THE EFFECTS OF MEASUREMENT, INPUT, AND AAC DEVICES ON WORD KNOWLEDGE OF CHILDREN WHO SPEAK USING AAC

by

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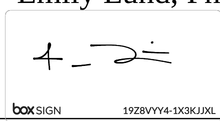

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ABSTRACT

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The purpose of this dissertation is to evaluate the impact of measurement, input, and AAC devices on word knowledge of children who speak using augmentative or alternative communication (AAC). The first study in this dissertation manuscript compares language sample elicitation strategies with children who speak using AAC (CAAC). A generic play-based elicitation strategy yielded the most valid samples when correlated with another valid measure. The second study compares two vocabulary input approaches to determine the approach that yields more words learned for CAAC. Explicit instruction yielded better vocabulary outcomes for all participants. Finally, the third study evaluates CAAC's taxonomic knowledge in comparison to their age-matched, vocabulary-matched, and IQ-matched peers. Findings suggest that cognition, vocabulary size, and AAC device use influence CAAC's taxonomic knowledge and that CAAC present with disordered taxonomic knowledge in language-based tasks. All results yield clinically relevant findings that will support CAAC in the early word learning process.

CHAPTER I: INTRODUCTION

Dissertation Line of Investigation

Some children with language disorders secondary to intellectual and/or developmental disabilities experience limitations with verbal speech (e.g. Erickson & Geist, 2016). The symptoms of this population's disabilities can interfere with coordination of bodily systems that are necessary to speak, which inhibits or prevents verbal speech. To supplement or substitute verbal speech, this population can speak using augmentative or alternative communication (AAC; ASHA, n.d.b).

Although many different types of AAC exist, this dissertation manuscript primarily refers to high-tech AAC devices with robust vocabulary. High-tech AAC devices are tablet-like computers with touch screens that display an application, or "app." These apps display the morphemes and thousands of individual words of a language in a grid-like format. Each morphological marker and word on these robust AAC devices are displayed individually on a single symbol. Each symbol (usually) displays the written word that it represents and includes an icon, or image, that represents the word. Children who speak using AAC (CAAC) can select words and/or morphemes on the AAC device to formulate a novel message, and the device will speak the message aloud to communication partners.

CAAC do not typically receive an AAC device and immediately begin to successfully communicate with the device. Rather, CAAC progress through language development milestones (e.g. Binger et al., 2020), usually as a result of intervention services (e.g. O'Neill et al., 2018). One of the earliest language development milestones for CAAC is acquisition of early vocabulary words (i.e. learning to produce single, meaningful words on the AAC device; Binger et al., 2020). This foundational milestone must be achieved for CAAC to progress to more advanced stages of language development. It is problematic, then, that the majority of CAAC remain “stuck” in this early word learning phase (Andzik et al., 2018; Erickson & Gesit, 2016). Approximately 70% of CAAC in the United States can produce fewer than 30 meaningful words on an AAC device (Andzik et al., 2018) for limited functions of communication (Erickson & Geist, 2016). These overwhelmingly low language outcomes for CAAC have a lasting, negative impact on CAAC’s education (Erickson & Geist, 2016), current and future friendships and relationships (Anderson et al., 2011; Therrien, 2019), and future careers (Bryen et al., 2007; McNaughton et al., 2002). Little is known about the early word learning process for CAAC. Investigations into the word learning process and effective word-learning intervention strategies for this population are sorely needed to improve this population’s language outcomes. This dissertation begins a line of work that addresses this gap in the literature. The overarching purpose of this three-manuscript dissertation is to investigate early word learning in CAAC with high-tech AAC devices. This dissertation is composed of three manuscripts that describe three separate studies. The purpose of each study and manuscript contributes to the overarching purpose of this dissertation.

Background and Significance

Beukelman and Light (2020) estimated that approximately five million people in the United States would benefit from using AAC because they experience limitations with verbal speech. Two recent studies provided more insight into current AAC use and need across the country. Both studies surveyed special education providers across the United States about students who receive special education services in the public school system (Andzik et al., 2018; Erickson & Geist, 2016). Andzik and colleagues (2018) reported on children ranging from preschool to 21 years of age (n = 15,643), and Erickson and Geist (2016) reported on children ranging from third to twelfth grade (n = 38,367). Surveys revealed that between 4.8-6.2% of their samples used high-tech AAC devices (Andzik et al., 2018; Erickson & Geist, 2016).

Results from these surveys suggest that there are children in the special education system who do not currently use high-tech AAC but would benefit from using this form of communication. Both surveys revealed that special education students rely on other forms of communication, such as verbal speech (Andzik et al., 2018; Erickson & Gesit, 2016), sign language (Erickson & Gesit, 2016), gestures, and low-tech AAC (Andzik et al., 2018). Additionally, both surveys revealed that a substantial proportion of students who use these alternative forms of communication cannot effectively use these forms to communicate. For example, Andzik and colleagues (2018) revealed that 6.9% of their sample primarily communicate through gestures and that 87% of these gesture users are ineffective communicators. Additionally, they reported that 6.5% of their sample speak using low-tech AAC (i.e. an AAC device without a battery, such as icons printed on laminated paper) and that 82% of these low-tech AAC users produced fewer than 30 meaningful words using their low-tech system. Erickson and Geist (2016) revealed that 75.1% of their sample speak verbally but that 21.7% of those verbal speakers could only produce two-word phrases. An additional 10.5% of those verbal speakers could only produce single words for limited functions of communication. Furthermore, this study reported that 10.9% of their total sample did not use any symbol system at all (e.g. verbal speech, AAC, sign language).

These other forms of communication lack the robust nature of high-tech AAC devices. Because high-tech AAC devices can display a dynamic screen (or a screen that changes to display different words and morphological markers), they have the capacity to store thousands of words, which can be combined to produce novel messages in a relatively time-efficient manner.

Because low-tech devices do not have dynamic display capabilities, the number of words that can be displayed (and thus can be communicated) is limited. Gesture use yields similar limitations, which can be exacerbated when children present with motor deficits. Therefore, it is likely that some of these children who lack a symbol system and children with profound limitations in their selected form of communication (e.g. verbal speech, low-tech AAC, gestures) would benefit from high-tech AAC. This is supported by Lin and Gold's (2018) findings that suggest that a proportion of children with special education and health needs do not have their AAC needs met (between 4-10.5% of children sampled in their study per parent report). Thus, although recent surveys suggest that 4.8-6.2% of children in special education use high-tech AAC (Andzik et al., 2018; Erickson & Geist, 2016), it is likely that the number of children who would benefit from AAC and, therefore, should be using high-tech AAC, is substantially higher.

These two surveys also describe the expressive language skills of children in special education programs who speak using high-tech AAC. Outcomes for this population are devastatingly low. Andzik and colleagues (2018) determined that high-tech AAC users would be considered proficient communicators if they demonstrated ability to produce 30 or more meaningful words on their AAC device (which is notably 10 words less than the average vocabulary size of a 16-month-old verbal child; Fenson et al., 1994). A shocking 62.3% of children in their sample who speak using high-tech AAC did not meet this standard, indicating that the majority of AAC users in their sample produce fewer than 30 meaningful words via high-tech AAC (Andzik et al., 2018). Erickson and Geist (2016) revealed equally limited results. This manuscript did not reveal the expressive language proficiency of high-tech AAC users specifically. However, they did report that 20.6% of their entire sample speaks using some form of AAC (i.e. high-tech or low-tech) and that 69.8% of these AAC users only demonstrated ability to produce a limited number of single-word messages for limited functions of communication. In summation, two important conclusions from these survey studies can be drawn. First, as highlighted in this paragraph, CAAC experience profound limitations in their ability to produce language using AAC. Second, the majority of CAAC are seemingly “stuck” in the early stages of language development (i.e. the word learning stage).

The consequences of these low language outcomes are devastating. Children who speak verbally are statistically significantly more likely than children who do not speak verbally to be placed in a classroom setting with their typically developing peers, gaining access to the general education curriculum. Children who do not speak verbally are also more likely to be placed at an entirely different school than typically developing peers (Erickson & Geist, 2016). Child friends of CAAC report that communication can be a barrier in their friendships with CAAC (Anderson et al., 2011). The influence of communication on daily living continues into adulthood. Adult AAC users report that their ability to communicate impacts their ability to make and maintain friendships (Therrien, 2019). Employers of AAC users indicated that ability to effectively communicate is a general requirement for most jobs (Bryen et al., 2007), and employed AAC users reported that ability to use their AAC device to communicate was critical to the success of their employment (McNaughton et al., 2002). In conclusion, the ability to communicate has a substantial impact on CAAC’s and adult AAC users’ academic, personal, and professional lives.

Theoretical Foundation

Binger and colleagues’ (2020) Cake Framework is the theoretical foundation of this dissertation. The Cake Framework identifies four phases of graphic symbol utterance and sentence development, or development of ability to produce adultlike sentences via AAC. Phase 1 is the earliest phase, and Phase 4 is the most advanced phase of language development in this framework. Phase 1, called Early Symbol Productions, primarily involves development of various communicative functions and ability to produce vocabulary words that are meaningful within context (i.e. word learning). Phase 2, called Early Symbol Combinations, includes production of early word combinations (e.g. two- to three-word combinations), which may not be in accurate word order. Phase 3, called Childlike Sentences, involves mastery of word order and production of longer sentences; use of grammatical morphemes may emerge here. Finally, Phase 4, called Adultlike Sentences, includes grammatically accurate sentence productions with clear meaning and increasing sentence complexity. Furthermore, authors stress the importance of growth in word class diversity (e.g. nouns, verbs, adjectives) and lexical diversity (words within a word class, such as dog, pencil, and toothbrush) across all four phases (Binger et al., 2020). The trajectory of language development outlined in this framework closely mirrors verbal language development (Binger et al., 2020).

Logically speaking, CAAC cannot reach phase 4 of language development (i.e. production of adultlike, complex sentences via AAC) without developing the skills listed in Phase 1. That is, children cannot produce adultlike sentences (Phase 4) if they cannot produce enough vocabulary words to do so (Phase 1). This Cake Framework identifies the critical need for CAAC to learn words in order to become proficient communicators via an AAC device. The manuscripts in this dissertation contribute to the body of literature that addresses this critical need.

In the earliest phase of this framework, Phase 1, CAAC (1) expand the functions of communication for which they communicate and (2) develop ability to produce new, meaningful words that are relevant to the context of conversation. The majority of students who use AAC in the Andzik and colleagues and Erickson and Geist surveys demonstrated ability to (1) use a limited number of functions of communication (Erickson & Geist, 2016) and (2) produce a limited number of vocabulary words (Andzik et al., 2018; Erickson & Geist, 2016) These findings indicate that the majority of AAC users in these studies lack proficiency in the expressive language skills of Phase 1 and, thus, present in Phase 1 of this framework. If the goal for AAC users is to be independent, effective communicators of complex, novel messages (i.e. Phase 4), then AAC users must master language skills in Phase 1 to advance to the following phases of this framework and of language development through AAC. Therefore, according to the Cake Framework, the two most important language skills for these students who are stuck in Phase 1 to develop is to (1) increase the number of functions of communication used and, (2) more relevant to this study, learn more new words (Binger et al., 2020).

With so many children “stuck” in Phase 1, it is vital that scientists investigate processes of early word learning and intervention strategies that enhance early word learning for this population, aiming to advance CAAC to later stages of language development. Each manuscript in this dissertation contributes to this need, identifying tools, strategies, and/or knowledge that support early word learning in CAAC.

Literature Overview of Manuscript 1

The field of AAC has experienced a philosophical paradigm shift over the past 35 years. Prior to the 1980s, if AAC was even implemented at all (Hourcade et al., 2004), AAC devices were not language-based, meaning that they did not provide the AAC user with all linguistic components necessary to develop language through AAC (e.g. core vocabulary, grammatical markers). This changed when Bruce Baker, a linguist with a unique perspective on AAC, and Prentke Romich Company released the first language-based device in the mid 1980s. Many AAC device making companies followed Baker’s lead and released new language-based systems shortly thereafter. As technological advances have skyrocketed throughout the 1990's to the present time, AAC devices have continued to improve in linguistic features, functionality, and accessibility (for review, see Chapple, 2011). This profound, philosophical change in AAC devices was quickly followed by research articles that depicted learning to communicate using AAC as language development through AAC (e.g. Goossens, 1989; Sevcik et al., 1995). Although this is a subtle shift in terminology, it is a fundamental shift in philosophy. This philosophical shift began a new line of thinking and body of literature that has drastically changed the field of AAC.

