pictures of nouns in environment - Points to self	- Answers WHERE, WHAT - Communicates wants - Follows simple commands - Repeats signs
2-3 years	- Emerging use of non-manual markers - Uses pronouns - Expanded handshapes - Possessives - Facial adverbs - Lexicalized fingerspelling - 3-4 sign sentences - Combines nouns, verbs - Two-step commands - Two-word questions	- Names nouns in pictures - 150-350 sign inventory - Counts from 1 to 5 - Uses emotion signs - Early understanding of timeline - Identifies, matches colors - Simple descriptors - Uses negatives - Understands simple fingerspelled words	- Uses classifiers - Requests help - Points to common areas in house to answer question - Conversational turn-taking - Answers WHO, WHICH, FOR++ [a] - Imitates characters in signed stories - Begins to tell stories about present situations

Table 6 *(continued)*

Age	Form	Content	Use
2-3 years	- Emerging use of non-manual markers - Uses pronouns - Expanded handshapes - Possessives - Facial adverbs - Lexicalized fingerspelling - Sentences of 3-4 signs - Combines nouns, verbs - Two-step commands - Two-word questions	- Names nouns in pictures - 150-350 sign inventory - Counts from 1 to 5 - Uses emotion signs - Early understanding of timeline - Identifies, matches colors - Simple descriptors - Uses negatives - Understands simple fingerspelled words	- Uses classifiers - Requests help - Points to common areas in house to answer question - Conversational turn-taking - Answers WHO, WHICH, FOR++ [a] - Imitates characters in signed stories - Begins to tell stories about present situations
3-4 years	- Uses verbs to connect subjects and objects - Topicalization - Complex handshapes - Classifier + action - Rhetorical questions	- Verb modification - Understands part-whole relationships - Understands quantity concepts - Understands antonyms	- Answers HOW, WHY, DO++ [a] - Describes physical needs
4-5 years	- Complex sentences - Expanded sentences with two traits - Conditionals - Understands handshape categories - Number distribution - Awareness that lexicalized signs are made of handshapes - Question bracketing - Agent marker - Topic continuation (holding a sign with one hand and continuing with other)	- Counts to 15 - Understands and uses time concepts - Setting up people/items not present - Verb modification for intensity - Understanding and use of categories - Distinguishes noun/verb - Understands similarities - Qualitative descriptors - Understands parts - Organize items by size - Noun modification	- Sustained conversation with at least 3 turns - Tells a simple story with beginning, middle, end - Body shift and eye gaze - Tells stories about personal experiences - Answers complex questions

Note. Tasks retrieved from the VCSL (Simms, Baker, & Clark 2013).

[a] FOR++ and DO++ are questions formed though repetition of the root word and non-manual question marker of furrowed brow. They roughly translate to “what for” and “what [do you] do”/“what [are you] doing,” respectively.

Although tested on a combination of both bilingual and monolingual children, the VCSL is intended for use with DHH children who use ASL as a primary language and therefore may present with limited applicability for children in some TC programs due to varied quality and quantity of ASL access. Further, use of the assessment in full requires training that may not be easily accessible for all SLPs who have DHH children on their caseload.

Purpose

The purpose of this study is to perform a pilot study to identify the value added through incorporating tasks from the VCSL to a SALT LSA of preschool children who use TC. These tools were selected because there is a research-base for using both SALT and VCSL individually for different populations (i.e., those who use spoken language and those who use ASL, respectively). It is hypothesized that integration of these tools may help provide a richer analysis of language development and provide codes to use clinically in future studies. This study aimed to answer two questions:

Question 1: Do communication samples from preschool-age DHH children who receive services in a TC classroom exhibit particular patterns, and if so, what discernable patterns appear to be evident?

Question 2: What benefits are there, if any, to incorporating elements from the VCSL into LSA of children who use TC?

Methods

This study was exploratory in nature and employed a two-part cross-sectional descriptive and correlational study. This study aimed to further develop understanding of how SLPs can most appropriately evaluate the language of DHH children who use TC. Data were collected through evaluation of prerecorded communication samples.

Participants

Thirteen participants were initially recorded; however, 12 were included in the study due to one of the participants unenrolling from the program before sufficient demographic information was available for the study. The participants consisted of children between 3 and 7 years of age who have bilateral HL and receive services in a TC classroom where instruction was provided by a Deaf adult using solely ASL as well as by a hearing adult using SimCom. There was not a calculation for the amount of time that each modality was used during the day. This model serves as the definition for TC classroom for this study. Data was also available for age of HL identification, type of hearing technology, and the child's age at the time of technology fitting. Table 7 further describes the demographics of the participants.

Table 7

Participant demographics

ID	Age	Gender	Home Language	HL degree	Age at Identification	Hearing Technology	Age at Fitting
P1	3;9	F	ASL	Mild, Moderate	Birth	HA	2;0
P2	3;11	F	English	Profound	Birth	CI	0;5
P3	4;1	F	English	Severe	Birth	BAHA	0;6
P4	4;3	M	English	Profound	Birth	CI	0;3
P5	4;7	F	Spanish	Profound	Birth	CI	3;0
P6	4;7	M	Spanish	Profound	1;6	CI	2;0
P7	5;0	F	English	Profound	Birth	CI	1;4
P8	5;2	F	English	Moderate, Severe	Birth	HA	0;8
P9	5;2	F	English	Moderate	Birth	HA	0;3
P10	5;6	M	English	Severe, Profound	2;0	HA, CI	3;6
P11	5;7	M	English	Profound	Birth	CI	0;6
P12	6;3	F	English	Mild, Moderate	Birth	HA	1;6

Note. CI: cochlear implant(s), HA: hearing aid(s), BAHA: bone-anchored hearing aid(s).

