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Clinical Focus

Language Sample Collection and Analysis in People Who Use Augmentative and Alternative Communication: Overcoming Obstacles

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Purpose: Language sample collection and analysis provides important information regarding the language abilities of individuals for whom standardized testing may not be appropriate, such as persons who use augmentative and alternative communication (PWUAACs). Despite its clinical utility, language sample collection and analysis has not been fully incorporated into the assessment of PWUAACs due to a variety of challenges. This study seeks to investigate the ability of language sample collection and analysis to provide clinically relevant information and explore ways to circumvent language sample collection and analysis challenges for PWUAACs.
Method: This is a case study of the narratives of two PWUAACs, one child and one adult. Analyses were conducted using manual calculations and computerized language sample analysis software (i.e., Systematic Analysis of Language Transcripts and Child Language Exchange System) and Realize Language.
Conclusions: Although the language samples took longer to complete relative to verbal controls, the information obtained from language sample collection and analysis provided valuable insight into the language system of the two participants that would not be revealed through standardized language assessment, including the distribution of their parts of speech and syntactic complexity. Given the important clinical data that may be obtained through language sample collection and analysis, we propose strategies to enable clinicians to overcome previously identified challenges.

According to the 2004 Individuals with Disabilities Education Act, clinicians must use appropriate assessment(s) to yield accurate information regarding each child's academic, developmental, and functional skills. Since standardized assessments may not be appropriate for persons who use augmentative and alternative communication (PWUAACs), clinicians may need to rely on criterion-referenced language assessments. Augmentative and alternative communication (AAC) refers to diverse methods of communication used in place of or as a supplement to verbal speech, depending on an individual's needs. AAC encompasses no-tech (e.g., gestures), low-tech (e.g., picture communication boards), and high-tech (e.g., speech-generating devices) modes of communication. Language sampling may be conducted with individuals who use low-tech and high-tech modes of communication. This research focuses on individuals who use high-tech speech-generating devices. Like all individuals who receive speech and language intervention, assessments including periodic evaluation are an integral part of speech and language intervention for PWUAACs.

Evaluating the Language of PWUAACs

Periodic evaluation is a necessary component of evidence-based practice, because it enables clinicians to determine appropriate goals for intervention and measure language acquisition and growth. Standardized tests are typically used to assess the language of verbal individuals due to their ability to provide normative sample information, statistical data, and standardized scores (Shipley & McAfee, 2016). The clinical utility of these assessments for PWUAACs remains unclear, since PWUAACs are typically excluded from the normative data. Moreover, these assessments often include strict behavioral requirements (Ebert & Scott, 2014)

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that decrease their ability to be administered to individuals with complex communication needs, including PWUAACs. Language sampling, which is often incorporated into the assessment of verbal individuals, is a promising nonstandardized assessment tool for PWUAACs (e.g., Hill, 2004, 2009; Hill & Romich, 2007; Kovacs & Hill, 2015, 2017; Savaldi-Harussi & Soto, 2016; Van Tatenhove, 2014). This is because language sampling provides important information regarding an individual's language abilities and communicative competence while circumventing the challenges of standardized assessments.

Language Sample Collection and Analysis in Verbal Individuals

Language sample collection and analysis is an evidence-based assessment technique frequently used to portray an individual's naturalistic language use (e.g., Costanza-Smith, 2010; Hewitt et al., 2005), as well as how an individual's language changes over time (e.g., Heilmann & Westerveld, 2013; Miller et al., 2016; Rojas & Iglesias, 2010). An additional benefit of language sample collection and analysis is that it compensates for the limitations of standardized assessments (e.g., Westerveld & Claessen, 2014). Language sampling assessment techniques have been recommended to reduce bias in children who do not speak mainstream dialects (Craig & Washington, 2000), those who are English language learners (Roseberry-McKibbin & O'Hanlon, 2005), and those who are learning to speak multiple languages simultaneously (Restrepo, 1998; Simon-Cereijido & Gutiérrez-Clellen, 2007). The lack of behavioral requirements necessary to participate in language sampling makes it an attractive assessment method for populations that may not be able to conform to the strict behavioral requirements of standardized assessments, such as PWUAACs (Costanza-Smith, 2010). Like other aspects of language development and assessment, research in the area of language sampling collection for verbal children may serve as a framework for language sampling in PWUAACs.

Language Sample Elicitation

There are four widely used language sample elicitation strategies: free-play, conversation, narration, and expository discourse. Free-play is a strategy in which language is elicited through play-based activities between the child and either the examiner or the child's caregiver (Crystal et al., 1976). Conversational elicitation strategies consist of an exchange on a subject unrelated to the current situation, yet somewhat familiar to the client or participant, which may include verbal prompts or questions about familiar topics (Pavelko et al., 2016). Narrative elicitation strategies yield language in the form of stories. Stories for narrative language samples may be original (Roth & Spekman, 1989), based on movies, fairytales, folktales, or events between people and/or animals (Scott, 1988) conveyed in two or more consecutive utterances (Labov, 1972). Language samples in the form of expository discourse are dialogues composed of factual or technical information through cause–effect explanations, procedural directions, and/or descriptions (Hadley, 1998). Differences in language use and complexity have been reported in research studies across different elicitation styles (e.g., Atkins & Cartwright, 1982; Leadholm & Miller, 1992; Longhurst & Grubb, 1974; Nippold et al., 2005). However, narrative language sample elicitation strategies appear to be most effective for eliciting longer samples and more complex language across ages (e.g., Evans & Craig, 1992; Nippold et al., 2014; Southwood & Russell, 2004; Stalnaker & Creaghead, 1982; Wagner et al., 2000; Wren, 1985; for an exception, refer to Atkins & Cartwright, 1982).

Macrostructural and Microstructural Analysis

After the language sample is collected, clinicians and researchers must conduct a language sample analysis. The first step in the analysis is to segment the utterances in the sample. The most widely used utterance segmentation strategies are based on communication units (C-units). C-units are defined as an independent clause and all of its dependent clauses (Loban, 1976). Following utterance segmentation, two broad categories of analyses may be conducted: macrostructural and microstructural measures. Macrostructural measures encompass global measures to evaluate skills across utterances and include, but are not limited to, productivity, lexical cohesion, and text structure. Microstructural measures examine smaller units of language, including, but are not limited to, lexical diversity and density, word length, word frequency, and finer grained lexical analyses. Both macro- and microstructural measures are useful for identifying individuals with language disorders (Manolitsi & Botting, 2011; Norbury & Bishop, 2003). The extensive data that can be obtained through language sample analysis under macro- and microstructural parameters enhance the clinical utility of language sampling as a component of a comprehensive language assessment (Ebert & Pham, 2017).

Research has supported microstructural measures in language sample analysis specifically using narrative elicitation strategies including mean length of utterance (MLU) and lexical diversity to assess syntax and semantics (e.g., Heilmann et al., 2010; Leadholm & Miller, 1992; Miller & Klee, 1995). Additional microstructural measures include syntactic complexity measured by number of different words, overall productivity measured through total number of words, and grammatical rates measured based on the number of omissions or erroneous words (Ebert & Scott, 2014). Computer software has been developed to improve the efficiency and accuracy of these calculations (e.g., MacWhinney, 1996, 2000; Miller & Iglesias, 2012). Two widely used computer software programs in language sample analysis are the Child Language Exchange System (CLAN; MacWhinney, 2000) and Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 2004). Some computer programs, including SALT and CLAN, contain databases of control data, allowing for clinicians and researchers to compare their client to peers with typical development.