With this philosophical shift in thinking, a wide variety of literature has been published within the last 30 years that contributes to what is known about language development through AAC. Many investigations have focused on identifying tools and intervention strategies that support CAAC in the early phases of language development. For example, researchers have identified a variety of assessment tools that clinicians and researchers can use to evaluate early developing augmented language productions. Some of these tools rely on parent report, such as the MacArthur-Bates Communication Development Inventory (Fenson et al., 2007), and some of these tools yield a score that can describe early language productions, such as the Communication Complexity Scale (Brady et al., 2012; Brady et al., 2018). Although extremely useful, these tools do not evaluate a sample of CAAC's expressive language productions, which may limit the clinicians' ability to comprehensively measure CAAC's early language productions (McCauley & Swisher, 1984; Schuele, 2010).

Language sampling is the elicitation and analysis of a sample of a child's expressive language skills. Clinicians can use language sample results to monitor progress in language growth and evaluate a client's ability to use language in natural interaction (Costanza-Smith, 2010; Schuele, 2010). Language sampling has been considered the gold standard of language assessment for verbal children (e.g. Heilmann et al., 2010). In order to elicit a valid language sample, or collect a sample of language that is representative of the child's expressive language abilities, clinicians must use specific elicitation procedures (Costanza-Smith, 2010; Hadley, 1998; Heilmann, 2010). These procedures vary based upon a child's expressive language abilities, so clinicians must use different elicitation procedures for children who produce complex sentences and children who are early language learners (Heilmann, 2010).

Language sampling had not been investigated with AAC users until recently, and none of these investigations included early language learners (e.g. Kovacs & Hill, 2017; Mooney et al., 2021; Savaldi-Harussi & Soto, 2016). Because language sample elicitation procedures vary based upon a child's expressive language abilities (Heilmann, 2010), results from studies with more advanced AAC users cannot be applied to early language learning CAAC. The most valid language sample elicitation strategy for early language learning CAAC had yet to be investigated. Thus, this gap in the literature inspired the first study in this three-dissertation manuscript: Determining an effective language sample elicitation strategy for early language learners who speak using AAC (Trevino & Lund, 2024).

Relative to moving early word learning forward, the first study identifies an evaluation tool that clinicians and researchers can use to evaluate CAAC's early language productions (Trevino & Lund, 2024). Clinicians can use this tool to assess CAAC's early word productions, which can support therapy planning and identify progress or lack thereof in intervention.

Literature Overview of Manuscript 2

Assessment is not the only area of AAC research that experienced drastic growth after this philosophical shift in thinking towards language. In addition to assessment studies, researchers have conducted intervention studies that evaluated the use of common verbal language intervention strategies with CAAC. For example, many investigations have evaluated the efficacy of modeling expressive language productions on an AAC device to support word learning (for review, see O'Neill et al., 2018). Although this intervention strategy has taken on many names and forms in the literature, it will be referred to as "augmented input" throughout this dissertation manuscript. Since the 1990's, various forms of augmented input have been a primary focus of language based AAC intervention studies for early language learning CAAC (e.g. Goossens, 1989; Quinn et al., 2020). Various reviews reveal that augmented input is an effective strategy to teach word learning (and other language milestones) to CAAC (e.g. Biggs et al., 2018; O'Neill et al., 2018).

With much supporting evidence for this intervention strategy, researchers have begun to investigate more nuanced components of augmented input to further its effectiveness with CAAC. For example, Quinn and colleagues (2020) evaluated whether augmented input embedded in a common storybook reading intervention (Read, Ask, Answer, Prompt) yielded word learning (among other language outcomes) for CAAC. Senner and colleagues (2019) taught parents to provide augmented input to their children who speak using AAC and evaluated CAAC's expressive vocabulary growth after parent-provided augmented input. These few examples demonstrate how a single intervention strategy, such as augmented input, can be implemented in many different ways and, thus, must undergo investigation to identify conditions under which its use is effective.

Two common, contradicting approaches to vocabulary instruction exist that are oftentimes used to teach vocabulary to verbal children: structured interventions and naturalistic interventions. In structured interventions, sometimes referred to as explicit instruction, the instructor provides direct, structured teaching about the target word's meaning (Beck & McKeown, 2007; Lund & Douglas, 2016). In naturalistic interventions, instructors embed vocabulary instruction into natural interactions with the child (e.g. Daugherty et al., 2001). Lund and Douglas (2016) found that the structured approach was more effective than the follow-in labeling approach for children who are deaf or hard of hearing with language differences or disorders. Thus, the modeling vocabulary approach used (i.e. either structured or naturalistic) can impact the effectiveness of vocabulary intervention for children with language differences or disorders (Lund & Douglas, 2016). These two contradicting approaches had yet to be compared with CAAC using the augmented input modeling strategy. Thus, the approach that is most effective and efficient with this population was unknown. This gap in the literature inspired the second study in this three-manuscript dissertation: Comparing two vocabulary intervention approaches for early language learners who speak using AAC (Trevino & Lund, in preparation).

Once authors had a valid tool to measure samples of early AAC language productions (Study 1), authors compared two word-learning intervention approaches in the second manuscript to identify the strategy that yielded the most efficient word learning for CAAC. The results of this study provide clinicians with an effective, research-based intervention protocol that they can implement immediately to target early word learning with this population (Trevino & Lund, 2024).

Literature Overview of Manuscript 3

As advances have been made in understanding processes of early word learning for CAAC, the way in which CAAC store these learned vocabulary words had yet to be investigated. Verbal children rely heavily on taxonomic knowledge to store learned words and retrieve these words while communicating with others (Wojcik, 2018). Taxonomy is the classification of words into hierarchical levels based on shared properties between referents and relations between referents. These hierarchical levels most commonly include the following three levels: superordinate (e.g. plants), basic (e.g. flower), and subordinate (e.g. rose; Lund & Dinsmoor, 2016; Waxman & Hatch, 1992). Verbal children develop this taxonomic knowledge during the language development process (Booth & Waxman, 2002; Booth & Waxman, 2009; Mervis & Crisafi, 1982).

Research suggests that verbal children with language disorders or differences (i.e. children with word finding deficits and children who are deaf or hard of hearing) present with deficits or differences in taxonomic knowledge (Lund & Dinsmoor, 2016; McGregor & Waxman, 1998). These findings suggest that children who are born with language disorders (i.e. children with word finding deficits) and children who have a language disorder that is related to limited language exposure (i.e. children who are deaf or hard of hearing) both experience deficits in taxonomic knowledge. Not only do CAAC present with expressive language deficits (e.g. Andzik et al., 2018; Erickson & Geist, 2016), but they also undergo a unique language development experience. Namely, CAAC develop language on a preorganized, visual language system, and they receive less exposure to language in their symbol system than their verbal peers do (Barker et al., 2013). Thus, based on the literature, because CAAC present with language deficits and receive limited language exposure in their symbol system, it is logical to hypothesize that CAAC would present with deficits or differences in taxonomic knowledge.

Because taxonomic knowledge supports word storage and retrieval (Wojcik, 2018), deficits or differences in taxonomic knowledge may have implications for the way that children store and retrieve learned words. This line of work had yet to be investigated with this population. This gap in the literature inspired the third study in this three-dissertation manuscript: Evaluating the taxonomic knowledge of CAAC.

In conclusion, the overall purpose of this dissertation is to investigate early word learning with CAAC. More specifically, this dissertation evaluates the impact of measures, input, and AAC devices on word knowledge of CAAC. Conclusions may have clinically relevant findings that support CAAC in the early word learning process.

CHAPTER II: DETERMINING AN EFFECTIVE LANGUAGE SAMPLE ELICITATION STRATEGY FOR EARLY LANGUAGE LEARNERS WHO SPEAK USING AAC

Authors: Courtney Trevino & Emily Lund

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Abstract

Purpose: This study evaluates three different language sample elicitation strategies to determine a valid elicitation strategy for early language learners who speak using augmentative or alternative communication (AAC).

Method: Ten children who speak using AAC participated in this study. Language samples were elicited from each participant using three strategies: the Communication and Symbolic Behavior Scales (CSBS), a generic play-based elicitation strategy, and automatic data logging. Samples were transcribed and coded. Additionally, each participant's school SLP completed a Communication Matrix. Data from coded language samples were correlated with Communication Matrix results to determine the elicitation strategy that yielded the most valid language sample in comparison to Communication Matrix results.

Results: Both the CSBS and the play-based strategy yielded clinically relevant information. Because the log lacked communicative context, resulting data from the log was limited. An analysis of variance revealed significant differences in the amount of information elicited from each elicitation strategy. The CSBS repeatedly elicited the most data, followed by the play-based strategy and then the log. Generic play-based strategy results yielded the most correlations with Communication Matrix data.

Conclusion: This preliminary data suggests that the play-based elicitation strategy elicited the most valid language sample when compared to the Communication Matrix from early language learners who speak using AAC. Additionally, results suggest that the CSBS may be an effective tool to measure the limits of this population's expressive language abilities.

Early language learners with and without disabilities use a variety of forms of communication, including body movements, gestures, vocalizations, and productions of meaningful single words (e.g. Crais et al., 2009; Romano et al., 2020; Rowland, 2011; Watt et al., 2006). Early language learners who experience limitations with verbal speech can develop ability to produce these early, meaningful word productions through an alternative mode of communication: augmentative and alternative communication (AAC). As with all clients, speech-language pathologists (SLP) must use effective tools to measure and track progress in expressive language productions of early language learners who speak using AAC. Thus, it is logical to conclude that practitioners need evidence-based guidance about how to best evaluate early developing expressive language produced through AAC.

Various tools exist that can be used to evaluate early developing expressive language. These tools often include caregiver report and tests that yield scores and/or ranking. However, caregiver report tools and omnibus tests of development are not always sufficiently sensitive to change. That is, they may not be best for progress monitoring (McCauley & Swisher, 1984), and they are not normed for children who speak using AAC (Kovach et al., 2016). Language sampling is an effective language evaluation tool that involves collecting and analyzing a sample of a client's expressive language. Language sampling has been referred to as the gold standard of real-time language evaluations for verbal children (e.g. Heilmann et al., 2010). Language samples can provide evaluators with comprehensive data, including a child's ability to use language during social interactions. Research suggests that language sample elicitation strategies (e.g. play-based, conversational, narrative) impact the extent to which the collected sample accurately represents the client's expressive language abilities (Heilmann, 2010). Early studies have used these language sampling elicitation strategies to elicit and evaluate AAC users' augmented utterances. However, none of these studies have compared language sample elicitation strategies to determine the strategy that elicits the most valid language sample from children who speak using AAC (CAAC). It is vital that researchers identify an elicitation strategy that is valid, meaning that it yields a language sample that correlates with another measure of the child's expressive language abilities. Identification of this elicitation strategy will allow practicing clinicians to elicit valid samples from their clients, yielding accurate progress monitoring and/or evaluation results.

Early Language Development

Children in prelinguistic and early linguistic stages of language development communicate using a variety of early forms of communication. These early forms often include a combination of body movements, gestures, vocalizations, and meaningful single word productions (e.g. Crais et al., 2009; Rowland, 2011; Watt et al., 2006, Wu & Gros-Louis, 2014). Prelinguistic development involves a very subtle, intricate progression of communication skills. For example, early language learners first learn to use vocalizations and gestures alone to communicate a message, and their gestures increase in maturity as the child ages. As their prelinguistic skills progress, children use vocalizations in conjunction with gestures to communicate a message (for review, see Crais et al., 2009). By 10-14 months old, expressive linguistic development begins as children say their first meaningful word (Bloom, 2002), and by 16-24 months old, children's expressive vocabularies begin to expand exponentially (Fenson et al., 1994). Once children have learned approximately 50 expressive single words, they progress to the next stages of language development (e.g. Nelson, 1973). As children progress through these intricate stages of development within each form of communication, they learn to communicate for a variety of functions of communication. Early language learners use fewer functions of communication, such as request and protest. As their language skills progress, they increase their communication function repertoire and begin to use a variety of communicative forms to communicate these functions (e.g. Crais et al., 2009; Rowland, 2011; Watt et al., 2006).