Hearing Status

The participants were documented as having a range in HL from mild/moderate to profound, with half having a bilateral profound HL. As noted previously, HL can impact language access and influence language development, including MLU-m and complex structures.

Home Language

Three different home languages were reported across the participants and included English, Spanish, and ASL. The home language is typically the one to which a child has the most exposure. Because this study examined multimodal and multilingual development, analysis took home language into account to consider the impact of language exposure on development.

Data Collection

The communication samples used in analysis were recorded in the hallways of the participants' school, and framework for sampling context consisted of the examiner reading a picture story and prompting a retell, followed by prompting naturalistic conversation during joint play with playdough. Some recordings are noted to have variations in contexts due to participants not being receptive to select tasks. The samples range in length from 11:38 to 20:00 minutes, with a mean time of 16:08. The examiners consisted of four students who were studying speech-language pathology through a small urban university at the time of recording. The examiners possessed varied levels of ASL mastery.

Identifying Applicability

The applicability of using VCSL tasks in LSA was determined through first describing differences in information provided by the VCSL and SALT Standard Measures Report. This was followed by identifying how many of the 114 VCSL tasks were demonstrated by each participant. The author, a graduate SLP student with a minor in sign language studies, created a spreadsheet for demonstration of the tasks by each participant, in which indications were made for (1) skills produced accurately, (2) skills omitted or errored in obligatory context, and (3) skills not targeted (i.e., no opportunity provided to warrant skill demonstration).

Finding Trends in Spoken and Visual Language Development

Transcriptions of the samples were analyzed using SALT Standard Measures Report. The scope of this project focused on the SALT data for MLU-m, which was measured using all spoken and signed utterances to allow for code-switching and code-blending. Overall MLU-m levels were compared between the participants and against developmental norms. Utterance length in sign was defined as number of individual signs in a signed utterance, as per the VCSL.

SALT analysis also included a code summary for each sample. The codes used included three codes from SALT, which are used for errored words ([EW]), errored utterances ([EU]), and imitated productions ([I]). Imitations are defined as a production by the participant that matches the modality and content of the examiner's most recent utterance. For example, an utterance was considered an imitation if the child used signs first produced by the examiner, but not if the child signed concepts that mirrored a spoken utterance from the examiner. This was maintained in instances of SimCom (e.g., if the participant said and signed a concept previously spoken by the examiner, the spoken form was considered an imitation whereas the signed form was not). An additional code ([SL]) indicated which utterances were signed. To account for utterances that might be classified as errored due to structural influence from ASL, a code for sign structure utterances ([SSU]) was included to indicate utterances that followed ASL syntax more closely than English syntax. Additional codes were created to represent individual VCSL tasks. These codes were derived from VCSL tasks that meet the following criteria: (1) listed for the age range of 1-5 years that (2) at least two-thirds of the participants are given an opportunity to produce and (3) may be classified as a distinct event. Tasks such as *understands conversational turn-taking* or sign inventory were excluded due to not having a clear and objective moment to code, and tasks such as *waves bye-bye* and *can count up to 15* were excluded due to not being elicited). Codes for handshape complexity, classifiers, and non-manual markers were included regardless of use across participants to maintain consistency with appropriate and multidimensional measurement of visual language development (Emmorey et al., 2008; Baker et al., 2016).

Correlations were calculated using Jamovi software to determine the presence of any statistically significant trends between age, MLU-m, VCSL-T, VCSL-C, and HL. Participant hearing status and age at technology fitting were also considered, as these have been noted to influence language development and performance (Tomblin et al., 2014; Ching et al., 2018).

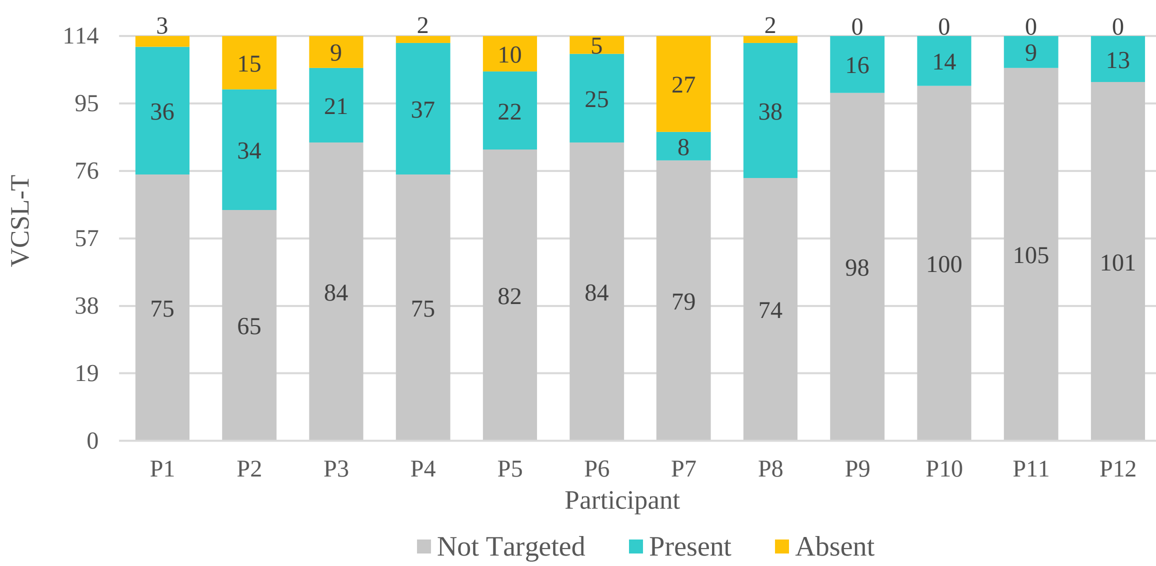
Results

VCSL Tasks and Codes

In the communication samples, participants had an opportunity to produce 9-49 skills from the VCSL. Figure 1 demonstrates the number of tasks not targeted, present, and absent.