Challenges of Language Sample Collection and Analysis in PWUAACs

Although language sampling provides important information regarding an individual's language abilities and communicative competence, the research on language sample collection and analysis in PWUAACs is in its infancy. Researchers have identified a variety of barriers to language sample collection and analysis in PWUAACs, including determining appropriate elicitation strategies, the length of time it takes to complete the sample, and a lack of standardized procedures for analyzing the language samples of PWUAACs.

Vocabulary Access

To begin, the elicitation strategies incorporated into the language sample collection of people who rely on spoken language to communicate may not be appropriate for PWUAACs because, unlike verbal individuals, the language of PWUAACs may be limited by the vocabulary available on their communication devices (Van Tatenhove, 2014). For example, if conducting language sample collection using the *Frog, Where Are You?* (Mayer, 1969) wordless picture book, it would be critical that the PWUAACs had words including "frog," "boy," and "dog" within their prestored vocabulary. Without access to these words, the PWUAACs may be limited in their ability to convey their narrative, or their language sample may be confounded by taxing their literacy abilities if the individual seeks to utilize a spelling feature on their device.

Length of Time

With regard to length of time, language sample collection typically takes less than 5 min for verbal children and, as such, has been identified as an efficient assessment method (Heilmann et al., 2010). Conversely, the efficiency of language sample collection has been identified as a barrier to incorporating language sample collection and analysis into the assessment battery clinicians use with PWUAACs due to the duration of language sample collection with this population. The average rate of verbal adults ranges from 115 to 165 words/min (Andrews & Ingham, 1971), whereas competent users of AAC are reported to communicate at eight to 10 words/min (Newell et al., 2003). To overcome this barrier, researchers have suggested the use of automated data logging (Van Tatenhove, 2014). Automated data logging features, when activated, track device use over extended periods of time for review by designated stakeholders. These features may provide insight into communicative functions, including vocabulary use, communication rate, parts of speech, and beyond. Automated data logging features present with the ability to provide clinicians and researchers with important information regarding an individual's language. However, there are several limitations that influence its ability to be a reliable, valid, objective measure. For example, automated data logging features cannot control for factors that may influence language production and use (Van Tatenhove, 2014), including context, instances of modeling and/or teaching, multimodal forms of communication, and lack of data from the communication partners' language use (Cross & Segalman, 2016).

Analysis Procedures

Another challenge that has been identified is a lack of standard analysis procedures (Van Tatenhove, 2014). Once the language sample is collected and transcribed, utterance boundaries are determined to prepare the sample for further analyses and provide meaningful data. As previously noted, C-units are the most frequently used segmentation method for language sample analysis (e.g., Lundine, Harnish, McCauley, Zezinka, et al., 2018; Roberts & Post, 2018; Tilstra & McMaster, 2007). In spoken language samples, temporal boundaries (e.g., timing, prosody) guide C-unit segmentation. Incorporating C-units as the utterance segmentation method in the language sample analysis of PWUAACs is challenging, because the language produced on a speech-generating device often lacks temporal boundaries (Kovacs & Hill, 2015) and clear utterance terminators (e.g., Kovacs & Hill, 2015; Van Tatenhove, 2014).

Following utterance segmentation, the language sample is evaluated across numerous parameters. Similar to the challenges noted in C-unit segmentation, measures traditionally used in spoken language sample analysis are often not incorporated in the language sample analysis of PWUAACs. For example, morphological skills are often not considered in the language sample analysis of PWUAACs despite their significant role in language development (Kovacs & Hill, 2017). Though clinicians and researchers recognize the importance of analyzing the morphological skills of PWUAACs, variable vocabulary configurations complicate calculating several aspects of morphology. This point may be illustrated using MLU in morphemes. Vocabulary configurations on a speech-generating device may or may not have the option to insert bound morphemes, making it challenging to determine how to consider one's use of, or lack of, bound morphemes. In some studies, verbal individuals' productions of irregular past tense verbs are counted twice (e.g., Lund & Duchan, 1993). However, other researchers have suggested it may be appropriate to consider these irregular forms as two morphemes in the language sample analysis of PWUAACs because accessing irregular past tense verbs on many AAC vocabularies requires additional encoding (Van Tatenhove, 2014). Another complicating factor is the fact that many vocabularies incorporate prestored phrases to improve communication rate; yet, there is currently no standardized approach regarding how to analyze these prestored phrases. Because of variables such as these, there is currently a lack of consensus on how to analyze MLU in morphemes within the language sample analysis of PWUAACs literature, complicating clinicians' and researchers' abilities to generalize data across studies (e.g., Ortloff et al., 2012; Van Tatenhove, 2014).

Access Method and Word Predictive Features

An additional factor that complicates clinicians' and researchers' ability to conduct language sample collection and analysis in PWUAACs is the lack of data regarding how to account for differences across access methods and how to consider the use of word predictive features. There are many PWUAACs who access their device using methods other than direct selection, such as single or dual switch scanning. However, to date, there are no research studies investigating how to appropriately collect and analyze a language sample with this population. Moreover, many device vocabularies incorporate word predictive features aiming to enhance communication rate. Despite their prevalence in AAC vocabularies, there is currently no literature discussing how selections made through the use of word predictive features should be considered in language sample analysis.

Summary and Current Study

The research has established language sample collection and analysis is a fundamental component of language assessment as it depicts language in a naturalistic context, circumvents challenges of standardized assessment, and can be conducted frequently to evaluate changes across time and context. Due to its lack of strict behavioral requirements, which are often found in standardized assessment protocols, language sample collection and analysis presents as an appealing technique to incorporate into the assessment of PWUAACs. Although there are a variety of factors that complicate the language sample collection and analysis of PWUAACs, language sample collection and analysis remains a pivotal component of comprehensive speech and language evaluations within this population (e.g., Hill, 2009; Hill & Romich, 2007) due to its ability to provide relevant information regarding an individual's communicative competence and language system. Despite its promise for this population, there is a dearth of research outlining appropriate language sample collection and analysis methodology, limiting clinicians' and researchers' ability to incorporate it within their practice. Applying the language sample collection and analysis procedures used with verbal individuals may act as a framework for language sample collection and analysis in PWUAACs and may help overcome some of the challenges clinicians and researchers may face. Therefore, the purpose of this research was to answer the following questions: (a) Does language sample analysis provide clinically relevant data that may be used to determine appropriate treatment goals for people who use high-technology AAC in the form of speech-generating devices? (b) Do any of the challenges of language sample collection and analysis of PWUAACs documented within the literature influence language sample collection and analysis of people who use high-technology AAC in the form of speech-generating devices, and what potential methods may overcome these obstacles?

Case Study Methods and Results

General Methods

This study received approval from the institutional review board at The Ohio State University. Language samples were collected from two PWUAACs, a child and an adult, with direct selection as their primary access method. Due to the robust evidence indicating narrative language sample elicitation strategies effectively elicit complex syntax (e.g., Channell et al., 2017; Nippold et al., 2014, 2017; Pavelko et al., 2016), showcase academically based language (Miller et al., 2016), and are integral within day-to-day social communication interactions (Spencer & Slocum, 2010), narrative elicitation methods with wordless picture books were used for the language sample collection of both participants. To stimulate samples of increased length and complexity (Atkins & Cartwright, 1982; Longhurst & Grubb, 1974), language sample elicitation protocols did not follow a rigid structure.