These early forms of communication (e.g. body movements, gestures, vocalizations, and meaningful single word productions) are not unique to typically developing children. These forms are also used by children with intellectual and/or developmental disabilities, such as children with Down syndrome (e.g. Abbeduto et al., 2007; Fidler et al., 2005; Romano et al., 2020), cerebral palsy (Mei et al., 2016), and intellectual disability secondary to other diagnoses (Vandereet et al., 2010). Some children with these disabilities experience limited ability to use verbal speech and, thus, learn to speak using AAC. Children who speak using AAC (CAAC) follow a similar developmental trajectory to verbal children. CAAC also use prelinguistic forms of communication, such as gestures and vocalizations, to communicate their messages (e.g. Falkman et al., 2002; Holyfield, 2019). Typically with intervention, CAAC learn to produce single meaningful word productions using their AAC device (e.g. O'Neill et al., 2018).

Binger and colleagues (2020) proposed the Graphic Symbol Utterance and Sentence Development Framework, or the "Cake Framework," which supports the claim that language development through AAC closely mirrors typical expressive language development norms. Specific to this investigation, the Cake Framework suggests that early stages of expressive language development through AAC (Phase 1 on the framework) includes productions of single, meaningful words. Additionally, this framework indicates that as children develop language through AAC, they experience growth in lexical diversity, or their vocabularies expand. Both of these components mirror language development in verbal children, supporting the conclusion that CAAC's early expressive language would include typical early forms of communication.

Speech-language pathologists provide intervention for CAAC to facilitate the language development process through AAC. It is imperative that professionals use valid and sensitive evaluation tools that capture the intricate details of CAAC's prelinguistic and early linguistic development. These data are necessary to accurately describe CAAC's expressive language skills, capture growth over time, and plan intervention.

Early Language Assessment Tools

Caregiver Report Tools

Various evaluation tools exist that describe prelinguistic and early linguistic expressive language. Many of these tools include caregiver or familiar persons report. For example, the MacArthur-Bates Communication Development Inventory is an early linguistic evaluation tool that uses a caregiver checklist to gather an inventory of expressive and receptive language skills (Fenson et al., 2007). The Communication and Symbolic Behavior Scales (CSBS) Developmental Profile elicits information from the caregiver about prelinguistic communication and related areas (Wetherby & Prizant, 2002). The Mullen Scales of Early Learning is an early linguistic evaluation tool that evaluates early sound productions and general language-based social interactions (Mullen, 1995).

The Communication Matrix utilizes caregiver report to evaluate development of early language and social skills (Rowland, 2004; Rowland, 2011). This tool evaluates prelinguistic and early linguistic skills. The tool is unique in that it provides a profile of a child's communicative abilities at varying levels of early-developing expressive language, which is more descriptive than the tools listed above. The Communication Matrix reveals seven "levels" of early language development: pre-intentional behavior, intentional behavior, unconventional communication, conventional communication, concrete symbols, abstract symbols, and language. The tool also identifies functions of communication that children use at each level. Caregivers and/or service providers answer questions about the child's communication; the results identify the functions of communication that the child has surpassed or mastered and the functions that are emerging or are not yet used within each level (Rowland, 2004; Rowland, 2011). This tool can be used to evaluate children who are developing verbal speech and children who are developing speech through alternative forms of communication, including AAC (Rowland, 2011).

Although useful, caregiver checklists present with limitations. Eadie and colleagues (2010) compared results from the Developmental Profile portion of the CSBS, which is a standardized, norm-referenced assessment tool, to a language sample. Participants included 360 females and 368 males (total 728) between 11.5 months and 13.5 months of age. Results found moderate correlations between the results of the two evaluation tools. Caregivers demonstrated strength in reporting gestures but more difficulty with reporting other intricate, early forms of communication that the language samples revealed, such as vocalizations. The fact that parents are not trained to evaluate communicative development, especially outside of gestures and words, likely contributed to the results of the study. Evidence suggests that caregiver report tools, including standardized, norm-referenced tools, do not, alone, provide a comprehensive description of all early language skills (Eadie et al., 2010; McCauley & Swisher, 1984). Because progress in prelinguistic development is oftentimes intricate and subtle, it is important that clinicians have tools that they can use to accurately assess these subtle changes (McCauley & Swisher, 1984; Schuele, 2010).

Tools that Yield Scores

Other evaluation tools exist that rely on the evaluator to analyze the child's early language skills; these tests yield scores that represents the child's level of early expressive language skills. The Bayley Scales of Infant and Toddler Development is a tool that evaluates early development across various facets, including cognition, language, and motor. The evaluation is conducted through observation of child behaviors and through parent questionnaire (Bayley & Aylward, 2019). The Communication Complexity Scale (CCS) evaluates natural communicative interactions. Evaluators observe the child's early expressive language and rate the child's skills using a descriptive scale, assigning the child a score from 1-12 (Brady et al., 2018; Brady et al., 2012). The AAC Profile, made specifically for people who speak using AAC, evaluates the AAC user's competency in operational, linguistic, social, and strategic areas of learning. Results yield scores that describe current and desired functioning across the four areas of learning (Kovach, 2009).

Although these tools have substantial value in the evaluation process, they do not provide a real-time sample of the child's expressive language skills during interaction. Although these tools can reveal progress over longer periods of time, they may not describe all of the child's expressive language abilities and weekly progress. If these tools do not measure a specific skill that a child has developed (e.g. pointing to request with vocalization), the tool will not provide a full representation of the child's expressive language ability (McCauley & Swisher, 1984).

Language Sampling

Language sampling is a common and reliable tool that clinicians use to assess and monitor progress in verbal expressive language (e.g. Heilmann, 2010; Heilmann et al., 2008; Schuele, 2010). A language sample provides a snapshot of a person's ability to use language in a natural interaction, and it reveals the extent to which a person's language disorder impacts natural conversation (Costanza-Smith, 2010). Language sampling has been referred to in the literature as the "gold standard" for language assessment in verbal children (Heilmann et al., 2010), for they yield comprehensive, detailed assessment results that describe expressive language skills and capture progress over time (Schuele, 2010). This tool may be viable assessment option for CAAC that compensates for the limitations of other early language assessment tools described above.

Clinicians use a variety of language sample elicitation strategies, such as play-based, conversational, and narrative strategies, to collect language samples. Research suggests that the type of elicitation strategy that is used impacts the quality of the language sample that is collected (e.g. Costanza-Smith, 2010; Hadley, 1998; Heilmann, 2010). Clinicians must use specific elicitation strategies at different stages of development to collect the most valid language sample, or the sample that best mirrors the speaker's expressive language abilities. For example, play-based elicitation strategies, which collect a client's natural language produced during play, yield the most valid sample for early language learners, and narrative elicitation strategies yield the most valid sample for school-aged children (Costanza-Smith, 2010; Heilmann, 2010).

Various tools exist that can elicit language samples from early language learners. The CSBS, in addition to the developmental profile gathered from parents, is an evaluation tool that elicits a sample of language from verbal early language learners. The CSBS protocol provides the evaluator with explicit instructions on facilitating interaction and eliciting communication from the child. For example, the protocol directs the evaluator to place a bottle of bubbles with a tightly screwed cap in front of the child a specific number of times and wait for the child to request for help from the evaluator. It should be noted that the resulting sample from this tool can be used to obtain a standard score that measures client's symbolic communication behaviors, early developing expressive language, and social and interactional skills across 18 different parameters. Additionally, evaluators score the child's symbolic play, constructive play, and language comprehension (Wetherby & Prizant, 2003). The Early Social Communication Scales is an additional language sample elicitation tool that is similar to the CSBS; evaluators code the resulting sample for a variety of early communicative behaviors, such as initiation (e.g. Kaale et al., 2014; Kasari et al., 2006).

An additional elicitation strategy used with early language learners is a generic play-based sample. During a play-based language sample, the clinician and client complete activities together or play with toys. Evaluators respond naturally to the child's communication bids. For example, if a child points to a desired toy, the evaluator hands the toy to the child. The evaluator transcribes the sample, including all communication attempts using any form of communication, and the evaluator analyzes early language variables of interest to evaluate and describe the client's expressive communication abilities (Costanza-Smith, 2010; Heilmann, 2010). It should be noted that an additional tool, called Communication Sampling and Analysis, exists to evaluate early language skills. However, the tool does not result in a language sample, for clinicians write down a child's most obvious, unprompted communication interactions in real time (Buzolich, 2009) rather than eliciting, transcribing, and analyzing a language sample.

Language Sampling and AAC

Early studies have investigated language sampling as an evaluation tool to analyze expressive language produced through AAC; researchers have used a variety of elicitation strategies to collect language samples from AAC users in these studies. However, none of these studies have compared elicitation strategies to identify the strategy that collects the most valid sample from CAAC in early stages of development. Additionally, none of these studies included early language learners (e.g. Kovacs & Hill, 2017; Mooney et al., 2021; Savaldi-Harussi & Soto, 2016).

Kovacs and Hill (2017) collected language samples from twins who speak using AAC. Both participants demonstrated ability to produce multimorphemic and multi-word phrases on an AAC device, indicating that these participants had surpassed early stages of language development. The authors collected language samples using automatic data logging ("the log"). The log is a tool within an AAC device that records all icons (i.e. words, letters, symbols) that are selected on the AAC device; this tool does not record any words that are not said on the AAC device, such as a communication partner's verbalizations. Rather than collecting a language sample using a specific elicitation strategy, authors used the log to gather a language sample comprised of all productions on the AAC device across single days and single months; only samples with 50 or more multimorphemic utterances were included and evaluated. Results revealed the number of multimorphemic utterances gathered, the number of samples gathered with multimorphemic utterances, and an alternative calculation for MLU for people who produce multimorphemic productions using AAC.

Savaldi-Harussi and Soto (2016) described procedures to collect and analyze language samples from AAC users, and they reported a case study that revealed an AAC user's language samples that were collected preintervention and postintervention. Researchers described and used a conversational elicitation strategy to collect the language sample from the participant, and they used Systematic Analysis of Language Transcription (SALT; Miller & Chapman, 2004) to analyze the data. SALT is a computerized language analysis tool; evaluators upload the transcript of a language sample that follows SALT coding procedures, and this software analyzes the transcripts and codes, providing evaluators with data that describes the language sample. Examples of resulting data from SALT analysis were provided. Using SALT, authors gathered data to evaluate the AAC user's MLU, Brown's Stage, total number of words said, total number of different words said, and word classes used (e.g. noun, verb, adjectives). Their results captured progress in language development when comparing pre- and postintervention samples.

Finally, Mooney and colleagues (2021) collected language samples from two AAC users, a child and an adult, to determine whether analysis of AAC users' language samples yielded clinically relevant information, or information that SLPs can use to make clinical decisions. This team of researchers used a narrative elicitation strategy; both participants were shown wordless picture books and were asked to generate a narrative that represented the story. Rather than video recording and transcribing each sample, researchers obtained a transcript of these participants' language samples using automatic data logging. Language samples were analyzed using SALT (Miller & Chapman, 2004), Realize Language (Cross & Segalman, 2016), and Child Language Exchange System (MacWhinney, 2000). Realize Language and Child Language Exchange System are two other computerized language analysis tools that, like SALT, analyze language transcripts. Using this elicitation method, authors gathered a wide array of clinically relevant data, including MLU, types of bound morphemes used, total number of words used, total number of different words used, type token ratio, word classes used, number of words said per minute/efficiency in use of AAC device, sentence complexity, and use of word prediction and/or keyboard. Although one participant only said 31 different words, the profile of results for both participants, such as types of word classes used, suggest that neither of these participants were early language learners. This elicitation strategy successfully elicited clinically relevant data for AAC users who have surpassed early stages of language development, which is synonymous with narrative elicitation with verbal speakers.

In summary, recent studies investigate various aspects of language sampling expressive language produced through AAC, but the validity of language sample elicitation strategies has not yet been investigated with this population. It is important to identify the most appropriate elicitation strategies for this population to ensure that elicited language samples are valid.