Figure 1

VCSL-T performance



Accurate demonstration of VCSL tasks (or VCSL-T) ranged from 8 to 34 of the 114 tasks as shown in Table 8. Tasks specific to the assessment sections for developmental tasks in the 3-4- and 4-5-year age ranges were referenced to indicate visual language complexity levels.

Table 8

Demonstration of VCSL tasks (VCSL-T) by each participant

Participant	Age	Home Language	VCSL-T	Age 3-4 Tasks	Age 4-5 Tasks
P1	3;9	ASL	36	3	5
P2	3;11	English	34	2	2
P3	4;1	English	21	0	0
P4	4;3	English	37	1	0
P5	4;7	Spanish	22	1	0
P6	4;7	Spanish	25	0	0
P7	5;0	English	8	0	0
P8	5;2	English	38	0	3
P9	5;2	English	16	0	0
P10	5;6	English	14	0	0
P11	5;7	English	9	0	0
P12	6;3	English	13	0	0

Codes for use in SALT were created to represent VCSL-T not already measured by SALT. To maintain applicability to the target population as well as feasibility for implementation by clinicians, not all tasks were converted into codes. Codes were created for tasks that at least 8 of the 12 participants (67%) had an opportunity to produce during the samples and represented skills that are demonstrably distinct events. Ten codes based on the VCSL were created, as well as two additional codes for recording errors in signed utterances and use of ASL structure. Table 9 describes the codes used.

Table 9

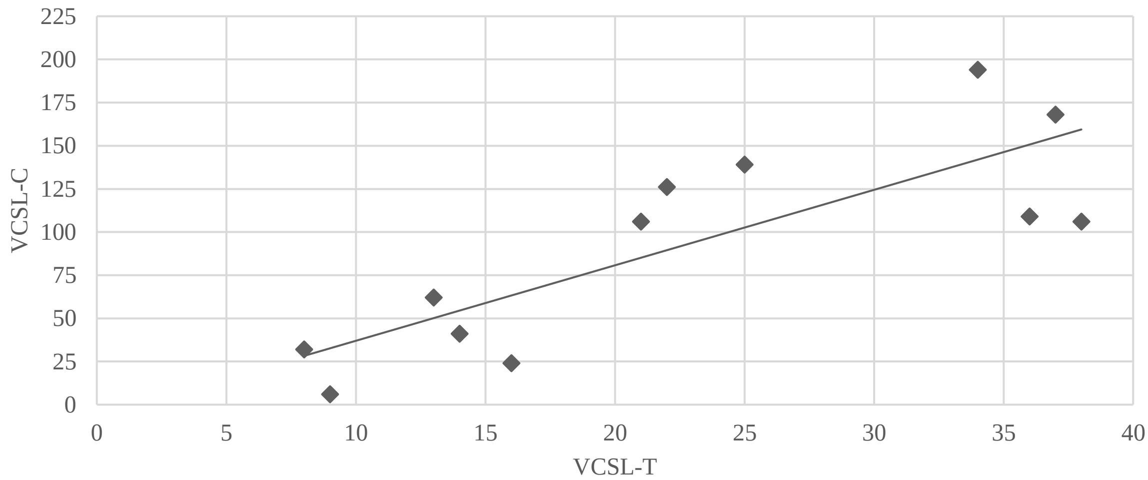
Analysis codes and descriptions

Code	Name	Description
[EW]	Errored Word	Spoken substitutions, insertions, and morphological errors
[EU]	Errored Utterance	Utterance with three or more errored words
[I]	Imitation	Word or sign follows examiner direct or indirect model
[POINT]	Point	Intentional pointing (e.g., to an item, person, or place)
[GEST]	Gesture	Gesture used to communicate (e.g., shrugging, miming)
[SL]	Sign Language	Indicates signs were used in the utterance
[ES]	Errored Sign	Substitutions, erroneous signs, and parameter errors
[HS:Sim]	Simple Handshape	C, A, S, 1, 5, and variations
[HS:Exp]	Expanded Handshape	B, F, O, L, G, and variations
[HS:Adv]	Advanced Handshape	W, D, P, H, V, Y, 3, and variations
[HS:Cmp]	Complex Handshape	X, R, M, N, T, 8, and variations
[NMM]	Non-Manual Marker	Facial grammar (e.g., head nod, facial morphemes)
[CL]	Classifier	Use of any classifier subtype
[Mltsgn]	Multiple Signs	Two or more signs in an utterance, excluding pointing
[SSU]	Sign Structure Utterance	Utterance utilizes ASL syntax

The mean number of VCSL-specific codes (VCSL-C) across all communication samples was 59.79. Values ranged from a minimum of 2 to a maximum of 151. Figure 2 compares VCSL-T and VCSL-C for all participants.

Figure 2

Correlation between VCSL-T and VCSL-C in communication samples



Analysis of how VCSL-T and VCSL-C compared to age was done to assess applicability across ages. Table 10 shows the correlation values for age, VCSL-T, and VCSL-C.