After collecting the language sample, analyses were conducted using microstructural measures, as the research has indicated that microstructural measures better distinguish individuals who present with language impairment and/or disorders in comparison to language-typical peers (Liles et al., 1995). The automated data logging, in the form of a language activity monitor (LAM) file, was used in transcription of each participant's language sample. Language sample collection was not audio- and/or video-recorded, and transcription of language samples was exclusively from information within the automated data log. Analysis methods used were identified through a review of the language sampling literature for people who rely on spoken language to communicate or PWUAACs. Realize Language (Cross & Segalman, 2016), a web-based tool that conducts automated analyses on select automated data logs with an annual subscription fee, was used due to its compatibility with the LAM files. These data were exported from each participant's device and underwent subsequent analyses using the conventions described in turn (i.e., measures manually computed using outlined procedure, which underwent intrarater reliability analysis) or using computerized language sampling software (i.e., results generated by computer software). Analysis measures applied to both cases include total number of utterances using utterance terminators, number of activations, average activations per word, words spelled, bits, selection rate, rate index, mean syntactic length, predicted MLU in morphemes, use of word prediction features (e.g., Kovacs & Hill, 2015, 2017; Van Tatenhove, 2014), word frequency (from Realize Language), parts of speech used (from Realize Language), number of core words within the top 10 words (supplementary measure), and percentage of core words used (supplementary measure).

Control data of verbal individuals' performance were used when databases were available to discuss each participant's results relative to norms established for their verbal peers. Refer to Table 1 for information regarding automated measures used for each participant.

Table 2 depicts the manual measures included within this research and a description of how the calculation was made. These manual measures were incorporated within this study due to their identification in the literature as clinically relevant measures for PWUAACs or supplementary measures, such as core words within the top 10 words and distribution of core words, to further investigate measures

Table 1. Automated measures used.

Software	Measure	Rationale
Realize Language	Top 10 Words	To gain information about expressive vocabulary
	Parts of Speech Distribution	To gain information regarding ability to form complex sentences incorporating a variety of parts of speech into her language
SALT	Standard Measures Report	To gain information across language domains surrounding transcript length, syntax/morphology, semantics, intelligibility, and rate relative to verbal peers
	Subordination Index Report	To gain information regarding the syntactic complexity of the language through assessing clausal density relative to verbal peers
	Word Lists, Bound Morphemes, & Utterance Distribution Report	To gain information regarding the use of designated word lists (i.e., question words, negatives, conjunctions, modal auxiliary verbs, personal pronouns), selected bound morphemes (i.e., /3S, /ED, /ING, /S, /Z), and distribution of utterance length relative to verbal language-matched peers
CLAN	EVAL	To gain information regarding rate, transcript length, expressive vocabulary, syntax, morphology, complexity, and parts of speech distribution relative to verbal peers

Note. SALT = Systematic Analysis of Language Transcripts; CLAN = Child Language Exchange System.

potentially valuable to consider in the language sample collection and analysis of PWUAACs. Core words are words that constitute one's core vocabulary, a small subset of words that play a dominant role in language use. The top 100 core words have been estimated to account for half of our language use (e.g., Berga, 2014). These supplementary measures are important to consider to investigate how these estimates of core word use, based on verbal individuals, relate to the language use of PWUAACs.

Interrater reliability was conducted on the manual measures for each participant between the first author and an undergraduate research coder trained on language sample analysis using Krippendorff's alpha. Initially, each coder independently coded each measure. Interrater reliability values of the language samples for Participants 1 and 2 were .97 and .99, respectively. When there were discrepancies between the coder's results, each coder independently reviewed their analysis for that calculation and made changes accordingly. If discrepancies remained, the coders met in person to discuss their rationale until consensus was achieved on each language sample analysis measure. A comprehensive description of each participant and the unique protocols and analysis measures used are provided in turn.

Participant 1 Methods

Participant 1 profile. Participant 1 is a nonverbal 10-year-old girl with a diagnosis of autism spectrum disorder and a history of abnormal electroencephalogram results and seizures. She attends a school that serves children with complex needs and a variety of developmental disabilities. Participant 1 currently uses direct selection to access an Accent 800 device by the Prentke-Romich Company with

Table 2. Manual measures.

Measure	Calculation	Rationale
Core words within the top 10 words	Sum of the number of core words within the top 10 words used	To gain information regarding linguistic competence
Distribution (%) of core words	$\frac{\text{No. of core words}}{\text{No. of noncore words}} \times 100$	
Mean syntactic length	Average morphemes/utterance excluding 1-morpheme utterances	
Words spelled	Sum of each word accessed through use of the spelling feature	
No. of utterances (UTs)	Sum of the total number of utterances determined by punctuation	
Predicted MLUm	(0.867 × MSL) – 0.459 morphemes	
No. of activations	Sum of activations on the device	To gain information regarding operational competence
Average activations per word	$\frac{\text{Total no. of activations}}{\text{Total no. of words}}$	
Bits	$\frac{\ln(\text{No. of keys})}{\ln(2)}$	To gain information regarding strategic and operational competence
Selection rate	$\frac{(\text{Selections} \times \text{Bits})}{\text{Seconds}}$	
Rate index	$\frac{\text{Communication rate}}{\text{Selection rate}} \times 60$	
Use of word prediction	Sum of instances "WPR" and "DWP" in the automated data log	

Note. UTs = utterance terminators; MLUm = mean length of utterance in morphemes; MSL = mean syntactic length; WPR = word prediction; DWP = derived word prediction.

the Language Acquisition through Motor Planning (LAMP) Words for Life vocabulary and has been using this device and vocabulary since 6 years of age. Prior to age of 6 years, Participant 1 used the Proloquo2Go vocabulary for an unspecified time. Additional information about her language was not collected for this study.

Participant 1 collection procedure. A modified version of the protocol used by Tager-Flusberg (1995) was incorporated into the language sample elicitation of Participant 1's language sample. This modified protocol was applied to this research as it was designed to collect language samples from verbal children with autism through a story generation task using the book titled *Frog, Where Are You?* (Mayer, 1969). This wordless picture book has been commonly used to elicit narrative language samples across research studies for a variety of populations (e.g., Ebert & Scott, 2014; Heilmann et al., 2016; Reilly et al., 2004) and is included within the SALT software database of control data, allowing for comparisons to be made with verbal controls. It is unknown whether she had previously read or seen the book.

Participant 1's language sample collection occurred at her school in a quiet classroom by the researcher and her school speech-language pathologist (SLP) over a 30-min time frame as part of her speech and therapy session. The language sample collection took 25.82 min, as measured by her automated data log. The wordless picture book was presented page by page to introduce the participant to the story line. After reviewing each page of the book, the story was restarted at the beginning, and Participant 1 was prompted to tell her SLP what happened throughout the story. Prompts were provided as needed to encourage language production (e.g., "What is happening on this page?") or for clarification if she used unintelligible verbal vocalizations (e.g., "I'm not sure what you're telling me, can you tell me with your talker?").

Participant 1 analysis. In addition to the language sample analysis measures used for both participants, Participant 1's language sample was analyzed using measures automatically generated by SALT (Miller & Iglesias, 2012), including the Standard Measures Report; the Word and Morpheme Summary; the Word Lists, Bound Morphemes, & Utterance Distribution Report; and the Subordination Index (Miller et al., 2016), due to their previous use with people who rely on spoken language to communicate and ability to provide control data.