Purpose

The purpose of this study is to identify an ecologically valid language sample elicitation tool that yields a valid language sample for early language learners who speak using AAC. In this study, we elicited three language samples using three different ecologically valid language sample elicitation strategies from early language learners who speak using AAC. The three chosen language sample elicitation strategies include the CSBS, play-based language sample, and automatic data logging. The CSBS was chosen because it provides a specific, structured protocol to elicit early communication (Wetherby & Prizant, 2003), and the play-based language sample strategy was chosen because the literature supports use of this strategy for verbal early language learners (e.g. Heilmann, 2010). Automatic data logging was chosen because it has been used in the literature with people who speak using AAC (e.g. Kovacs & Hill, 2017) and is likely used in practice. Authors hypothesized that the CSBS would elicit the most valid language sample because it has a validated protocol with communication temptations that are designed to elicit early language (Wetherby & Prizant, 2003).

Participants' speech-language pathologists completed a Communication Matrix (Rowland, 2004; Rowland, 2011), which is a valid tool that has been used with CAAC to measure early developing expressive language (e.g. Quinn et al., 2020, Quinn & Rowland, 2017) and validate another early language evaluation tool (Brady et al., 2018). Results from each language sample were compared to Communication Matrix results to identify which language sample elicitation strategy elicited a valid language sample when compared to the results of the Communication

Matrix. Language samples included all forms of communication, such as gestures, vocalizations, verbalizations, and AAC productions. The following questions were addressed:

1. What clinically relevant data can be captured by each language sample elicitation strategy?
2. Is there a difference in the amount of clinically relevant data that can be elicited from CAAC with each elicitation strategy: CSBS, play-based, and log?
3. Does one of the elicitation strategies yield more correlations with the Communication Matrix results than the other elicitation strategies?

Method

The Texas Christian University Institutional Review Board approved this study (IRB#2022-54).

Participants

Children who participated in this study were recruited from a rural school district; this school district used the inclusion criteria listed below to identify potential participants. Of the 11 consent forms that were sent to parents, 10 were returned, and all 10 of those children participated in this study. Inclusion criteria indicated that participants must (a) be at or between the ages of 3;0 – 10;11; (b) have a developmental disability; (c) be developing language through AAC per their individualized education plan (participants who can produce some words verbally but use AAC to supplement verbal speech were included), and (d) have undergone an AAC evaluation and device trials to determine the most appropriate AAC device and language for this child. Participants were excluded if they (a) have an acquired disability (e.g., traumatic brain injury) and/or (b) produce more than 50 single, meaningful words on their AAC device per their school-based speech-language pathologist's report. Children with an acquired disability were excluded because language disorder characteristics associated with acquired disabilities (e.g. aphasia; ASHA, n.d.a) can differ from language disorder characteristics associated with developmental disabilities (e.g. autism; ASHA, n,d,c). Because children with acquired disabilities present with differing expressive language deficits, they may need alternative evaluation strategies, which could have skewed results. Additionally, children were excluded if they produced more than 50 because this milestone is commonly considered an indicator of advancement to the next stage of language development (e.g. Nelson, 1973; Rescorla, 1989).

All children accessed their AAC devices through direct selection using a finger. Eight of the participants used LAMP Words for Life™, and two of the participants used Proloquo2go™. Participants presented with a variety of diagnoses, including autism spectrum disorder, intellectual disability, cerebral palsy, Down syndrome, and/or deaf or hard of hearing. English was the primary language spoken in the home for all participants. All participants are white; four participants are Hispanic, four participants were not Hispanic, and two participants did not respond to the ethnicity question. See Table 1 for details describing each participant.

Table 1
Participant Data.

Child	Diagnosis	Chronological Age at Data Collection (year;months)	Language Representation Used	Amount of Time Using AAC[a]	Communication Matrix Results[b]
Child 1	ASD, ID	10;4	LAMP	3 years	58
Child 2	ASD	5;3	Proloquo2go	2 years	64
Child 3	ASD, ADHD	3;11	LAMP	7 months	76
Child 4	ASD	4;4	LAMP	7 months	40
Child 5	ID	3;11	LAMP	2 months	58
Child 6	ID	6;0	LAMP	1 year	109
Child 7	CP	4;1	Proloquo2go	6 months	93
Child 8	Down syndrome, DHH	5;11	LAMP	3 years	56
Child 9	Down syndrome, DHH	7;6	LAMP	1 year	89
Child 10	ID	5;2	LAMP	1 year	97

Note. AAC = augmentative and alternative communication; ASD = autism spectrum disorder, CP = cerebral palsy, ID = intellectual disability, ADHD = attention deficit hyperactivity disorder, DHH = deaf or hard of hearing.
[a]Note that these children lived through the COVID-19 pandemic. Although some of these children have been using AAC for multiple years, they spent an extended period of time away from school during the pandemic. These children may not have had access to their AAC device at all or may have experienced different exposure to AAC during the pandemic, which could impact expressive language skills.
[b]Communication Matrix results represents scores explained by Rowland (2015; used in Quinn et al., 2020). Participants received 2 points for a mastered or surpassed rating, one point for an emerging rating, and 0 points for a not used rating. Total possible points that could be earned is 160.

Procedure

The first author, a trained speech-language pathologist, elicited three separate language samples from each participant using the following elicitation strategies: the CSBS, a play-based elicitation strategy, and automatic data logging. Language samples were elicited from each child individually in a quiet room at the child's school. Additionally, each participant's school-based speech-language pathologist completed the Communication Matrix and a brief survey describing the child's AAC device and intervention services. A description of data collection strategies is provided below.

CSBS

Evaluators followed the protocol in the CSBS manual (Wetherby & Prizant, 2003) when using this elicitation strategy with one exception: the food inside the clear jar was replaced with a toy chicken to prevent potential exposure to allergens. Each participant sat at a desk across from the evaluator; only Child 4 sat on the ground across from the evaluator for approximately half of the evaluation because this child demonstrated preference for the ground. The evaluation includes four major sections. (1) The evaluator provides the child with toys that the child needs help to open or activate, such as bubbles. The evaluator uses a structured protocol that dictates the exact number of times that toys should be presented and the way that the evaluator should respond to communicative attempts or lack thereof. (2) The child is given books to read and/or look at. (3) The child and evaluator play with a variety of pretend play toy sets; the test gives the evaluator explicit instructions on what toys to use, what can be said to the child, and how to prompt the child to engage in play. (4) The child plays with common problem-solving toys, such as nesting cups. The child could use any form of communication (e.g. AAC, gestures, sign, verbalizations). The evaluator followed the structured CSBS protocol for all responses to participants' communicative acts. Interactions between the child and the evaluator were video and audio recorded. The CSBS took approximately 30 minutes to complete per child.

Play-Based Elicitation Strategy

Protocols for this elicitation strategy followed protocols used to elicit a play-based language sample in Lund's (2018) study. The evaluator and participant sat on the floor of a therapy room. Various toy sets were visible but out of reach for the child; toy sets included Mr. Potato Head, a farmhouse with animals, a car, and a cookie baking set, which included cookies, frosting, a pretend knife, and a baking sheet.

Throughout the elicitation, the evaluator engaged in play with the child and made general comments, such as “whoa,” and “that’s cool.” The evaluator also prompted general interaction using generic conversation starters, such as, “what do you think,” and “what should we do?” The evaluator did not model any linguistically rich expressive language, such as “let’s put the baby in the bed.” The evaluator responded naturally to any form of communication that the child used. For example, if the child pointed at the farm set, the evaluator moved the farm set within the child’s reach. If the child communicated using verbalizations or AAC productions, the evaluator responded by imitating the child’s productions. For example, a child picked up the car, said “yellow” on the AAC device, and pointed at the yellow car. The evaluator said, “yes, yellow” verbally and on the AAC device. It should be noted that some children produced explorations, or babbles, on their AAC devices. The evaluator either responded with a question, such as “what do you mean,” or the evaluator followed the meaning of the production. For example, if the child said the word, “stomp,” the evaluator stomped her feet. The play-based elicitation took approximately 15 minutes to complete for each participant. The 10 minutes with the most meaningful expressive language productions were analyzed.

The play-based elicitation strategy differs from the CSBS in that the CSBS is extremely structured. When administering the CSBS, evaluators present each toy a specific number of times that tempt the child to interact with the evaluator. Even the portion of the evaluation that includes pretend play gives the evaluator instructions about how to interact with the child and how to guide the child to pretend play with toys. In contrast, the play-based elicitation strategy is much less structured. It does not prompt evaluators to tempt children to communicate but, rather, provides a generic play environment in which children can naturally interact with the evaluator.

Automatic Data Logging

This elicitation strategy did not involve face-to-face interaction between the evaluator and the participant. Instead, the automatic data logging feature was turned on at the beginning of the school day. The log recorded utterances produced on the participants' AAC device throughout the child's typical day in his or her classroom. This transcript was collected by the research team, and then the automatic data logging feature was turned off.

Because some participants are preschool students, they attended school for only half-day. Therefore, preschool participant logs captured approximately 3.5 hours of data, and all other participants' logs captured approximately 7 hours of data. Thus, the language sample collected from automatic data logging is all data recorded on participants' devices from 8:00am to 11:30am; Child 4 is the exception, for she attends preschool in the afternoon only. Therefore, this child's language sample is comprised of data that is recorded from 11:30am – 3:00pm.

It should be noted that Child 2 and Child 7 speak using the Proloquo2go™ language representation, and this language representation tracks data logging differently than the language representation of the other eight participants. The data logging feature in the Proloquo2go™ app does not log single word productions on the AAC device; rather, this data logging feature only logs messages that are produced by touching the message window. The message window compiles all single word productions on an AAC device; words are only removed from the message window when the AAC user clears the message window. When the AAC user selects the message window, the AAC device will speak aloud the string of words in the message window. Thus, single-word productions were not individually recorded in the data logging feature for the two children who speak using Proloquo2go™; only words that were in the message window when the participants selected the message window were recorded. Additionally, Proloquo2go™ does not time stamp the data that it logs. Therefore, the full log transcript from these two participants were included, for authors were unable to determine the time of day that the child produced each recorded message.

Communication Matrix

Participants' school-based speech-language pathologist completed a Communication Matrix (Rowland, 2004). Professionals adhered to procedures in the manual when completing the Communication Matrix.

Transcription and Coding

Transcription

The authors developed a transcription and coding manual. All transcriptions were transcribed using SALT procedures (Miller & Chapman, 2004) and included transcriptions of nonverbal communicative behaviors. Transcription of each language sample elicited through the CSBS and the play-based strategy involved two steps: (1) simultaneously watch the video and transcribe the interaction between the participant and the evaluator and (2) rewatch the video while editing any errors found in the original transcription. Researchers transcribed all word productions made by the participant and the evaluator through any form of communication, which included verbalizations, AAC productions, and sign language. Additionally, researchers transcribed all vocalizations, gestures, body movements (defined below).

The first author transcribed all CSBS and play-based language samples and trained an SLP graduate student to transcribe both samples. Throughout training, the graduate student transcribed four CSBS samples and seven play-based language samples. Differences were discussed. Then, the graduate student reviewed the remaining nine language samples that were transcribed by the first author. Agreement was calculated by dividing the total number of agreed upon transcribed utterances by the total number transcribed utterances, and agreement was above 99%.

Although automatic data logs yield a written transcript of language produced on the AAC device, this transcript needed to be transformed to follow SALT transcription protocols (to allow for uniform analysis). The first author trained an SLP undergraduate student to transform log transcriptions into SALT transcriptions. The student and first author both transformed the same automatic data log transcription, and agreement was 96%. The SLP undergraduate student transformed all other logs into SALT transcriptions.

Coding

After transcription of each language sample was completed, the first author coded every language sample. Coding each language sample involved two steps: (1) watch the language sample video and code each communicative act written in the transcription, and (2) rewatch the language sample video and review codes, correcting for any errors. Table 2 displays a list of codes from the coding manual. The transcription and coding manual will be made available to readers upon request.

Table 2
Language Sample Coding Categories and Codes.