Table 10

Correlations between VCSL-T and VCSL-C during communication sample

		Age	**VCSL-T**
VCSL-T	Pearson's r	-0.524	—
	p-value	0.080	—
VCSL-C	Pearson's r	-0.595 *	0.816 **
	p-value	0.041	0.001

Note. * p < .05, ** p < .01, *** p < .001

The analysis shows there is a strong positive correlation between VCSL-T and VCSL-C. VCSL-T represents performance on the full VCSL assessment which, as noted, requires higher training and expertise for clinicians to administer. However, VCSL-C can be incorporated into an assessment method that is already endorsed and used. This project is focused on methods most accessible to the general SLP population in clinical settings, and therefore VCSL-C will be the primary reference for visual language skills.

MLU

The participants had between 6 and 194 utterances included in the SALT analysis set for the standard measures report. Overall MLU-m for all participants ranged from 1.14 to 4.43, with an average MLU-m of 2.37. Table 11 shows the overall MLU-m for each participant along with standard deviation based on findings from Rice et al. (2010).

Table 11

Participant MLU-m compared to same-age peers

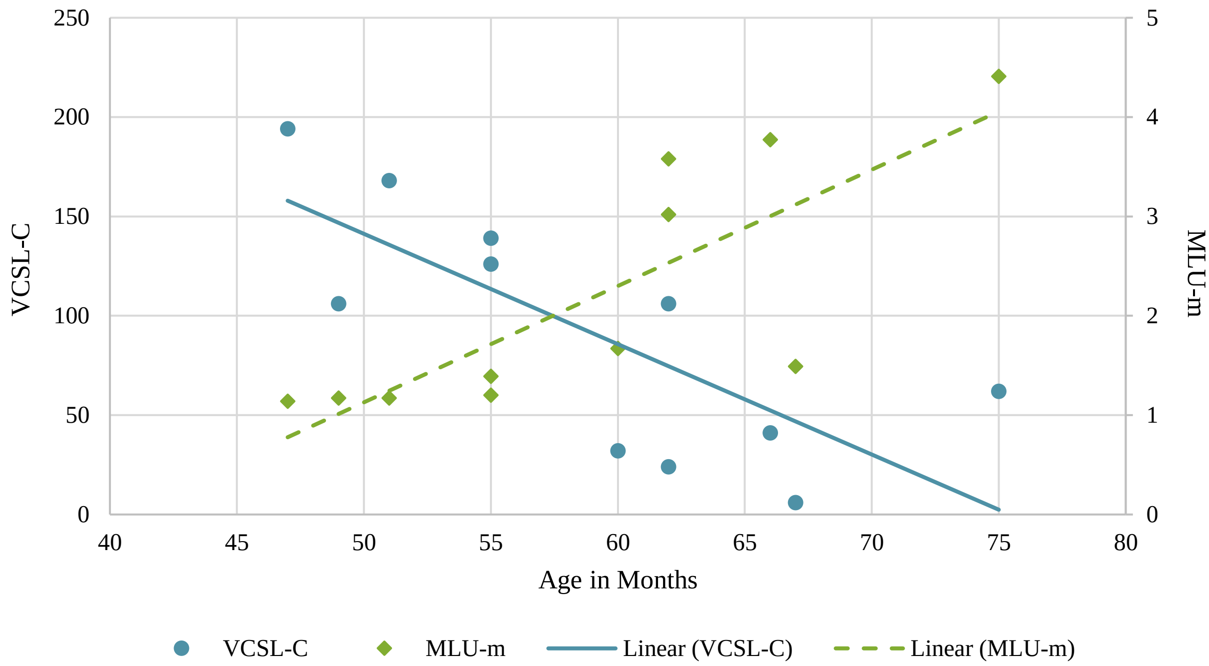
Participant	Home Language	Age	Norm	MLU-m	SD
P1	ASL	3;6-3;11	4.09	4.43	+0.507
P2	English			1.14	-4.403
P3	English	4;0-4;5	4.57	1.17	-4.474
P4	English			1.17	-4.474
P5	Spanish	4;6-4;11	4.75	1.20	-4.494
P6	Spanish			1.39	-4.253
P7	English	5;0-5;5	4.88	1.67	-4.458
P8	English			3.02	-2.583
P9	English			3.58	-1.806
P10	English	5;6-5;11	4.96	3.77	-1.700
P11	English			1.49	-4.957
P12	English	6;0-6;5	5.07	4.41	-0.880

Note. Reference MLU-m normative values based on performance of monolingual English speakers (Rice et al., 2010)

To describe comparative development of spoken and visual language over time, VCSL-C and MLU-m were both compared to age levels. As demonstrated in Figure 3, MLU-m increased with age, while VCSL-C decreased with age.

Figure 3

Trends in participant age, VCSL-C, and MLU-m



Multi-sign utterances ranged from 2 to 5 signs, with 57% (17/30) of utterances being sign-only imitations. Some of the samples included imitations and instances of SimCom. SimCom may present a disadvantage when being included in analysis of sign MLU and development of complex visual language development due to being intended as supplementary rather than standalone utterances. To account for this, multi-sign utterances were collected and organized by age with indications of the length as well as if the utterance was produced in a SimCom context (and therefore not intended as a standalone production) and if it was produced independently (rather than produced following an indirect or direct model). This was done to further visualize the level of complex language mastery observed in ASL productions. Table 12 details the multi-sign utterances and indicates which were produced in a SimCom context or as an imitation of signed utterances produced by the examiner.