Participant 1 Results

Data derived from Realize Language. Data obtained through Realize Language included top 10 words used and parts of speech distribution. The following were identified as her top 10 words during the language sample: dog, river, fly, voice, bee, frog, big, loud, owl, and tree. Her speech was composed of nouns (67%), adjectives (13%), verbs (9%), interjections (2%), prepositions (2%), adverbs (2%), and other (5%). Within Realize Language, the "other" category within the parts of speech analysis is the total of all instances of words that are considered "unknown prestored" and "unknown spelling." "Other" vocabulary in Participant 1's language sample is referencing when she used one of her teacher's names that was added to her prestored vocabulary during the language sample collection time.

Data derived from SALT. Participant 1's language sample was compared to the youngest age group within the database. These children were between 4.4 and 5 years old (n = 15). This group was selected because it was the youngest group to whom we could compare, and Participant 1 is currently categorized as Brown's Stage I (Brown, 1973). Several SALT measures were excluded (i.e., Mazes and Abandoned Utterances, several measures of Verbal Facility and Rate, and Omissions and Error Codes) from the analysis due to variables between verbal speech versus AAC. The SALT analysis produced a report that provided information on transcript length, syntax/morphology, semantics, intelligibility, and verbal fluency and rate. Refer to Table 3 for a summary of the report measures for Participant 1.

With regard to transcription length, Participant 1's total number of utterances was commensurate with the number of utterances produced by the control group. However, she produced significantly fewer words (n = 53) than the control group (n = 241). In addition, it took her significantly more time to produce her narrative (25.82 min) than the control group (3.60 min).

In the domain of syntax/morphology, Participant 1 produced language with lower clausal density than the control group, suggesting she uses less syntactically complex language. Participant 1's utterances mostly have a subordination index of 0, indicating that no clauses were used. In contrast, the language samples of the control group (n = 15, age range: 4.4–5 years) primarily had a subordination index of 1, indicating that one clause was used. The SALT Word Lists, Bound Morphemes, & Utterance Distribution Report revealed that Participant 1 uses notably shorter utterances than verbal controls, most frequently using 1 morpheme or word/utterance in contrast to 5 words/utterance or 6 morphemes/utterance. Participant 1 did not use any of the assessed bound morphemes within her sample (i.e., /3S, /ED, /ING, /S, /Z). This was outside a standard deviation from the mean for the bound morphemes /ED, /ING, and /S, while remaining within a standard deviation of the mean for /3S and /Z.

In the domain of semantics, Participant 1 produced less words in total and fewer different words. However, she had a significantly higher type–token ratio than the control group, indicating a higher level of lexical richness than the control group. Participant 1's language was consistent with the control group in measures of number of question words (n = 0), negatives (n = 1), and modal auxiliary verbs (n = 0). Her use of conjunctions (n = 0) and personal pronouns (n = 0) was outside a standard deviation of the mean and outside the range of the control group.

Manual measures. Participant 1's top 10 words included one word that was also considered to be a top 100 core word (AAC Language Lab, 2013). Nine percent of Participant 1's sample consisted of core words, and the remaining 91% was composed of other vocabulary, including nouns, adverbs, adjectives, and so forth.

Participant 1's automated data log did not reveal any instances in which she used word prediction or spelling

Table 3. Participant 1's Standard Measures Report measures.

Language measure	Participant 1 Score	± *SD*	Database *M*	Min	Max	*SD*	%*SD*
Current age	10[a]	25.76	4.88	4.33	5.0	.20	4
Transcript length							
Total utterances	39	.04	38.53	28	76	12.33	32
C&I verbal units	39	.61	33.27	23	57	9.39	28
Total completed words	53[a]	–3.14	241	173	401	59.82	25
Elapsed time	25.82[a]	25.80	3.60	2.33	6.02	.86	24
Syntax/morphology							
SI							
SI-0	29[a]	30.73	.87	0	2	.92	106
SI-1	8[a]	–3.03	26.67	18	42	6.16	23
SI-2	0[b]	–1.11	2.13	0	7	1.92	90
SI-3	0	–.26	.07	0	1	.26	387
SI score	.22[a]	–9.79	1.05	.97	1.24	.09	8
MLU in words	1.36[a]	–6.24	5.98	4.84	7.56	.74	12
MLU in morphemes	1.36[a]	–5.71	6.50	5.11	8.44	.90	14
Bound morphemes							
/3S	0	–.48	.20	0	1	.41	207
/ED	0[b]	–1.47	7.13	0	18	4.85	68
/ING	0[b]	–1.26	3.40	0	9	2.69	79
/S	0[a]	–1.69	4.13	1	9	2.45	59
/Z	0	–.63	.40	0	2	.63	158
Semantics							
No. of different words	31[a]	–3.55	77.20	57	106	13.02	17
No. of total words	53[a]	–2.82	197.13	143	306	51.08	26
Type–token ratio	.58[a]	3.03	.40	.30	.50	.06	15
Question words							
Total	0	–.74	.67	0	2	.90	135
Type	0	–.73	.47	0	2	.64	137
Negatives							
Total	1	0.00	1.00	0	4	1.25	125
Type	1	.06	.93	0	3	1.10	118
Conjunctions							
Total	0[a]	–2.05	26.20	5	46	12.79	49
Type	0[a]	–3.00	3.33	2	5	1.11	33
Modal auxiliary verbs							
Total	0	–.83	.53	0	2	.64	120
Type	0	–.83	.53	0	2	.64	120
Personal pronouns							
Total	0[a]	–3.31	21.80	10	33	6.58	30
Type	0[a]	–3.29	4.47	3	8	1.36	30
Verbal facility and rate							
Words/min	2.05[a]	–4.20	68.37	46.34	114.91	15.80	23

Note. C&I verbal units = number of utterances in current analysis set; SI = subordination index; SI-0 = 0 clauses; SI-1 = 1 clause; SI-2 = 2 clauses; SI-3 = 3 clauses; SI score = total number of clauses divided by the total number of utterances; MLU = mean length of utterance.
[a]Outside a standard deviation from the mean and outside the range of the control group. [b]Outside a standard deviation from the mean.

features throughout her language sample. In addition, she did not use utterance terminators. Therefore, researchers were unable to use utterance terminators as an utterance segmentation method within the analysis. Participant 1's automated data log revealed that she activated her device in 210 instances, yielding an average of 5.67 activations per word. Her selection rate was 0.856 bits/s, with a rate index of 0.04 words/bit. Furthermore, Participant 1's mean syntactic length (i.e., average morphemes/utterance excluding 1-morpheme utterances) was 2.36 morphemes/utterance, and her predicted MLU in morphemes (i.e., (0.867 × mean syntactic length) − 0.459 morphemes) was 1.59 morphemes/utterance.