Code Category	Code Within Each Category
Form	Body Movement, Gestures, Vocalization, Sign, AAC, Verbal (adapted from Rowland, 2011)
Level	Unconventional (Level 3), Conventional (Level 4), Concrete (Level 5), Babble, Abstract (Level 6), Language (Level 7; adapted from Rowland, 2011)
Communicativeness	Communicative, Not Communicative (adapted from Tager-Flusberg et al., 2009)
Function	Refuse/Reject, Request More Action, Request New Action, Request More Object, Request New Object, Request Absent Object, Request Attention, Show Affection, Greet, Offer, Direct Attention, Polite, Answer Yes/No Question, Ask Question, Name, Comment, Respond, Function Unknown (adapted from Rowland, 2011)
Number of Different Word Class	Noun, Verb, Pronoun, Adverb, Adjective, Preposition, Conjunction, Interjection, Article, Affirmation or Negation (e.g. yes, yeah, no), Wh-Word (adapted from Binger et al., 2020)
Turn Taking	Initiate, Turn Take, Respond, Bid (adapted from Kaiser & Roberts, 2013)
Extras	Echolalia or Route Phrase, Imitation (adapted from Tager-Flusberg et al., 2009), Message Window, Frozen Form (e.g. Lieven et al., 1997)

Note. The levels listed in parentheses in the Level code category correspond with the levels in the Communication Matrix.
Code definitions are written in the manuscript.

Each line of transcription was considered for coding. All child communicative acts of any form were coded. Child word productions (i.e. verbalizations, AAC productions, or sign language) were coded for Form, Level, Purpose, Function, Word Class, Turn Taking, and Extras as applicable. In instances when participants imitated the evaluators' production, transcribers evaluated the context of the interaction to determine whether the imitated communicative act was intentionally communicative or simply served the purpose of imitation. Imitations that did not have communicative purpose were coded as Not Communicative and were excluded from analysis. Echolalic and route phrase productions were coded for Form, Purpose, Turn Taking, Relevance, and Function as applicable. Child gestures and body movements were coded for Form, Level, Function, and Turn Taking. If a child produced a body movement that was not intentionally communicative, such as rocking a doll, this line of transcription was not coded.

The Form code category included the following codes: Body Movements, Gestures, Vocalizations, Sign, AAC, and Verbalizations. Gestures were defined as intentionally communicative movements that are universally accepted to communicate a specific meaning, such as pointing, head shaking, giving a toy, and reaching for a desired item. Body Movements were defined as immature movements, which typically develop prior to gestures, that intentionally communicate a message. Examples include twisting one's body away from a communication partner, hitting, and attempting to meet one's needs.

The Level code category was adapted from the Communication Matrix and included the following codes: Unconventional Communication, Conventional Communication, Concrete Symbols, Babbles, Abstract Symbols, and Language (Rowland, 2011). Unconventional Communication (Level 3) included prelinguistic, communicative behaviors that are not socially acceptable to use as children age (Rowland, 2011). Examples include body movements, such as turning one's body to reject task completion, and less mature gestures, such as reaching for a desired item (rather than pointing to ask for it). Conventional Communication (Level 4) included prelinguistic, communicative behaviors that children continue to use as they age into adulthood (Rowland, 2011). Examples include nodding one's head yes and no, using the "come here" finger, and pointing to a desired item. Concrete Symbols (Level 5) are communicative productions that physically represent a referent, indicating 1:1 correspondence between a symbol and its referent. Examples include pointing to a picture in a book to request that item and handing over an empty box of crayons to request crayons. Per Rowland's (2011) recommendations, animal sounds made to represent the animal itself were also coded as Concrete Symbols. Although AAC productions seemingly meet this definition, Rowland indicates that AAC productions on robust AAC devices, such as LAMP Words for Life™, are considered Abstract Symbol productions and, thus, were coded as such, as indicated below.

Abstract Symbols (Level 6) included single, meaningful word productions that were said through any form of communication (e.g. verbal, sign language, and AAC; Rowland, 2011). Language (Level 7) included any intentional and meaningful symbol combinations to create a phrase; symbols could be produced through any form of communication (e.g. verbal, sign language, and AAC; Rowland, 2011). Authors added the code Babble to the Level code category. The code Babble was used to describe AAC utterances that were intentionally produced (i.e. not an accidental selection) but that did not carry specific meaning. Specifically, utterances that were coded as a Babble were (a) AAC productions in which icons were selected at random (e.g. exploring the device) without showing intent to select specific icons or (b) AAC productions in which the child demonstrated communicative intent behind the production (e.g. made eye contact with the evaluator after producing the word), but it is unlikely that the child produced the selected word meaningfully because the word is irrelevant to conversational context and is not a developmentally appropriate vocabulary word. For example, one child said "reject" and made eye contact with the evaluator; because "reject' is not a word that children learn in early language acquisition and was not relevant to the context of the situation, this production was coded as Babble. It should be noted that words were irrelevant to the topic of conversation but were developmentally appropriate words for the child, such as “Angry Birds” were not coded as a Babble. These productions were coded as Abstract (meaning single, meaningful word production), for the child could have been initiating a new topic of conversation.

The Turn Taking code category included the following codes: Initiate, Turn Take, Take Bid, and Bid. Bid is the only code that was used to code the evaluator’s productions. A Bid was coded when the evaluator prompted the child to communicate or interact; the bid could prompt the child to either engage in interaction with the evaluator or follow a direction. The other three codes in this coding category were used to code child productions. If a child responded to the evaluator’s Bid, that transcription line was coded as Take Bid. If the evaluator and child were engaging in general turn taking without the evaluator bidding the child to interact, the child transcription lines were coded as Turn Take. If a child initiated a new topic of conversation, the code Initiate was used.

Refer to Table 2 for the codes that were included in the Number of Different Word Classes code category (adapted from Binger et al., 2020). Authors only coded this category when the child produced a meaningful, single-word production that was relevant to the context of the conversation. For example, if a child held up a car and said “car” on the AAC device, that utterance would have been coded as Noun, for the child meaningfully said a noun. However, if a child produced an utterance that was not relevant to the context of the situation, authors could not be sure that that single-word production was a meaningful production. For example, one child spontaneously said, “Angry Birds,” which was not relevant to the context of the interaction. Authors did not assign this utterance a Number of Different Word Classes code, for authors could not be sure that this word was said meaningfully. Utterances that were babbles, imitations, and echolalic or route phrase productions did not receive a code from the Number of Different Word Classes code category. Authors also did not code this coding category for any two-word utterances in which one word was unintelligible, for the unintelligible word impacted the authors' ability to be certain of the word class of the intelligible word. For example, one child's unintelligible utterance was transcribed as "x water," with the "x" representing the unintelligible word. In this utterance, "water" could be a noun (e.g. glass of water) or verb (e.g. water the plants). Thus, no code from this coding category was assigned to this utterance.

Finally, the Purpose code category included two possible codes: Communicative and Not Communicative. These codes were only used for word productions, for any non-communicative body movements were not coded. Not communicative word productions included any messages that were produced by the child but did not carry intent to communicate. Examples included accidental selection of icons on the AAC device, babbles and imitations that did not carry intent to communicate, and echolalic/route productions that did not carry intentional meaning.

The first author coded all language samples. A trained second coder, who is an undergraduate SLP student, reviewed the coding for 9 total transcripts. Agreement was calculated by dividing the total number of agreed upon coded utterances by the total number of coded utterances. Agreement was at 100% for the Form, Communicativeness, and Extras coding categories, and agreement was above 99% for the Level, Functions, Turn Taking, and Number of Different Word Class coding categories.

Measures

The first research question sought to describe the type of information that can be elicited from each language sample elicitation strategy. To address this question, authors calculated the mean and standard deviation of number of codes that appeared in each language sample elicitation strategy within the following coding categories: Form, Level, Communicativeness, Functions, Number of Different Word Classes, and Turn Taking. It should be noted that in language samples collected by the log, authors were only able to code utterances using codes from the Form coding category. Authors were unable to assign codes from any other coding category to utterances collected by the log. Because these participants were early language learners, their productions are understood within context. Log samples only provide a record of icons selected on the AAC device and do not provide any context. Thus, when coding these log samples, the authors were unable to use other contextual cues and behaviors to determine if a production on the AAC device was a babble, accidental selection, or meaningful word production. Authors could only determine that the production was said on the AAC device and, therefore, was coded accordingly using the Form category code, "AAC.".

The second research question evaluated whether there are differences in the amount of clinically relevant data that is elicited with each elicitation strategy. Authors completed a one-way repeated measures ANOVA to compare the number of times that all codes within a single category were coded across each language sample elicitation strategy. The independent variable was assessment type (i.e. CSBS, play-based, and log), and the dependent variable was the number of times that a coding category was coded within a language sample. Pending a check of all relevant assumptions, variables were entered into the model. Significant results yielded a follow-up pairwise comparison using a Bonferroni-corrected *p*-value of .05. The coding categories that were included in this analysis include Form, Level, Communicativeness, Functions, Number of Different Word Classes, and Turn Taking.

The third question evaluated the validity of each language sample elicitation strategy for CAAC. To address this question, authors correlated language sample results with the

Communication Matrix results. To quantify Communication Matrix results, authors used scoring recommendations from the Communication Matrix (Rowland, 2015; used in Quinn et al., 2020) to calculate a total score at each level of communication for each participant. This variable is called Communication Matrix total score. Participants received 2 points for a mastered rating, 1 for an emerging rating, and 0 for a not used rating. There was no variability in total scores in Levels 1 through 3 between participants; all participants had mastered every function of communication at each of those three levels. Thus, total scores were not utilized for correlation statistics for those three levels. Total scores were calculated and evaluated for Levels 4 through 7. An additional variable was calculated that used the same procedures listed above to sum total Communication Matrix scores from Levels 6 and 7 together to create a combined score (adapted from Rowland, 2015). This score represented the child's ability to say meaningful words and phrases to communicate various functions of communication.

Three additional variables were calculated using comparable data from the coded language samples: *percent of functions coded*, *sum of functions coded*, and *sum of meaningful words said*. These variables were chosen because they represent the data that is comparable between the Communication Matrix and coded language sample results. To calculate this *percent of functions coded* variable, authors pulled all child communicative acts that were coded at a single level (e.g. Level 4). The number of different functions of communication that were coded at a particular level were summed. Codes "function unknown" and "respond" were not included because they were created by the authors in this coding system and are not options on the Communication Matrix. Authors then referred to the Communication Matrix to determine the total possible number of functions that could be coded at that level. Authors calculated a percentage by dividing total number of functions coded by total possible number of functions that could be coded at that level. This was completed for Levels 4 through 7 across each language sample elicitation strategy for each child.

To calculate the *sum of functions coded* variable, authors pulled all child communicative acts that were coded at a single level (e.g. Level 4). The total number of times that any code from the function coding category was coded was summed. This was completed for Levels 4 through 7 across each language sample elicitation strategy for each child.

Finally, to calculate *sum of meaningful words said*, authors added the total number of times that the child used a meaningful word to communicate a message. Noncommunicative productions, such as babbles, were excluded. Route phrases, echolalia, imitated messages, and unintelligible words were excluded. Two-word phrases in which both words were meaningfully produced and intelligible counted as 2. Two-word phrases with one intelligible word and one unintelligible word counted as 1. This was calculated across each language sample elicitation strategy for each child.

To address research question 3, authors analyzed correlation between the Communication Matrix variables (Communication Matrix total score and Communication Matrix total combined score for levels 6 and 7) and the language sample variables (percent of functions coded, sum of functions coded, and sum of meaningful words said). Pending a check of all relevant assumptions, variables were entered into the model (p = .05).

Results

Research Question 1

The mean number of codes that appeared in each language sample elicitation strategy within the following coding categories are reported in Table 3: Form, Level, Communicativeness, Functions, Number of Different Word Classes, and Turn Taking.

Table 3

Descriptive Data Showing Number of Codes Per Category Coded in Each Sample.