Table 12

Multi-sign utterances, by participant

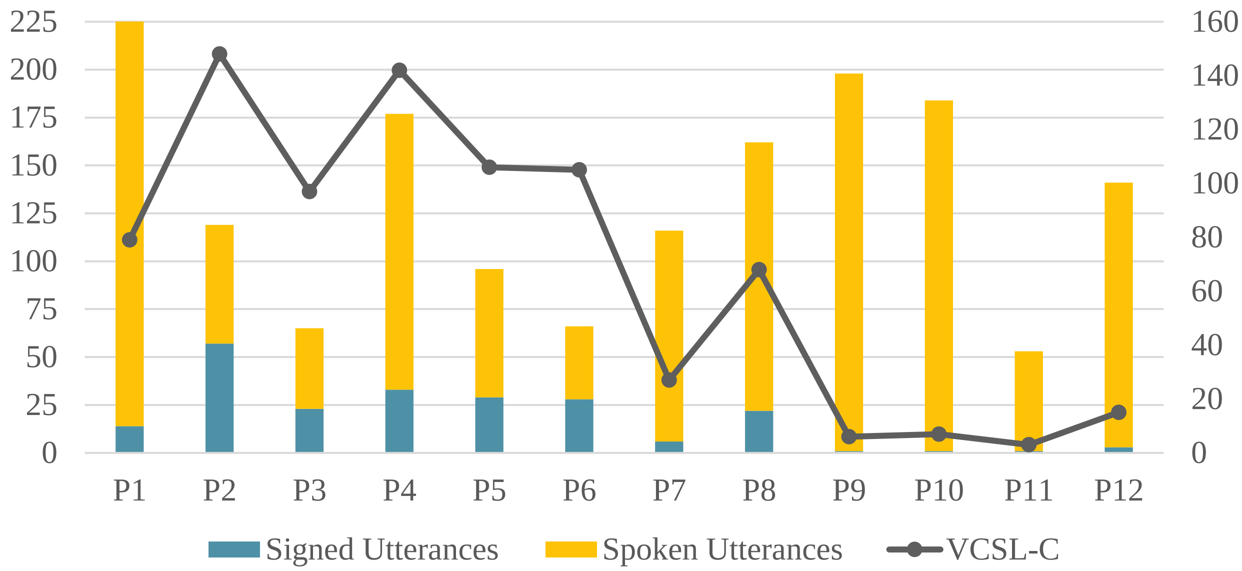
Participant	Utterance	Signs	SimCom	Imitation
P1	MY + IN + HOME	3	+	–
P2	WONDER + THINK	2	–	+
	SHARE + FAVORITE	2	–	+
	EAT + ICE_CREAM	2	–	+
	PIGGY + FLAVOR	2	–	+
	WILL + MOM	2	–	+
	SAD + CRY	2	–	+
P3	ORANGE + APPLE + MILK + DROP + LOLLIPOP	5	–	+
P4	X + ELEPHANT	*n/a*	+	–
	LIKE + CAR	2	+	+
	I + LIKE + DOG	3	+	+
	BIG + SMALL	2	+	+
	HOT + X	*n/a*	–	+
P5	BLUE + EYE + YELLOW + HAIR	4	–	+
	GOOD + BOY	2	–	+
	SIGN + TALK	2	–	+
P6	PIGGY + ICE_CEAM + SAME	3	–	+
	PIGGY + BEST	2	–	+
	WILL + EAT	2	–	+
	TELL_ME + STORY	2	–	+
	FAKE + ICE_CREAM	2	–	–
	LOOK + ICE_CREAM	2	–	+
	MAKE + X	*n/a*	–	+
P7	*Point* + PLEASE + YOU	2 + *point*	–	–
	PLEASE + MORE	2	–	–
	WANT + MORE + PLEASE	3	–	–
P8	X + BOY + GIRL	*n/a*	+	+
	BLUE + TRAIN	2	–	–
	OFF + ROOM	2	+	–
P9	*No multi-sign utterances observed*	*n/a*	*n/a*	*n/a*
P10	HELP + PLEASE	2	–	–
P11	*No multi-sign utterances observed*	*n/a*	*n/a*	*n/a*
P12	*No multi-sign utterances observed*	*n/a*	*n/a*	*n/a*
Total (+)			7/30	21/30
Average length of multi-sign utterances		2.7		

Note. Utterances with unintelligible signs (X) excluded from number of signs calculation.

To assess if trends were present between the number of signed utterances, the number of spoken utterances, and VCSL-C, uses of each were compared. Results showed younger participants to use more signed utterances as well as a higher VCSL-C, as demonstrated in Figure 4.