Participant 2 Methods

Participant 2 profile. Participant 2 is a nonverbal 34-year-old man, with a diagnosis of cerebral palsy with cognitive abilities within the typical range. He no longer receives speech-language therapy services and maintains meaningful employment. Participant 2 uses the Unity vocabulary on the 144-location setting, which he has been using since 5 years of age, on an Accent 1400 device by the Prentke-Romich Company. He has used eye gaze as his primary access method for the past 3 years and previously navigated the device through switch scanning. Participant 2 was a long-time single switch scanner and was able to scan at a speed 0.2 s. Despite this speed, due to the number of icons on his speech-generating device, he participated in several trials with eye gaze. Initially, eye gaze access was slower than scanning speed. As eye gaze technology improved and his current speech-generating device aged, Participant 2 engaged in a 3-month trial of eye gaze to ascertain if he could improve his rate of communication using eye gaze instead of scanning. He tracked his improvement through use of the build in LAM and Realize Language data. At the end of the trial, he was able to communicate via eye gaze at least 50% faster than using scanning. Participant 2 primarily communicates using symbols.

Participant 2 procedure. Participant 2's narrative language sample was elicited through the Cinderella Story narrative protocol established by AphasiaBank (MacWhinney et al., 2011). This protocol was used due to its prior use in research and clinical assessment (e.g., Forbes et al., 2012) for adult populations (e.g., Richardson & Dalton, 2016).

Participant 2 was provided with the protocol and the classic version of "Cinderella" with the words covered (Grimes, 2005), both of which were retrieved through AphasiaBank. Participant 2 independently reviewed the prompts and wordless picture book. Following his review of the materials provided, Participant 2 developed his narrative over a 45-min time frame and provided the researcher with the automated data log and notebook file to conduct analyses. Though narrative language samples are routinely elicited within a direct clinician–client interaction, Participant 2 completed the Cinderella task independently at home, referencing the prompts as needed. Allowing Participant 2 to complete the task independently allowed for him to compensate for the increased timing necessary to form grammatically correct sentences via a speech-generating device in comparison to verbal speech due to the disparity in communication rate.

Participant 2 analysis. In addition to the language sample analysis measures used for both participants, Participant 2's language sample was analyzed using the EVAL feature within CLAN software (MacWhinney, 2000) based on its previous use with people who rely on spoken language to communicate and ability to provide control data.

Participant 2 Results

Data derived from Realize Language. Data obtained through Realize Language included top 10 words used and parts of speech distribution. The following were identified as his top 10 words during the language sample: the, to, and, her, a, of, she, that, stepmother, and had. Participant 2's language was composed of verbs (18%), nouns (18%), determiners (15%), prepositions (12%), pronouns (10%), conjunctions (9%), adverbs (5%), adjectives (5%), and questions (2%).

Data derived from CLAN software. Participant 2's language sample was analyzed using CLAN and compared to the control data available from verbal adults (n = 128, age range: 18–64 years). Refer to Table 4 for a summary of the report measures for Participant 1.

With regard to transcription length, Participant 2's total number of utterances and MLU utterances were commensurate with the control group. However, it took him significantly more time to produce his narrative (42 min 53 s) than the control group (3 min 14 s).

In the domain of syntax/morphology, Participant 2 had a significantly longer MLU in words and morphemes than the control group. In addition, he produced more verbs per utterance and more nouns per verb than the control group. Regarding his parts of speech distribution relative to the control group, Participant 2 used more nouns and past participle, while using fewer adjectives and pronouns. Moreover, his sample presented with an increased number of open class (i.e., content words including, but not limited to, nouns, verbs, adjectives, and adverbs), words yielding more open class per closed class (i.e., function words including, but not limited to, determiners, pronouns, and prepositions) within his sample than the control group. There were no significant differences in the other measures of syntax/morphology. In the domain of semantics, the frequency of different types of words used, types of tokens used, and type–token ratio was not significantly different than the control group. In the area of verbal facility and rate, Participant 2 produced language at a significantly slower rate, 14.41 words/min, than the control group who produced 146.34 words/min.

Manual measures. Participant 2's top 10 words included four words that were also considered to be a top 100 core word (AAC Language Lab, 2013). Participant 2's distribution of core versus noncore words in his language sample included 183 core words out of 618 total words used. Thirty percent of Participant 2's sample consisted of core words, and the remaining 70% was composed of other vocabulary.

Participant 2's language sample contained 29 utterances when using utterance terminators as the utterance segmentation method. His data log revealed 146 instances of word prediction and 43 instances of derived word prediction, totaling 189 instances in which word prediction features were used. Participant 2 used the spelling feature to access 155 words within his sample. His automated data log revealed he activated his device in 2,336 instances, yielding an average of 3.78 activations per word. His selection rate presented as 6.51 bits/s, with a rate index of 0.0369 words/bit. Furthermore, Participant 2's mean syntactic length was 18.97 morphemes/utterance, and his predicted MLU in morphemes was 15.991 morphemes/utterance.

Discussion

The purpose of this research was (a) to investigate language sample collection and analysis's ability to gain clinically relevant data to determine appropriate treatment goals for people who use high-technology AAC in the form of speech-generating devices and (b) to examine the challenges of language sample collection and analysis for people who use high-technology AAC in the form of speech-generating devices to provide potential methods to overcome

Table 4. Participant 2's language sample collection and analysis automated measures from CLAN software.

	Adult		Database			
Measure	Score	± *SD*	*M*	Min	Max	*SD*
			Transcript length			
Total utts	38	–0.285	46.278	12	178	29.091
MLU	38	–0.283	46.238	12	177	29.064
Duration	42:53[a,b]	N/A	3:14	:55	9:39	1:42.909
			Syntax/morphology			
MLUw	16.237[c]	2.596	10.329	5.359	19.727	2.276
MLUm	18.974[c]	2.702	11.963	6.718	22.818	2.594
Density	.446[c]	–1.986	.493	0.42	0.549	0.024
Verbs/utt	2.763[c]	2.84	1.706	1	3.455	0.372
% Nouns	28.986[b]	3.719	19.083	11.952	26.977	2.663
% Plurals	3.543	0.204	3.353	1.481	5.592	0.929
% Verbs	19.646	0.349	18.976	12.745	23.759	1.921
% Aux	2.576	0.363	2.239	0.326	4.734	0.93
% 3S	.322[b]	–1.16	4.964	0.593	13.488	4.001
% 1S/3S	1.61	0.142	1.429	0.51	6.522	1.278
% PAST	10.628	0.863	6.244	0.317	17.021	5.08
% PASTP	3.221[b]	3.395	1.14	0.317	2.715	0.613
% PRESP	2.093	0.623	1.535	0.292	4.552	0.896
% prep	9.018	0.979	7.417	3.012	13.043	1.636
% adj	1.771[c]	–1.24	3.222	0.658	6.309	1.17
% adv	5.314	–0.941	6.856	3.561	12.935	1.638
% conj	1.288	–0.666	1.893	0.355	4.159	0.907
% det	11.111	0.827	9.57	5.023	16.667	1.864
% pro	9.984[c]	–1.356	13.414	7.065	22.617	2.529
Noun/verb	1.636[c]	2.293	1.13	0.667	2.083	0.221
Open/closed	.971[c]	3.448	.701	0.537	1.165	0.078
#open-class	306[c]	1.117	189.881	42	530	103.984
#closed-class	315	0.282	272.294	60	813	151.22
			Semantics			
FREQ types	206	0.907	156.357	52	294	54.729
FREQ tokens	621	0.568	472.421	102	1373	261.738
FREQ TTR	.332	–0.472	.368	0.197	0.57	0.078
			Verbal facility and rate			
Words/min	14.41[a,b]	N/A	146.341	83.636	204.417	26.649

Note. utts = utterances; MLU = mean length of utterance; MLUw = mean length of utterance in words; MLUm = mean length of utterance in morphemes; Aux = uncontractible auxiliary; 3S = third-person singular; 1S/3S = identical forms in first and third person; PAST = past tense; PASTP = past participle; PRESP = present participle; prep = prepositions; adj = adjectives; adv = adverbs; conj = conjunctions; det = determiners; pro = pronouns; open = open class words; closed = closed class words; FREQ types = total word types; FREQ tokens = total word tokens; FREQ TTR = type–token ratio.