Code	CSBS	Play-Based Sample	Log
Form	209.80 ± 126.76[a]	80.50 ± 37.68	67.60 ± 58.11
Level	143.00 ± 68.18[a]	50.60 ± 21.96[b]	.00 ± .00[c]
Communicativeness	77.70 ± 74.80	43.20 ± 29.85[b]	.00 ± .00[c]
Functions	143.20 ± 70.65[a]	48.40 ± 21.97[b]	.00 ± .00[c]
Number of Different Word Classes	33.70 ± 50.10	14.50 ± 16.39	.00 ± .00
Turn Taking	129.30 ± 60.65[a]	44.40 ± 18.09[b]	.00 ± .00[c]

Note. Results represent mean ± standard deviation. CSBS = communication and symbolic behavior scales

[a] means that the CSBS mean is significantly different from the play-based sample mean

[b] means that the play-based sample mean is significantly different from the log mean

[c] means that the log mean is significantly different from the CSBS mean

Research Question 2

Prior to conducting an ANOVA, assumptions were evaluated. An evaluation of Cook's distances revealed no influential outliers. Although Shapiro-Wilk's test revealed violations to normality, ANOVA is robust to normality violations, so analysis proceeded (Field, 2018). Mauchly's Test of Sphericity revealed violations to sphericity. All Epsilon (Σ) were < .75, according to Greenhouse and Geisser (1959) calculation, and, thus, was used to correct the one-way repeated measures ANOVA.

A one-way repeated measures ANOVA was conducted with elicitation type (i.e. CSBS, play-based, or log) as the independent variable and mean number of times that codes within a coding category were coded was the dependent variable. There was a statistically significant difference in the number of times that Form was coded between each elicitation strategy, *F*(1.17

10.55) = 8.71, p = .011, partial η^2 = .49. Follow-up pairwise comparison revealed that Form was coded more times in the CSBS than the play sample (p = .007) but that there was no difference between the CSBS and the log (p = .063) and the play sample and the log (p = 1.00).

There was a statistically significant difference in the number of times that Level was coded between each elicitation strategy, $F(1.08, 9.67) = 40.55$, $p < .001$, partial η^2 = .82. Follow-up comparisons reveal significant differences between all three comparisons (all $p < .001$); Level was coded most times in the CSBS sample and least times (not at all coded) in the log sample.

There was a statistically significant difference in the number of times that Communicativeness was coded between each elicitation strategy, $F(1.11, 10.02) = 9.88$, p = .009, partial η^2 = .52. Follow-up pairwise comparisons revealed that Communicativeness was coded more times in the CSBS than the log (p = .028) and that Communicativeness was coded more times in the play-based sample than the log (p = .004). Note that Communicativeness was not at all coded in the log. There was no difference between the CSBS and play-based sample (p = .197).

There was a statistically significant difference in the number of times that the Functions category was coded between each elicitation strategy, $F(1.09, 9.78) = 37.23$, $p < .001$, partial η^2 = .81. Follow-up pairwise comparisons revealed significant differences between all three comparisons: CSBS and play-based sample (p = .001), CSBS and the log ($p < .001$), and the play-based sample and the log ($p < .001$). Note that Functions were not at all coded in the log.

There was a statistically significant difference in the number of times that Turn Taking was coded between each elicitation strategy, $F(1.07, 9.62) = 41.52$, $p < .001$, partial η^2 = .82. Follow-up pairwise comparisons reveal significant differences between all three comparisons (all

p < .001); Turn Taking was coded most times in the CSBS sample and least times (not coded at all) in the log.

There was no statistically significant difference in the number of times that Number of Different Word Classes was coded in each sample, $F(1.04, 9.39) = 4.23$, $p = .068$, partial $\eta^2 = .32$. Note that this coding category was not at all coded in the log. Because results were not significant, follow up pairwise comparisons were not evaluated. This result suggests that there was no difference in the total number of meaningful single words said in each sample.

Research Question 3

Prior to conducting correlations, an assumptions check revealed approximate linearity for all variables and no influential outliers. Pearson's r was used for all correlations. Shapiro-Wilk normality tests revealed violations to normality for some variables, so bootstrapping was used for all non-normally distributed data.

The authors evaluated the covariance between the Communication Matrix total combined score for Levels 6 and 7 and the *sum of meaningful words said* variable. The Communication Matrix total combined score for Levels 6 and 7 was significantly positively related to the *CSBS sum of meaningful words said* (r = .738, bias-corrected and accelerated 95% CI [.186, .940]) and the *play-sample sum of meaningful words said* (r = .787, bias-corrected and accelerated 95% CI [.435, .949]). Because these variables could not be calculated for the log language sample, correlations could not be run for this variable. See Tables 4 and 5 for the remaining correlation results, which include the following variables: *percent of functions coded* (Table 4) and *sum of functions coded* (Table 5).

Table 4
Correlations Between Communication Matrix and Language Sample Percent Functions Coded.

Variable	CSBS Percent Functions Coded	Play Sample Percent Functions Coded	Log Percent Functions Coded
Communication Matrix Total Score Level 4	.016	.49	-
Communication Matrix Total Score Level 5	.28 [-37, .78]	-	-
Communication Matrix Total Score Level 6	.56	.69*	-
Communication Matrix Total Score Level 7	.77 [-.27, 1.00]	.36 [-.42, .88]	-

Note. Bias-corrected and accelerated Bootstrap 95% Confidence Intervals (CI) reported in brackets, – indicates that correlations could not be run because variable values were 0, meaning that there is no data to report. CSBS = Communication and Symbolic Behavior Scales. * p < .05.

Table 5
Correlations between Communication Matrix and Language Sample Sum of Functions Coded.

Variable	CSBS Sum of Functions Coded	Play Sample Sum of Functions Coded	Log Sum of Functions Coded
Communication Matrix Total Score Level 4	.47	.70*	-
Communication Matrix Total Score Level 5	.28 [-42, .79]	-	-
Communication Matrix Total Score Level 6	.68* [.12, .93]	.72* [.25, .93]	-
Communication Matrix Total Score Level 7	.75 [-.39, .99]	.77 [-.46, .98]	-

Note. * p < .05, bias-corrected and accelerated Bootstrap 95% CI reported in brackets, – indicates that correlations could not be run because variable values were 0, meaning that there is no data to report.

Post-hoc inspection of the *percent of functions coded* and *sum of functions coded* data revealed limited variability across participants at Levels 4, 5, and 7. Participants' data at Level 4 was consistently high, suggesting that all children demonstrated increased proficiency in using conventional gestures at various functions of communication to communicate. Additionally, participant's data at Level 7 was consistently low, suggesting that all children demonstrated limited ability to combine two or more words together to produce a meaningful phrase, consistent with the inclusion criteria for this study. Finally, Level 5 was rarely coded in each sample. Because all children used a robust language device (i.e. LAMP Words for Life™ or Proloquo2go) all AAC productions were coded as Level 6. Children rarely used other forms of communication that would be considered Level 5, such as using an object to represent a referent or animal sound to represent an animal. Rowland (2011) mentions that many children may skip this stage. Because AAC productions were coded as Level 6 rather than Level 5, most participants' data was at or close to 0 for this level. The unpredicted lack of variation at Levels 4, 5, and 7 likely contributed to lack of significant findings at these levels across correlations, for there was not enough variation to evaluate covariance. Level 6 is the level with the most variance between children and was the level with consistent significant findings.

In conclusion, the play-sample yielded more significant correlations with the communication matrix than the CSBS, suggesting that in this study, the play-sample is the most valid language sample in comparison to the other two options. However, the CSBS provided more exemplars of communicative acts that can be coded, so the CSBS might be particularly sensitive to minute change over time. Descriptive data revealed, however, that both the CSBS and play sample yielded a substantial number of communicative acts across most categories.

Discussion

The purpose of this study was to determine a language sample elicitation strategy that collects a valid language sample from early language learners who speak using AAC. Specifically, this study evaluated (a) the type of information that can be collected from each elicitation strategy, (b) the differences in the amount of data that can be collected from each elicitation strategy, and (c) the validity of each sample by comparison to Communication Matrix (Rowland, 2004) results. The three language sample elicitation strategies used in this investigation include the CSBS (Wetherby & Prizant, 2003), a generic play-based sample, and automatic data logging transcripts.

Results suggest that both the CSBS and the play-based elicitation strategies yield the following clinically relevant data: form, level of communication, communicativeness of productions, function, word class, turn taking, and a variety of "extra" data points, including imitated productions and route phrase/echolalic productions. These findings align with research that suggests that language samples yield clinically relevant information for verbal speakers (e.g. Heilmann, 2010; Schuele, 2010) and people who speak with longer sentences using AAC (Mooney et al., 2021; Savaldi-Harussi & Soto, 2016). Furthermore, these findings align with research that suggests that a play-based elicitation approach is an appropriate language sample elicitation strategy for early language learners (e.g. Heilmann, 2010).

Automatic data logging results were extremely limited. The log did not provide communicative context, and early language learners' productions are heavily reliant on context (e.g. Crais et al., 2004; Crais et al., 2009). Using data from the log, authors were unable to determine whether single word productions were meaningful and communicative. Additionally, no data could be gathered about other forms of communication, such as gestures, vocalizations, and verbalizations, which play a vital role in early language development (e.g. Crais et al., 2009).

The log elicitation strategy could only reveal that the client used a single form of communication: AAC. Thus, authors were only able to code Form on the language samples, yielding much less clinically relevant data in comparison to the two other elicitation strategies. These findings differ from recent investigations that evaluated clinically relevant data that was gathered through the log (e.g. Kovacs & Hill, 2017; Mooney et al., 2021). However, these other investigations included participants who had surpassed the early stages of language development through AAC, suggesting that this may be an appropriate evaluation tool for more advanced language learners. Kovacs and Hill (2017) even excluded samples that had too many single-word productions and not enough multimorphemic productions to evaluate. This methodological decision suggests reservation in drawing conclusions about expressive language abilities from single-word productions gathered by the log, which supports the findings in this study. To summarize, automatic data logging may yield clinically relevant information for people who produce more complex language through AAC (e.g. Kovacs & Hill, 2017; Mooney et al., 2021). However, it likely is not an appropriate tool to use with early language learners whose language must be evaluated in context to decipher intent and meaning.

Results also indicated that the CSBS consistently elicited the most communicative acts, followed by the play-based sample and then then log. Although the CSBS elicited the most communicative acts, the elicitation strategy that yielded the most samples that best aligned with Communication Matrix results was the generic play-based strategy. The CSBS's structured protocol required that the evaluator provides communication temptations repeatedly throughout the sample (Wetherby & Prizant, 2003). It is possible that these repetitive prompts to communicate yielded a sample that differs from the CAAC's independent ability to communicate. In contrast, the play-based sample did not require the evaluator to prompt communication and, instead, required the evaluator to respond naturally to the child's independent communicative productions. Participants' SLPs were instructed to complete the Communication Matrix so that it represented the child's current ability to communicate, which likely did not take into consideration the child's ability to communicate with extensive communication temptations. Therefore, authors hypothesize that both the Communication Matrix and the generic play-based sample provided data about the child's independent ability to communicate. Additionally, authors hypothesize that the CSBS yielded data about the child's ability to communicate with extensive temptations and prompts. It is possible that this elicitation strategy inflated the child's communication skills and/or elicited specific types of forms, levels, and functions of communication that differ from the child's natural communicative acts. It is, therefore, possible that the CSBS or the play sample may be appropriate for use depending on the goals of the professional. If a professional wants to measure how language is used as it typical for a child in a functional setting, a play-based sample may be best. If a professional wants to measure the limits of a child's communication abilities or to elicit specific communicative acts, the CSBS may be a better option.

Clinical Relevance

These results have immediate clinical implications for practicing SLPs who work with early language learners who speak using AAC. Based on results, practicing professionals can use the play-based elicitation strategy to elicit language samples from early language learners who speak using AAC. Furthermore, professionals can use the coding categories in Table 2 to identify clinically relevant variables that can be analyzed for this population. The fact that this elicitation strategy is free (whereas the CSBS involves a test purchase) and takes less time to complete than the protocolized CSBS is unintended but beneficial for practicing professionals.

Knowledge about an appropriate language sample elicitation strategy for this population is vital to clinical practice. Although omnibus evaluation tools, such as the Communication Matrix, are extremely valuable in representing a child's language abilities, they are less sensitive to minute changes over time and, thus, may not be best for progress monitoring (McCauley & Swisher, 1984). Because progress in early developing expressive language is granular (e.g. Crais et al., 2009), progress monitoring tools that are sensitive enough to capture this granular change are sorely needed. Language sampling may fill this void. Although the sensitivity of language samples has not yet been evaluated with this population, language sampling has been identified as an appropriate progress monitoring tool for verbal speakers (e.g. Hall-Mills, 2018; Heilmann et al., 2010; Schuele, 2010). Future investigations should evaluate the sensitivity of this tool for early language learners who speak using AAC.