Figure 4

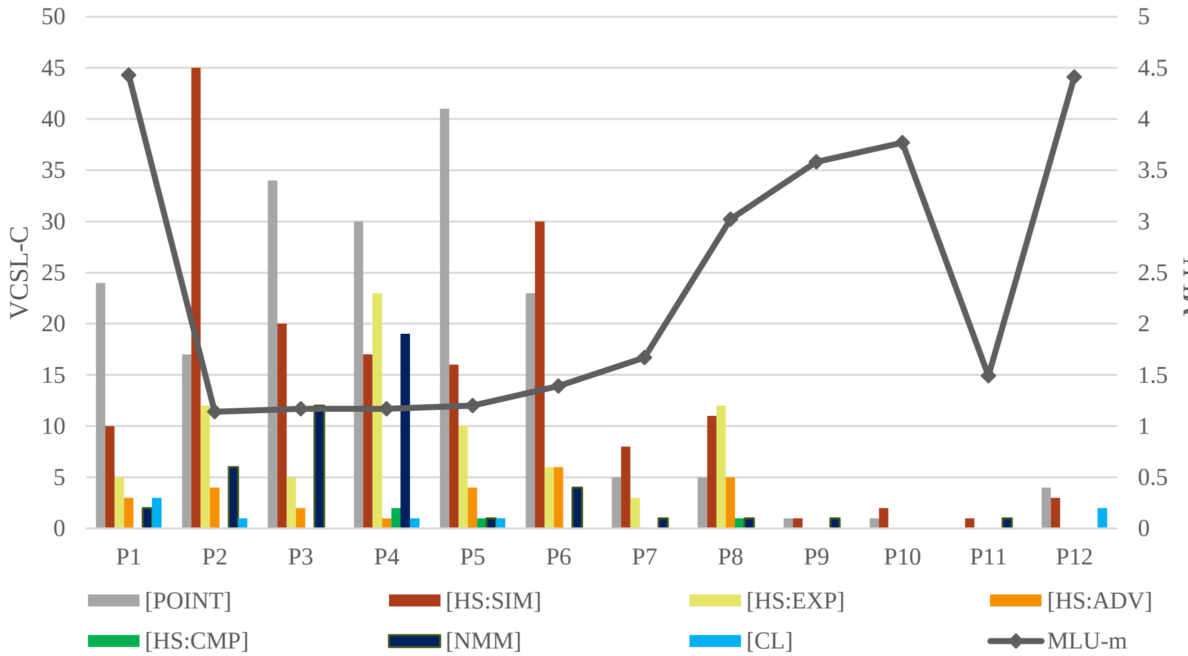
Comparative use of signed utterances, spoken utterances, and VCSL-C



Use of each code was compared within and across participants to further analyze visual language complexity. As demonstrated in Figure 5, the codes used most frequently were those for pointing, use of simple handshapes, use of expanded handshapes, and non-manual markers. These codes were used more by younger participants. Pointing, simple handshapes, and expanded handshapes are considered lower complexity skills. It should also be noted that the non-manual markers primarily used were head nods and head shakes, which are lower complexity skills compared to other non-manual markers (e.g., body shift, eyebrow movement, mouth posture). These results indicate a primary use of lower complexity skills by participants, with reduced overall use in older participants.

Figure 5

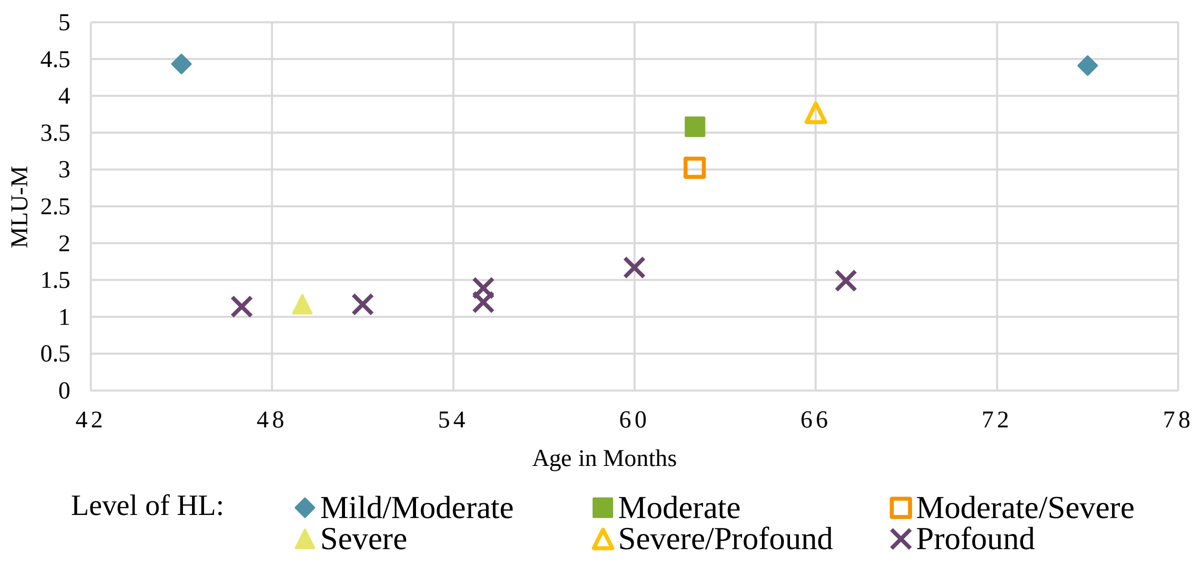
Trends in MLU-m and use of individual codes within VCSL-C



To account for the potential impact of HL on the performance of this group, it was necessary to incorporate HL and its relationship to MLU-m. Figure 6 demonstrates the trends in MLU-m across ages, with indications for level of HL for each participant.

Figure 6

Trends in participant age, MLU-m, and level of hearing loss



To further examine the influence of HL on language development, correlation values were calculated to analyze its relationship to MLU-m and visual language skills. As indicated in Table 14, a strong correlation was observed between HL and MLU-m in which participants with milder HL demonstrated a greater MLU-m. Correlations between HL and VCSL-C or between MLU-m and VCSL-C were not observed to be significant.

Table 13

Trends VCSL-C, HL, and MLU-m

		VCSL-C	HL
HL	Pearson's r	-0.177	—
	p-value	0.582	—
MLU-m	Pearson's r	-0.057	-0.837 ***
	p-value	0.859	< .001

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Trends Across Home Languages

Home language can influence performance in terms of which languages are demonstrated in a sample and how complex the development is of the individual languages. Home language was therefore considered in analysis as an indication of the language to which each participant has the greatest exposure. For most participants with either English or Spanish as a home language, MLU-m steadily increased with age. Only one participant, P1, had a home language of ASL. P1 demonstrated rates of VCSL-C and use of signed utterances that did not differ greatly from that of the older participants with a spoken home language. An appreciable difference was observed in this participant’s MLU-m, which above that of other participants and did not follow the positive correlation trend in age and MLU-m seen in the other participants.