[a]Manually calculated. [b]Outside a standard deviation from the mean and outside the range of the control group. [c]Outside a standard deviation from the mean.

aforementioned challenges. The findings of this study indicate that language sample collection and analysis provided robust information regarding the language profile of each participant to inform treatment. Select measures, chosen based on their ability to provide clinically relevant changes or their connection to one of the previously identified challenges of language sample collection and analysis of PWUAACs, will be discussed below.

Rate and Duration of Language Sample Collection

Participant 1 presented with a speaking rate of 2.05 words/min within her 28.52-min language sample. The control group had an average speaking rate of 68.37 words/min, yielding a 3.60-min average sample duration. Participant 2 presented with a speaking rate of 14.41 words/min within his 43-min 52-s language sample. The control group had an average speaking rate of 146.341 words/min, yielding a 3-min 12-s language sample duration. These data are consistent with the findings of previous research, which has found PWUAACs competently speak at a rate of 8–10 words/min (e.g., Newell et al., 2003), whereas verbal adults tend to speak at 115–165 words/min (e.g., Andrews & Ingham, 1971). Although both participants took a substantially greater amount of time to provide their language sample relative to verbal peers, it is not unrealistic that a language sample could be completed within one treatment or evaluation session with each sample collection taking less than 45 min. Thus, if clinicians are able to dedicate a session to collecting a language sample, time constraints should not serve as a barrier to language sample collection and analysis for PWUAACs.

Clinicians may also consider using the elicitation method that was used with Participant 2 in instances in which it is not feasible to dedicate a session to collecting a language sample. Participant 2 completed this task independently given the appropriate materials and prompts with his data logging feature activated. This relieved any possible time constraints that may have occurred if this language sample was collected in a typical evaluation setting through a direct client–clinician interaction. Though this methodology presents with its own limitations (e.g., inability to control for potential cues in the client's environment), SLPs may wish to contemplate using indirect methods of language sample collection for PWUAACs, with automated data logging features activated if it would be appropriate for their client, allowing for the SLP to gather information through language sample analysis without dedicating a treatment session to language sample collection. If language sample collection and analysis occurs indirectly (e.g., independently by the client, caregiver-directed, and paraprofessional-directed) with adequate education of the procedure and a protocol in place, many of the aforementioned challenges (i.e., lack of awareness of context, modeling, teaching, communication partners, language use) may be alleviated if the protocol and procedure are implemented appropriately. If the SLP would like to gain additional information regarding the input from the individual collecting the sample or multimodal means of communication, they may further prompt that the language sample collection is video-recorded to supplement the information obtained through the automated data logging features.

Analyzing the Language Samples of PWUAACs

Determining Utterance Boundaries

Utterance boundaries are an important component of language sample analysis as they provide information regarding language productivity, calculating subsequent measures (e.g., MLU in morphemes, MLU in words, mean syntactic length), and in determining the reliability of a language sample. Each participant's language sample was divided into C-units, with Participant 1 producing 39 and Participant 2 producing 38. Both participants were within a standard deviation of the mean of their respective control group. Determining appropriate utterance boundaries proved to be influenced by each participant's language complexity. Participant 2 used complete sentences throughout his language sample, which enabled the researchers to determine appropriate utterance boundaries without difficulty. In contrast, Participant 1's sample was dominated by utterances at the sentence fragment and elliptical phrase levels. This complicated our ability to determine utterance boundaries as the C-unit segmentation guidelines for SALT transcription state: "Sentence fragments are counted as separate C-units when the final intonation contour of the utterance indicates that a complete thought has been spoken" (SALT Software, 2019, p. 3). As a PWUAAC, Participant 1 was unable to alter the intonation contour on her speech-generating device to mark the end of her thought. Despite this challenge in determining appropriate utterance boundaries for Participant 1's language sample, the type of elicitation strategy used aided in overcoming this challenge. More specifically, because a story generation task was used to elicit the language samples, researchers could refer to the wordless picture book used to elicit the sample to help determine appropriate utterance boundaries as each page of the wordless picture book served as a reference point to guide C-unit segmentation and allowing for utterances in the form of elliptical phrases. For example, for Participant 1, the researcher used the book to guide C-unit segmentation and determined there to be 39 utterances within the sample. The undergraduate research coder initially completed utterance segmentation for this participant without using the book as a reference point; thus, she determined there to be 11 utterances, only counting noun–verb combinations as a C-unit. Once provided with the wordless picture book to achieve a reference point to guide her through the utterance segmentation process, reliability was achieved at 100%. This is something that SLPs may wish to consider when collecting a language sample from a PWUAAC who is an emergent communicator, furthering the need for research of appropriate protocols to implement into the language sample collection and analysis of this population.

Morphosyntactic Measures

Subsequent measures based on utterance boundaries analyzed in this research include MLU, distribution of utterance lengths, and use of bound morphemes for Participant 1 and MLU for Participant 2. These measures reveal information regarding each individual's linguistic productivity. Participant 1's MLU and distribution of utterance lengths varied significantly from the control group. Verbal controls had an average MLU in morphemes of 6.50 morphemes/utterance, with a primary utterance length of 6 morphemes and a greatest utterance length of 13 morphemes, while Participant 1 presented with an average MLU in morphemes of 1.36 morphemes/utterance and a primary utterance length of 1 morpheme and greatest utterance length of 3 morphemes. These data accentuate the clinical utility of language sample collection and analysis for PWUAACs through highlighting information that may not be adequately captured within the rigid measures of standardized assessments and determining that an appropriate treatment goal would be to expand her utterance length.

Additionally, SALT analyses revealed that Participant 1 was not incorporating any bound morphemes within her language sample. Without use of bound morphemes, Participant 1 does not have as refined of an ability to use a variety of language functions, including expressing regular past tense and possession. This draws into question if Participant 1 has a receptive understanding of bound morphemes, indicating a future direction of therapy with this individual may be to assess her receptive understanding to ensure she has the ability to comprehend words, phrases, and sentences of higher complexity. Participant 2's language sample presented with an MLU in morphemes and an MLU in words of 18.97 and 16.24, respectively. These values are both 2

*SD*s above the mean when compared to his verbal peers, revealing, when analyzing these measures, Participant 2 is considered advanced relative to his peers.