Limitations and Future Directions

Limitations impact the conclusions that can be drawn from this study. First, although some participants are Hispanic, all participants were white. This limitation impacts ability to apply findings to all early language learners who speak using AAC, specifically non-white children. This study should be repeated with CAAC of varying races and linguistic backgrounds to determine applicability across all children and to ensure that the profession is using elicitation strategies that are most appropriate for each individual child. Second, this study did not include children with acquired disabilities nor bilingual children for methodological purposes. Future studies should replicate this study with these populations to determine valid elicitation strategies for these populations. Third, this study only includes children who speak using LAMP Words for Life™ and Proloquo2go™. Thus, conclusions can only be drawn for children who speak using these language representations. This study should be replicated with children who speak using other language representations. Fourth, this study had a small sample size and should be replicated with more children.

Additionally, it should be noted that a vital component to effective language sampling is the clinician's ability to observe and evaluate early communicative acts that the child produces in the sample, which was not addressed in this study. Therefore, an important future study would evaluate practicing SLP's ability to identify early communicative behaviors and observe small changes over time in a language sample. Finally, when this study evaluated elicitation strategies that yielded a valid language sample, all early forms of communication, including verbalizations, AAC productions, sign language, vocalizations, and gestures, were included in the evaluation. This study did not focus solely on the various elicitation strategies' ability to evaluate AAC-only productions. It is possible that the elicitation strategy that best elicits all early forms of communication differs from the elicitation strategy that best elicits early language productions through AAC. A follow-up study that investigates the amount, complexity, and validity of expressive language produced through AAC in each language sample should be conducted to further investigate this topic.

This study contributes to the literature about effective language evaluation tools that can be used with early language learners who speak using AAC. Even though additional research is needed, this study is the first step towards evaluating and validating an additional expressive language evaluation tool for this population. Future studies should focus on further evaluation of the type of data that can be elicited from each strategy, specifically considering amount and complexity of AAC productions as they related to the child's natural abilities.

Conclusion

The purpose of this study was to evaluate three language sample elicitation strategies for early language learners who speak using AAC. Results revealed that both the CSBS and the play-based elicitation strategies yielded clinically relevant data for this population. Automatic data logging results lacked context and, thus, provided extremely limited data. Further evaluation revealed that the CSBS consistently elicited samples that provided the most data, followed by the play-sample and then the log. However, the play-based strategy yielded the sample that most consistently correlated with Communication Matrix results. In this early investigation of language sampling CAAC, authors conclude that the play-based strategy yielded results that best represent the participants' natural communicative skills in this study.

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Data Availability Statement

Data sets from this project can be obtained upon reasonable request to authors.

Author Contributions

Courtney Trevino and Emily Lund contributed equally to the following roles in this project: conceptualization and methodology. Courtney Trevino was the lead contributor for the following roles in this project: investigation, formal analysis, data curation, and writing. Emily Lund was the lead contributor for the following roles in this project: resources and review/editing writing. Emily Lund supported completion of the following roles in this project: investigation, formal analysis, and data curation.

CHAPTER III: COMPARING TWO VOCABULARY INTERVENTIONS FOR CHILDREN WHO SPEAK USING AAC

Authors: Courtney Trevino & Emily Lund

Abstract

Purpose: The purpose of this study is to compare the effects of two vocabulary interventions (a structured, explicit instruction intervention and a naturalistic, incidental teaching intervention) for children who speak using AAC (CAAC).

Method: This study used an adapted-alternating treatments single-subject design to compare the effects of both interventions with CAAC who are early language learners, meaning that they produce less than 50 meaningful words on their AAC devices. Three CAAC who speak using robust, high-tech AAC devices participated in this study across 9 weeks. All participants attended two intervention sessions weekly: one explicit instruction session and one incidental teaching session. The order that children received the intervention sessions within each week was randomized. Ten words were taught in each session. All target words were probed prior to intervention and after intervention to determine the total number of words learned in each intervention.

Results: All children learned words in both interventions. However, all children learned words more efficiently in the structured, explicit instruction intervention.

Conclusions: This preliminary data suggests that a structured, explicit instruction intervention yields better vocabulary outcomes than a naturalistic, incidental teaching intervention for early language learners who speak using robust, high-tech AAC.

One of the earliest expressive language skills that children who speak using augmentative or alternative communication (AAC) develop is the ability to produce single, meaningful vocabulary words on the AAC device (Binger et al., 2020). Modeling production of meaningful words on the AAC device is an effective intervention strategy to teach this early vocabulary acquisition (e.g. Drager et al., 2006; Harris & Reichle, 2004). Two common vocabulary intervention approaches that use modeling to teach new words to verbal children include a naturalistic approach (Daugherty et al., 2001; Valdez-Menchaca & Whitehurst, 1988) and a structured approach (Beck & McKeown, 2007; Coyne et al., 2007). Although both intervention approaches have been linked with vocabulary gains in verbal children (e.g. Coyne et al., 2007; Daugherty et al., 2001), recent studies suggest that the structured approach yields better vocabulary outcomes for verbal children with or at risk for vocabulary deficits (e.g. Coyne et al., 2007; Lund & Douglas, 2016). This structured intervention approach has yet to be investigated with children who speak using AAC (CAAC); all current word learning studies with CAAC investigate the impact of modeling when using a naturalistic approach (Drager et al., 2006; Harris & Reichle, 2004; Hall, 2014; and Romski et al., 2010). Thus, the purpose of this study is to compare the effects of a naturalistic word learning intervention to a structured word learning intervention with CAAC to determine the intervention approach that is most effective with this population.

Language Development through AAC

Some children with intellectual and/or developmental disabilities experience limitations with verbal speech. To supplement or substitute verbal speech, these children can communicate using an augmentative or alternative communication (AAC) device (ASHA, n.d.b). Various types of AAC devices exist. Low-tech AAC devices include nonelectronic equipment that a person can use to communicate a message (e.g. a communication board, which is a piece of paper with multiple images to which a person can point to communicate; ASHA, n.d.b). High-tech AAC devices include electronic equipment that CAAC can activate, causing the device to speak a message aloud (ASHA, n.d.b). Some high-tech devices are linguistically simple; they produce a limited number of recorded, simple messages (e.g. a GoTalk™ or a single switch that produces a single message aloud upon activation). For clarity purposes, this manuscript will refer to these linguistically simple, electronic devices as "mid-tech AAC." High-tech AAC devices also include tablets or tablet-like equipment with an application that displays the words and morphemes of a language (ASHA, n.d.b). Children who speak using these linguistically robust, high-tech AAC devices can combine words and morphemes together to create utterances. The tablet will then speak their message aloud. This paper primarily focuses on these linguistically robust, high-tech AAC devices. Thus, the terms "AAC" and "AAC device" throughout this manuscript will refer to these robust, high-tech AAC devices. Other types of AAC devices will be called low-tech or mid-tech AAC devices.

When CAAC obtain an AAC device, they typically do not produce meaningful messages on the device instantaneously. CAAC progress through developmental milestones as they learn to produce meaningful language on an AAC device. One of the first things that CAAC must learn when they obtain an AAC device is to say single, meaningful words on the device (Binger et al., 2020). Vocabulary acquisition is an essential step in the language development process. Logically speaking, children cannot progress to the production of phrases and sentences if they have not acquired enough vocabulary words to do so. Therefore, CAAC's ability to progress through developmental linguistic milestones and produce complex and meaningful language is dependent upon early vocabulary acquisition.

Word Learning and AAC

Early word learning is foundational to the process of language development through AAC (Binger et al., 2020); nonetheless, the literature indicates that CAAC may experience difficulty in acquiring early vocabulary words. Two studies surveyed special education providers across the United States regarding the expressive language abilities of CAAC. Andzik and colleagues (2018) found that 62.3% of CAAC in their sample demonstrate ability to produce fewer than 30 meaningful words on their AAC devices. Additionally, Erickson and Geist (2016) revealed that 69% of CAAC in their sample demonstrate ability to produce a limited number of single words on their AAC devices (this particular finding includes all types of AAC devices). These data suggest that (a) the majority of CAAC are in the early word learning stage of language development through AAC, indicating that early word learning is a highly relevant topic of investigation for this population, and (b) that the CAAC population in general may experience difficulty with early acquisition of vocabulary words, which can limit progress in expressive language development through AAC. Thus, researchers must pinpoint the most effective intervention strategies to facilitate early word learning for CAAC, ultimately supporting progression to more advanced stages of language development through AAC.

Modeling expressive language productions on an AAC device supports word learning for CAAC (e.g. Drager et al., 2006; Harris & Reichle, 2004). For example, if a person says, “stop,” verbally, that person can also model production of that word by producing “stop,” on the AAC device. This modeling strategy is described using a variety of terms across intervention studies that have the goal of targeting word learning for CAAC. For example, the strategy called “augmented input” requires that communication partners produce some verbalized words on the AAC device while talking (Romski & Sevcik, 1996). “Aided AAC modeling” requires that, after providing a model on the AAC device, the interventionist provides an expanded verbal model of the target word (Binger & Light, 2007). "Aided language modeling" requires that, during naturalistic play, communication partners point to the referent of the target word, model production of the target word on the device, and then speak that word aloud (Drager et al., 2006). "Aided language stimulation" requires that communication partners model word productions on the AAC with all ongoing expressive language productions (Goosens, 1989), and "natural aided language" combines aided language stimulation with strategies of the natural language paradigm and incidental teaching (Cafiero, 2001). In this paper, the term "augmented input" will be used to describe the act of modeling expressive language productions on an AAC device.

Interventions that include augmented input show positive results for CAAC word knowledge. For example, using single-subject design, Harris and Reichle (2004) embedded aided language stimulation, which includes augmented input, into three different scripted play routines in a naturalistic manner (i.e. during play, the interventionist pointed to a referent, pointed to the correlating AAC symbol, and said the target word aloud). The three preschool CAAC participants with moderate cognitive deficits used low-tech AAC communication boards that displayed six vocabulary words using black-and-white symbols. All participants demonstrated an increase in accurate object labeling using low-tech AAC during and after intervention. Similarly, using single-subject design, Drager and colleagues (2006) embedded aided language modeling, inclusive of augmented input, into three different naturalistic play activities (i.e. during play, interventionists pointed to target objects, pointed to the correlating AAC symbol, and said target word aloud). The two autistic CAAC participants used low-tech AAC communication boards that displayed six vocabulary words using colored symbols. Both participants demonstrated an increase in accurate object labeling using low-tech AAC during and after intervention.

Furthermore, using single-subject design in a dissertation study, Hall (2014) embedded aided language stimulation into interactive activities (e.g. book sharing). The autistic CAAC participant used low-tech AAC communication boards that displayed six words using colored symbols. Results revealed that the participant produced words during intervention sessions that were reported by parents as "unknown words" prior to intervention; the author concluded that the intervention yielded word learning for this participant.

One larger study, a randomized controlled trial, also explored the effects of augmented input. Romski and colleagues (2010) randomized 62 CAAC participants into one of three interventions: (1) augmented input, (2) augmented output (provided verbal prompts or hand-over-hand to require participants to select target words), and (3) spoken communication (provided verbal prompts to say target words verbally). Participants used mid-tech communication devices, such as GoTalk™ and CheapTalk™, and target vocabulary were identified by parents as words that were unknown to participants. Language sample results from the 18th and last (24th) intervention sessions revealed that children in the augmented input and output groups produced more target vocabulary words than the children in the spoken communication group. Authors concluded that the augmented interventions, including the augmented input intervention, yielded expansion in vocabulary size for participants.

Many other investigations evaluate the effects of augmented input on other early language skills, such as turn taking (e.g. Kent-Walsh et al., 2010), communicative acts (e.g. Trembath et al., 2009; Trottier et al., 2011), number of times the AAC device was used (e.g. Douglas et al., 2023; Brock & Thomas, 2021), and number of different words produced (e.g. Kasari et al., 2014; Quinn et al., 2020). Although participants may have learned new words in these studies, word learning itself was not directly reported. Thus, augmented input may have a myriad of positive effects for CAAC.