Full results and comparisons of participant home language, MLU-m, number of signed utterances, and VCSL-C are demonstrated in Table 13.

Table 14

Comparative MLU-m, use of signed utterances, and VCSL-C

Participant	Home Language	Age	MLU-m	Signed Utterances	VCSL-C
P1	ASL	3;9	4.43	14	109
P2	English	3;11	1.14	57	194
P3	English	4;1	1.17	23	106
P4	English	4;3	1.17	33	168
P5	Spanish	4;7	1.2	29	126
P6	Spanish	4;7	1.39	28	139
P7	English	5;0	1.67	6	32
P8	English	5;2	3.58	22	106
P9	English	5;2	3.02	1	24
P10	English	5;6	3.77	1	41
P11	English	5;7	1.49	1	6
P12	English	6;3	4.41	3	62

Note. VCSL-C: Total number of VCSL-derived codes included in LSA through SALT.

Discussion

VCSL Applicability

SALT and the VCSL both have means of providing insights into the language abilities of DHH children who use TC, with each providing different sets of information. SALT is structured to evaluate spoken language abilities and provides more detailed information on morphosyntactic development, such as utterance length and English morpheme use. SALT is widely considered an appropriate tool for assessing language; however, guidance on how to most effectively implement its use for analysis of visual language has not been established.

In contrast, the VCSL provides more information on the development of visual language phonology, content, and use. As demonstrated previously in Table 4, the VCSL assesses a wide range of skills across language form, content, and use. Some of the skills, such as turn-taking and sequenced storytelling, can be reflected in either ASL or English. However, it also includes skills that are unique to ASL, such as non-manual markers and handshape complexity. Implementing use of codes into SALT that reflect developmental skills from the VCSL can provide SLPs with greater insight into the language development of children who use TC, including the possibility of a language difference, and better inform clinicians in the process of diagnosing a language delay or disorder. Adaptation of all tasks from the assessment may not necessarily be feasible, as some items don't necessarily have a distinct event to code (e.g., looking at environment, tracking movement, alertness), and protocols may need to be created for consistent probing methods for specific tasks such as counting, labeling colors, and understanding time concepts, etc.

All participants in this study demonstrated visual language skills assessed in the VCSL. However, demonstrated mastery of ASL skills tended to decrease as age increased, as did the number of complex visual language skills mastered. This suggests that visual language abilities decrease over time in this population. Although older participants demonstrated fewer mastered visual language skills, they also demonstrated fewer ASL errors and omissions in obligatory context. This is, in part, due to the comparatively low use of SL by older participants. This phenomenon may also be due to spoken language being a more comfortable or reliable method for meeting the needs of the obligatory contexts. Further, this trend may indicate, in part, that the participants may be avoiding use of emerging skills or using them infrequently enough that certain skills are lost over time rather than mastered. Considering the participants typically receive instruction either in ASL from a Deaf adult or though SimCom from a hearing adult, the possibility remains that they are demonstrating pragmatic language skills through adjusting language use to match the communication partner's use (which most closely aligns with that of the hearing instructor). A sample collected by a Deaf adult using exclusively ASL may result in different comparative levels

Use of the selected codes for this study provided an operational means of measuring trends in mastery of visual language skills, suggesting use of these representative codes to be a viable option for SLPs to use to perform holistic assessment of children who use visual and spoken modalities.

Multimodal and Multilingual Language Development

When examining visual morphosyntax, all participants demonstrated sign MLU below that of same-age peers who have ASL as a primary language. As noted by Rice et al. (2010), lower MLU is indicative of lower language abilities. Signed utterances produced during SimCom production are often a supplement rather than an independent message; however, few signed utterances were produced in a SimCom context. Most signed utterances were produced as standalone utterances characterized primarily by brief and incomplete phrases, indicating limited mastery of forming multi-sign utterances in a signed modality such as ASL. These results therefore suggest this population may demonstrate either low reliance on SL or inadequate visual language development compared to monolingual signing peers. However, further investigation into the potential impact of the complementarity principle, which states that language use and acquisition among bilingual individuals differs across different domains of life, would need to be explored before determining the driving factor(s) (Grosjean, 2015). Nine participants produced multi-sign utterances. It is important to note that many of the observed multi-sign productions by participants were imitations of evaluator productions rather than spontaneous productions, which does not require as high of a level of sentence formation mastery. The imitations were almost exclusively instances where the child followed along as the examiner signed the story. Younger participants were observed to produce more multi-sign utterances that were often story imitations. Older participants produced few or no multi-sign utterances, however they were characterized by being spontaneous more often. Most of the spontaneous multi-sign utterances by older participants were simple requests such as “HELP + PLEASE” or “PLEASE + MORE.” Younger participants also tended to use expanded, advanced, and complex handshapes more frequently than older participants, across all single- and multi-sign utterances within the communication samples. This may be due to language use transitioning from SL to LSL over time or insufficient support for acquiring and maintaining signed skills. Most of the participants had a spoken language as a home language, which suggests low comparative use of, and exposure to, ASL outside of the classroom setting. The potential impact of the complementarity principle should be implemented into further examinations of these phenomena to determine if these patterns differ in different communication contexts and environments (Grosjean, 2015). Although children in TC classrooms may have varied goals in terms of communication and language acquisition, the design of this program included intervals of instruction provided in ASL only, which suggests that one of the aims of the program includes visual language competency that is adequate for academic use. However, the trends observed overall in this study indicate low visual language complexity in bilingual ASL/English children with English as a primary language and use when compared to those who have ASL as a primary language. This indicates that, although ASL is embedded into the TC classroom curriculum, ASL exposure within the program is not sufficient for adequate visual language development.