Measures of Word Frequency, Class, and Lexical Diversity

Among the many measures of word frequency, class, and lexical diversity analyzed in this research through automated analyses are each participant's top 10 words, parts of speech, and type–token ratio. Participant 1 most frequently communicated through using nouns, as shown in her top 10 words and parts of speech distribution from Realize Language. Though her language is dominated by use of nouns, her type–token ratio was 1 *SD* above the mean in comparison to the control group (e.g., $n = 15$, age range: 4.4–5 years). These data were used as Participant 1 is an emergent communicator, as evidenced by her MLU, and these control data were the earliest stage communicators available within the SALT software for comparisons using this narrative language sample task. This reveals that, despite Participant 1's narrow parts of speech distribution, she combined the words in her vocabulary to convey concepts for which she did not have the exact word in her lexicon (e.g., "Bee inside igloo" for a bee inside a beehive). Without language sample collection and analysis, this strength may not have been captured due to measures of expressive vocabulary (e.g., confrontational naming tasks) typically used within standardized language assessments (e.g., Expressive Vocabulary Test–Second Edition; Williams, 2007) generally seeking a target response versus using a more natural, global lens to evaluate one's expressive vocabulary. The language sample analysis of Participant 1 revealed a profile indicating a robust noun vocabulary and relatively sparser vocabulary across the other parts of speech, including verbs, adjectives, and determiners. Therefore, an appropriate treatment goal would be to target broadening her parts of speech used to include increased verbs, adjectives, and determiners. SALT further analyzes specific word lists, including question words, negatives, conjunctions, modal auxiliary verbs, and personal pronouns. These data revealed that all of the verbal control children used some form of conjunction or personal pronoun; however, she did not incorporate any within her sample. These data further inform us of some specific word lists that can be targeted to complement the goal of increasing the parts of speech used within her language.

Participant 2's parts of speech distribution was analyzed through Realize Language and CLAN software. Each analysis portrayed that Participant 2 presented with a much broader distribution of parts of speech than Participant 1. Participant 2's top 10 words, calculated automatically by Realize Language software, revealed "stepmother" was one of the top 10 words within Participant 2's language sample. This emphasizes that task-specific fringe vocabulary is relevant within this narrative elicitation task.

Core Word Measures

The top 100 core words have been estimated to account for half of our language use (e.g., Berga, 2014) and have been a topic of recent discussion in the literature of PWUAACs (e.g., Bean et al., 2019; Boenisch & Soto, 2015; van Tilborg & Deckers, 2016). To investigate the use of core words within each participant's language sample, this research investigated the prevalence of core words within each individual's top 10 words and the percentage of the top 100 core words (AAC Language Lab, 2013) within each sample. The language sample analysis of Participant 1 revealed one of the words used most frequently within her sample (i.e., her top 10 words) was considered a core word and 9% of the words used within her sample were included within the top 100 core words. The language sample analysis of Participant 2 revealed four words used most frequently within his sample were considered to be core words and 30% of the words used within his sample were within the top 100 core words. These data suggest narrative language sampling tasks may be providing information relevant to the expressive vocabulary used above and beyond core vocabulary. This is valuable as there is a body of research highlighting the importance of expressive vocabulary's profound impact on other aspects of language including, but not limited to, listening comprehension (Andringa et al., 2012), speech recognition (Bent et al., 2016), and naming in verbal fluency tasks (Rodríguez-Aranda & Jakobsen, 2011).

Language Sample Measures Specific to PWUAACs

Measures incorporated within this study to further investigate measures specific to the language sample analysis for PWUAACs include average activations per word, bits, selection rate, rate index, mean syntactic length, and use of word predictive features for both participants and additional measures of number of utterances using utterance terminators and number of words spelled for Participant 2. These measures were assessed to gain information regarding each participant's language access, efficiency, and use. Several of these measures will be discussed below.

Average activations per word, bits, selection rate, and rate index are all measures that provide insight into the operational and strategic competence of each participant as they each reveal information regarding an individual's rate and access. Within this research, these measures were valuable in determining baseline values areas that could be assessed for a PWUAAC to evaluate progress within themselves; however, there are currently no norms available to compare how each participant's language sample analysis values for these measures would align with their verbal peers. An example of how these data can contribute to goal selection for a PWUAAC can be found through considering Participant 1's average activations per word ($n = 5.67$ activations per word) and her vocabulary, LAMP Words for Life, which is configured to have each word accessible within three selections. This suggests she is using words beyond what she typically uses within her day-to-day environment and that a potential treatment goal would be to promote increased exposure to fringe vocabulary in order to improve efficiency navigating to these words in the future. As this calculation was completed considering all selections made within the duration of the language sample collection, a limitation of this calculation is its inability to account for selections made to clear the speech display within language sample collection.

The use of word predictive features was assessed for each participant, as well as the number of spelled words for Participant 2. Participant 1 did not utilize any word predictive features, whereas Participant 2 used word prediction and derived word prediction in 146 and 43 instances, respectively. Participant 2's high use of word prediction demonstrates his advanced operational competency in using his device and his ability to use strategic competence to increase his access to vocabulary, which he may not be aware of the correct sequence, or to access his target word at a faster rate. Participant 2 further portrayed his operational competence and literacy through using the spelling feature to access a word in 155 occurrences throughout his 618-word language sample, equating to access approximately 25% of his total words used. Of the 155 words accessed through using the spelling feature, "Cinderella" was accessed exclusively through the spelling feature (i.e., with no assistance from word prediction or derived word prediction), with 10 or more selections each time it was accessed. Thus, 210 or more of Participant 2's 2,336 selections, approximately 9% of his selections to access nearly 3% of words used, within his language sample were in effort to access "Cinderella." This further emphasizes how narrative language sampling tasks may access task-specific fringe vocabulary.

Participant 2's language sample was further analyzed through implementing utterance terminators as an utterance segmentation strategy. Using utterance terminators, Participant 2's language sample contained 29 utterances, inconsistent with 38 utterances as determined using C-unit segmentation. This difference in number of utterances as a product of the segmentation strategy emphasizes the importance of consistency in the segmentation strategy used due to its influence over the total number of utterances and subsequent analyses including, but not limited to, MLU in morphemes, MLU in words, verbs per utterance, and mean syntactic length. In this research, it was advantageous to use C-unit segmentation due to the use of C-unit prevalence within the research of verbal peers (e.g., Lundine, Harnish, McCauley, Zezinka, et al., 2018; Tilstra & McMaster, 2007), allowing for comparisons to be made between Participant 2 and control data. Clinicians and researchers should consider the availability of control data from target populations prior to choosing which strategy to incorporate within their language sample analysis. If the language sample analysis is to be compared to people who rely on spoken language to communicate, it is inadvisable to use utterance terminators as the utterance segmentation strategy, as it would confound any comparison to verbal individuals due to the lack of utterance terminators in verbal speech.

Overcoming Obstacles

This research provides insight regarding the aforementioned challenges of language sample collection and analysis for PWUAACs: timing and sample length, validity of automated data logging, elicitation strategies, utterance boundaries, morphology, and use of word predictive features. In these case studies, timing and sample length did not present as an obstacle to language sample collection. Each participant conveyed their language sample within a time frame, consistent with a typical evaluation or treatment session with each of their total number of utterances within a standard deviation from the mean of their respective control groups. If a language sample of 50 utterances was the target for a clinician's or researcher's evaluation, each session could have been extended by approximately 15 min (i.e., increasing Participant 1's duration to 45 min and Participant 2's to 1 hr).

The validity of automated data logging has been drawn into question for the language sample analysis of PWUAACs (e.g., Cross & Segalman, 2016; Van Tatenhove, 2014); however, these concerns have referenced using automated data logging analyze large sums of data over time as opposed to using a specific elicitation strategy at a designated time, as done in the language sample collection and analysis of verbal individuals. Through collecting the language sample using a specific elicitation strategy at a designated time, one is able to mitigate the questions raised regarding validity of using automated data logging, as you would be aware of the context, multimodal forms of communication (if done through a direct client–clinician interaction or video recording), and prompts provided.

With regard to elicitation used for language sample collection, it is imperative the clinician or the researcher has an understanding of what is accessible on an individual's vocabulary to determine an appropriate task. For example, Participant 1 stated "Bee inside igloo" when there was a bee inside of a beehive. This informs us that she had an understanding of what was being depicted within the book; however, she may not have had the word necessary to convey her target word. When the researcher reviewed the words accessible on the LAMP Words for Life vocabulary, it was confirmed that she did not have the word "beehive" and was demonstrating strong strategic competence in expressing her thought. Additionally, for participants who have access to and use spelling and word predictive features, it is important to inquire how frequently they use these features in their day-to-day language use. For example, in Participant 2's language sample, task-specific fringe vocabulary appeared to be chiefly accessed through word predictive features (e.g., "stepmother"). However, "Cinderella" was accessed through spelling without word prediction in each instance it was used within his sample. Though this influenced measures of rate, total number of activations, and average activations per word, it is important to consider that one of the primary goals of language sample collection and analysis is to depict language within a naturalistic environment. If a PWUAAC who uses the spelling feature on their device to access names that are not within their prestored vocabulary through spelling, despite its influence over several language sample analysis measures, it is questionable if the lack of that specific name within their prestored vocabulary would be grounds to consider an elicitation task unsuitable.

Within this research, determining appropriate utterance boundaries did not present as a challenge when analyzing Participant 2's language sample, including more complex sentences, but presented as a challenge when analyzing the sample of Participant 1 whose language sample was primarily composed of sentence fragments and elliptical phrases. Determining Participant 1's utterance boundaries was challenging due to that the C-unit guidelines for segmenting sentence fragments relying on the final intonation contour of the utterance indicate that a complete thought has been spoken (SALT Software, 2019). For the purposes of this research, a wordless picture book was used for language sample elicitation. This aided the coders' abilities to determine utterance boundaries due each page's ability to portray the implied subject. Thus, further research is needed to investigate the most appropriate way to define utterance boundaries for PWUAACs and circumvent the challenges as a result of intonation differences between verbal speech and PWUAACs. Nevertheless, when collecting a language sample from a PWUAAC who is an emergent communicator, it may be worthwhile to use story generation as the elicitation strategy to potentially alleviate some difficulty in determining utterance boundaries based on the findings of Participant 1's case study.

Morphology, specifically MLU in morphemes, has been referenced as a challenge in the language sample collection and analysis of PWUAACs (e.g., Van Tatenhove, 2014). Within this research, MLU in morphemes was calculated using traditional measures used with verbal individuals within SALT for Participant 1 and CLAN for Participant 2. Though PWUAACs may access morphological endings differently, this research team sought to capitalize on the language sample analysis software available and obtain measures that aligned with the control group; thus, incorporating traditional measures of calculating MLU in morphemes was most appropriate for this study. Nonetheless, it is imperative that clinicians and researchers must come together to develop a consensus in how to best assess morphology within the language sample collection and analysis of PWUAACs to provide reliability across research studies and clinical practice.

Lastly, there is currently no information regarding how to consider the use of word predictive features within the language sample analysis of PWUAACs. Within this research, Participant 2 frequently used word predictive features within his language sample. Beyond calculating the number of instances word prediction and derived word prediction were used, his use of word predictive features was not further investigated. To advance the discussion surrounding language sample collection and analysis in PWUAACs, clinicians and researchers may wish to investigate if and/or how the use of word predictive features should be best considered in language sample analysis and, similar to assessing morphology, should seek to develop consensus to increase the abilities for clinicians and researchers to draw comparisons across studies within the literature.

Limitations

This research undisputedly supports our hypothesis; however, limitations must be considered when analyzing the results. This research is composed of two case studies from diverse participants, which provides a meaningful introduction into language sample collection and analysis for PWUAACs; however, these participants encompass a subset of PWUAACs and may not be representative of the entire population. Specifically, this research's focus was on language sample collection and analysis for individuals who use high-tech AAC modalities. Researchers collected basic background information regarding the participants (e.g., age, device type, education); however, extensive background information was not obtained, which may have been valuable to further analyze each participant's language samples (e.g., previous language, hearing, and/or cognitive assessment, demographics). Additionally, language sample collection was not video- or audio-recorded. As a result, the researchers were unable to further analyze the participants' environment or observe behavioral components, including vocalizations and/or nonverbal communication, that may be relevant to the participants' language use.

Future Directions

This research initiated discussion surrounding narrative language sampling for PWUAACs and depicts its utility as an assessment method for this population. Further research is necessary with a larger group of participants to corroborate these findings and investigate best practice for language sample collection and analysis. Additional research is necessary that is video-recorded, obtains more extensive background information on participants, and attempts to conduct additional methods of language assessment to investigate how different assessment measures align with one another. Audio- and/or video-recorded language sample collection sessions would allow for additional subsequent analysis of any present vocalization and nonverbal modes of communication (e.g., gesture) and should be examined in future studies in the language sample collection and analysis of early communicators and PWUAACs. Likewise, studies are needed that investigate several language samples from each participant to evaluate reliability and growth over time. Further discussion is warranted in determining an appropriate elicitation task for this population and how it varies across age, language ability, context, and device vocabulary. It is possible that, because Participant 2 completed this at home on his own, his retell may be more akin to a paper retell than a conversation retell. For instance, Participant 2 frequently used the spelling feature within the Cinderella narrative language sampling task (i.e., to access 25% of words used). This may lead some to question this task's ability to assess language without literacy potentially confounding results, as language sample collection and analysis in verbal peers does not have a literacy component. One may argue that if the individual uses spelling on their device regularly, language sample collection and analysis tapping into words beyond the confinements of their prestored vocabulary is assessing strategic competence and their language in a more naturalistic context than if each word was in their prestored vocabulary. Additional research is warranted surrounding how the results of a language sample may be impacted by different communication partners leading the language sample collection (e.g., comparing the results of a sample collected by a parent and by an unfamiliar person). Research may also seek to explore questions raised by this study, including what percentage of core words within the narrative language samples of typically developing individuals, due to the inconsistent proportion of core words used within Participant 2's language sample relative to what is estimated of verbal adults within the literature. Moreover, there is a need for researchers and clinicians to come to a consensus on how to consider several variables within the language sample collection and analysis of PWUAACs, including how to consider word predictive features and how to calculate MLU, to provide consistency in research and clinical practice. Lastly, to support clinicians and researchers in implementing language sample collection and analysis for PWUAACs within their clinical practice, research should seek to investigate options for a protocol for the language sample collection and analysis of PWUAACs.

Conclusions

As demonstrated in the case studies, language sample collection and analysis appears to be an assessment method that has clinical utility in determining appropriate treatment goals for PWUAACs and should be incorporated into the assessment of these individuals. The utility of the language sample analysis for PWUAACs is enhanced when databases are available that provide control data to compare the PWUAACs to verbal peers. Challenges identified in the literature can be circumvented through collecting language samples during a designated time frame using a specific elicitation task to increase the validity of automated data logging, creating a preliminary protocol for language sample collection and analysis for PWUAACs to streamline elicitation and subsequent analyses, and coming to a consensus on best practice for measures including MLU in morphemes and word predictive features. These findings lay the foundation for a plethora of future research endeavors to simplify language sample collection and analysis in PWUAACs and to investigate its evolving challenges as a result of exciting technological advances improving opportunities for those with complex communication needs.

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