Overall MLU-m was more than 1 SD below the mean suggested by Rice and colleagues (2010) for most participants. Participants with more mild levels of HL were also observed to have a higher MLU-m. Two participants, whose home language is Spanish, demonstrated MLU amounts that are consistent with the trends observed in the other participants within this study who had a home language of English. This observation is consistent with the paralleled trends in morphosyntactic development by both monolingual and simultaneous multilingual children as described by Nicoladis and Genesee (1997). However, one notable difference observed in the participants with a home language of Spanish is that they did not produce utterances in their home language and used signed communication almost exclusively (only two spoken utterances were observed across these participants, consisting of “whoa” and “mm”). This could potentially be related to relatively reduced consistent exposure to the spoken languages (i.e., reduced exposure to each spoken language individually due to availability in their typical settings) and the relatively higher accessibility of the signed modality compared to spoken (due to both a profound HL and technology fitting after the age of 1 year). Use may have also been influenced by the communication context, as the samples were collected in the school setting, where Spanish is not used, and the examiners did not use Spanish.

Impact of Language Access and Exposure

One further trend observed was that of participants with a greater degree of HL demonstrating a lower MLU-m compared to participants with a lesser degree of HL. The oldest participant, P12, demonstrated an MLU-m that was below the mean, but within 1 SD. P12 was diagnosed with a bilateral mild and moderate HL, fitted with HAs at age 1;6, and was indicated as having English as the home language. These characteristics do not notably deviate from those of other participants and suggest that the relatively strong performance was not because of fitting age nor home language, but rather age and level of HL. Trends across participants in comparative performance suggest progressive approximation towards the mean as age increases. However, two noteworthy outliers were seen in this trend. The highest MLU among all participants was observed in the youngest participant, P1, who also was the only participant to demonstrate an MLU-m above the mean value. P1 was diagnosed with a bilateral mild and moderate HL and fitted with HAs at age 2;0. This indicates that P1 has a relatively reduced length of spoken language exposure (1;9) and suggests fitting age does not contribute to the relatively strong performance of this participant. Further, performance still surpasses that demonstrated by the participant with the same level of HL. However, P1 was the only participant with ASL reported as a home language. These results are consistent with findings by Hrastinksi and Wilbur (2016) and suggest that learning ASL does not hinder spoken language development and warrants further investigation into the impact of ASL exposure on language development in DHH children who use TC. The other outlier in MLU was P11, whose MLU-m was comparatively furthest behind that of same-age peers. Demographic data for this participant does not suggest contributing factors, as P11 was diagnosed with a profound bilateral loss at birth and underwent CI implantation at age 0;6, which does not notably deviate from the other participants included in the study.

Limitations

This study has potential limitations. One limitation is the evaluators, who were students studying speech-language pathology. The evaluators had limited ASL proficiency overall, with variations in skill and signing methods noted. This may have influenced the comparative use of spoken language to SL and may have contributed to shorter signed utterances. However, the skills demonstrated by the evaluators is representative of typical ASL mastery observed across practicing SLPs. Second, the sample size and representation of different demographic groups was also limited, and the scope of the project was limited to primarily considering the demographic characteristics of age, home language, and level of HL. Third, the recordings were not obtained with the VCSL in mind, and therefore not all tasks from the VCSL were probed. Participants may have demonstrated more VCSL tasks if direct targeting were used, as well as recruiting examiners with more extensive ASL skills. A fourth limitation concerns the way the sample recordings were retrieved. Positioning was not ideal for sign interaction, and primarily consisted of the evaluator and child sitting beside each other and facing the same direction, with both facing a book or toy and the camera in front of, and visible to, the participant. Lastly, playdough was used as a language facilitation activity, which is not typically an efficient way to facilitate language output.

It is important to note that other factors may also contribute to language development in this population that were not included in this study, including parent or caregiver mastery and use of languages and modalities, maintenance and calibration of hearing technology, and consistency of hearing technology use.

Conclusions and Recommendations

DHH children who use TC may not have adequate exposure to both languages, as indicated by relatively low skill complexity across both languages in the majority of participants. Results from this study suggested progressive reduction in visual language skills over time. Increased exposure to ASL and increased access to auditory language were associated with higher mastery of English development. Further, increased exposure to ASL enhanced mastery of complex visual language skills without impeding development of spoken language.

The VCSL provides valuable information on visual language development that can help provide a comprehensive and multidimensional clinical assessment of preschool-age DHH children who use TC. Supplementing LSA with visual language analysis through VCSL-C is a viable way for SLPs to provide holistic language assessment of this population. It does not provide a complete evaluation of visual language abilities as would be obtained through administration of the VCSL in full. However, it may be used by SLPs with experience in visual language development as a quantitative element of comprehensive multimodal assessment, as well as by SLPs with limited experience in visual language development as a screening tool for referral to a VCSL-trained clinician.

Future studies examining visual language skills in this population should consist of examinations by individuals who are fluent in ASL, to reduce the potential for participants to reduce or omit more complex visual language skills to reflect the conversational abilities of the examiner. Samples should also be incorporated that provide a full view of the participants and target a more naturalistic position for signed interaction. Further, future studies should include greater representation of groups with different home languages, types of hearing technology, and fitting ages.

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