Although there are positive effects on word learning documented for augmented input with AAC (Drager et al., 2006; Harris & Reichle, 2004; Hall, 2014; and Romski et al., 2010), none of the studies investigated the impact of augmented input when using robust, high-tech AAC devices that many CAAC currently use to communicate (e.g. LAMP Words for Life™, Proloquo2go™). This is important because, logically speaking, learning to produce a vocabulary word on a single communication board that displays six icons may be different than learning to produce a vocabulary word on a robust AAC device that stores thousands of words. CAAC may need to navigate through pages on the robust AAC device to find a target vocabulary word, which is not necessary on a low-tech communication board with 6 symbols. Thus, the impact of augmented input on vocabulary acquisition when using robust, high-tech AAC devices has yet to be investigated.

Word Learning and Verbal Children

Two common word learning approaches that are used to teach new words to verbal children include a naturalistic approach and a structured approach. Other studies have evaluated the impact of these intervention approaches on word learning with children with disabilities to determine which approach is most effective (e.g. Lund & Douglas, 2016). A next step in the investigation of augmented input is to evaluate these approaches for CAAC as well.

Naturalistic Word Learning Approach

Some vocabulary interventions for verbal children adhere to a naturalistic approach, sometimes called incidental teaching. In incidental teaching, words are taught during natural exchange between the interventionist and the child (e.g. Daugherty et al., 2001; Valdez-Menchaca & Whitehurst, 1988). An important component of this naturalistic word learning exchange is a strategy called follow-in labeling. When implementing follow-in labeling, the interventionist waits for the child to demonstrate interest in an item or activity. The interventionist then follows the child's lead and labels the item or activity in which the child is demonstrating interest (Lund & Douglas, 2016; Valdez-Menchaca & Whitehurst, 1988). This natural exchange yields a teaching opportunity during which the child can learn this new word.

Studies indicate that this incidental teaching vocabulary instruction approach teaches words to typically developing verbal children (Valdez-Menchaca & Whitehurst, 1988), verbal children with developmental delay (Daugherty et al., 2001) and children with autism (McDuffie & Yoder, 2010). Existing investigations regarding the effects of augmented input on word learning utilize a naturalistic, incidental teaching approach (Drager et al., 2006; Harris & Reichle, 2004; Hall, 2014; and Romski et al., 2010). Thus, extant literature about early word learning with CAAC has specifically focused on this naturalistic approach; conclusions across these studies suggest that this approach teaches vocabulary words to CAAC.

Structured Word Learning Approach

Some vocabulary interventions for verbal children adhere to a more structured approach, oftentimes referred to as explicit or direct instruction. In this structured intervention approach, words and their definitions are taught explicitly and in depth to students. Explicit instruction vocabulary interventions typically include all or some of the following components: description of the word's definition, instruction about and/or practice pronouncing the word, multiple exposures to the word, and activities that encourage deep processing of the vocabulary word (e.g. determining if the word was used correctly or not; e.g. Beck & McKeown, 2007; Coyne et al., 2007).

Research suggests that explicit instruction is an effective word learning intervention strategy for verbal children (e.g. Beck & McKeown, 2007; Coyne et al., 2007; Lund & Douglas, 2016). Explicit instruction for children without disabilities is particularly useful for teaching words that are unlikely to occur in their day-to-day environments (e.g. academic vocabulary). However, extant literature suggests that explicit instruction may be a superior intervention strategy in comparison to incidental teaching even for everyday vocabulary for children with or at risk for vocabulary deficits (e.g. Coyne et al., 2007; Lund & Douglas, 2016). Coyne and colleagues (2007) compared the effects explicit instruction to incidental teaching with kindergarten children at risk for vocabulary deficits and found that children demonstrated increased knowledge of target vocabulary words when taught through explicit instruction. Similarly, using single-subject design, Lund and Douglas (2016) found that children who are deaf or hard of hearing learned more words from an explicit instruction intervention than an incidental teaching intervention. For children at risk for vocabulary delays, knowing that explicit instruction may be a more efficient strategy matters: children who are delayed in their vocabulary knowledge must learn words at a relatively fast rate to begin closing the knowledge gap with their peers who do not struggle with vocabulary.

Vocabulary Approaches and CAAC

The effects of these two vocabulary intervention approaches have yet to be compared with CAAC. However, in a dissertation study, Ho (2000) used single-subject design to compare the effects of a structured intervention to a naturalistic intervention on symbol learning (i.e. percent of symbols on an AAC device identified correctly). The three CAAC participants used low-tech AAC devices with black and white symbols. Ho found that participants learned more symbols and met criterion more quickly in the structured intervention, suggesting that a structured intervention may be beneficial for more efficient learning in CAAC.

The purpose of this study is to compare the effects of an explicit instruction vocabulary intervention to the effects of an incidental teaching vocabulary intervention with early language learners who speak using AAC on robust, high-tech devices (i.e. CAAC who produce less than 50 meaningful words on their AAC devices; Nelson, 1973). In this study, three CAAC participants received two vocabulary intervention sessions weekly: one using an explicit instruction approach and one using an incidental teaching approach. Participants learned different wordlists in each intervention type. Probing took place prior to beginning each wordlist and after each intervention session to measure number of words learned in each intervention. The following question was addressed:

1. Does an explicit instruction vocabulary intervention or an incidental teaching vocabulary intervention yield more words learned for early language learners who speak using AAC?

Methods

The Texas Christian University institutional review board approved this study (IRB#2023-19). Authors employed an adapted alternating-treatments single-subject design to compare CAAC's vocabulary outcomes resulting from two different interventions: an explicit instruction intervention and an incidental teaching intervention. The adapted alternating treatments design allows for comparison of the effects of two different interventions on an irreversible behavior (i.e. word learning) within a single subject. This design includes two conditions: a baseline condition, in which preintervention skills are evaluated, and an experimental condition, in which both interventions are implemented with a unique set of target items (e.g. with two different sets of vocabulary words). The effects of the two interventions are evaluated by comparison of the rate of acquisition of target items in each intervention (Sindelar et al., 1985).

Participants

Of the three consent forms that were distributed, all three were returned. Two participants were in kindergarten, and one participant was in second grade. Two participants were female and one was male. Two participants' annual household income was reportedly below $50,000, and one participant's was reportedly below $150,000. Child 1 comes from a bilingual household (English and Spanish spoken equally in the home), and Children 2 and 3 come from monolingual, English-speaking households. See Table 1 for profiles of each child participant.

Table 1
Participant Data.

Child	Diagnosis	CA	Race/Ethnicity	Years Using LAMP WFL	Leiter-3 Nonverbal IQ	TELD-4 Raw Score[a]	PPVT-5 Standard Score
Child 1	Not Reported	5;11	White/Hispanic	1 year	75	17	67
Child 2	Down Syndrome, DHH	8;7	White/Not Hispanic	2 years	61	14	48
Child 3	ID	5;11	White/Hispanic	2 years	61	20	57

Note. CA = chronological age, DHH = deaf or hard of hearing, ID = intellectual disability, Leiter = Leiter International Performance Scale-Third Edition, PPVT-5 = Peabody Picture Vocabulary Test-Fifth Edition, TELD = Test of Early Language Development–Fourth Edition, WFL = Words for Life.
[a]TELD-4 raw scores are reported because these Child 2's chronological age exceeds the norms to convert the raw score to a standardized score.

Additional inclusion criteria for this study included the following: (a) spoke using AAC, specifically LAMP Words for Life™, (b) demonstrated the ability to produce between 15 – 60 meaningful words using AAC (ensuring participants were ready to learn meaningful words and were still in the early word-learning stage of language development; e.g. Nelson, 1973; Rescorla, 1989), and (c) had a developmental disability. Criterion (a) was included because the intervention protocol for the explicit instruction intervention included navigation description. Navigation description requires that the interventionist names the icons that must be selected to navigate to and produce the target word (e.g. "to say the word mouse, first touch the dog, then the pets, then the mouse"). To standardize this procedure across participants, ensuring that results across participants were comparable, participants needed to speak using the same language representation (i.e. LAMP Words for Life™) so that the navigation description was the same for all participants.

Potential participants were excluded if they (a) were diagnosed with or suspected of having autism spectrum disorder or (b) had an acquired disability. Children with autism spectrum disorder were excluded because research suggests that they may process language differently than children with other diagnoses (e.g. ASHA, n.d.c; Herringshaw et al., 2016), which could impact their response to interventions in this study. Children with an acquired disability were excluded because expressive language deficits resulting from an acquired disability can differ from language deficits resulting from a developmental disability (e.g. ASHA, n.d.a).

Materials

Wordlists for Intervention

To prepare for intervention, authors developed 10 wordlists of 10 words each (totaling 100 words) to be taught in the intervention condition. Wordlists were made up of nouns and verbs because these word classes are developmentally appropriate word classes to learn in early language development (Nelson, 1973). Vocabulary words in wordlists were identified from the Stanford Wordbank (Stanford University, n.d.), which is a list of words commonly learned in early language development. All nouns and verbs from the word bank that can be transparently represented in a picture were identified (e.g. foot, airplane, jump, run), and the earliest developing, picturable nouns and verbs from the Wordbank were included in wordlists. Authors added one word that was not on the Stanford Wordbank list to meet balancing criteria (described below): iPad. A practicing speech-language pathologist who serves CAAC verified that this term was appropriate for this population. Common core vocabulary words (e.g. want, play, stop, go) were not included in the wordlists for this study. Participants in this study had reportedly already acquired some or all of these words and, thus, were not appropriate to teach in intervention.

Authors balanced wordlists for word class and for number of icons on the AAC device that needed to be touched (or “hit”) to navigate to the target vocabulary word. To balance for word class, authors included six nouns and four verbs in each wordlist. To balance for the number of icons that needed to be hit to produce the target word, four nouns and three verbs in each list required three hits to say those target words. Additionally, two nouns and one verb in each wordlist required two hits to say those target words. Each wordlist had no more than three words from a single category (e.g. three animals, three transportation words), and each category was kept to a single intervention (i.e. animals were taught in the direct instruction intervention only, and transportation words were taught in the follow-in labeling intervention only). This category containment prevented participants from learning the location of a category (e.g. animals) in one intervention and then using that knowledge to find another target word from the same category in the other intervention. Wordlists used in the explicit instruction intervention are in Appendix A, and wordlists used in the incidental teaching intervention are in Appendix B.

Pictures of Words in Wordlists

Each word was represented by two different pictures: one black and white line drawing that was used for probing and one colored picture that was used for intervention. Authors used the validated black and white line drawings from Snodgrass and Vanderwart's (1980) article for all wordlist words that were represented in that article. Black and white line drawings for all words that were not represented in that article (all verbs and some nouns) and all colored pictures were retrieved from the internet. Two children who did not speak using AAC validated that all pictures (both colored and black and white) that were retrieved from the internet accurately represented the target word by correctly naming the picture in a confrontation naming task.

AAC Devices

All participants used the LAMP Words for Life™ language representation for at least one year prior to the start of the study, and all participants accessed their AAC device using direct select with a finger without any support or accommodations. LAMP Words for Life™ was chosen through an AAC evaluation and AAC device trials for all three participants. All participants used the LAMP WFL Full vocabulary set without any words hidden, meaning that all thousands of words that this language representation displays were available to be selected during intervention. Authors *did not* create a page on the participants' AAC devices that displayed the target words from the intervention wordlists. Rather, all target words were located in the preprogrammed, original location in the LAMP Words for Life™ application.

Procedures

Overview of Procedures

All probing and intervention sessions took place at an elementary school in two rooms that are used to deliver special education services. Both rooms were approximately 8 ft. x 8 ft., had at least two chairs and one desk, and were well lit. Probing and intervention procedures were adapted from a word learning study with children who are deaf or hard of hearing (Lund & Douglas, 2016). Per the adapted-alternating treatments single-subject design protocol, participants underwent two conditions: probing condition and intervention condition. In the probing condition, all words in a wordlist were probed three times to ensure that children knew two or fewer words in a wordlist prior to intervention. Words produced zero or one time correctly were considered unknown words prior to intervention, and words produced two or three times were considered known words prior to intervention. If a participant knew more than two words in a single wordlist, the wordlist was either not used or known words within that wordlist were replaced with unknown words (while maintaining wordlist balance).

After the probing condition, children entered the intervention condition. Participants individually attended two intervention sessions weekly on different days of the week for nine consecutive weeks; one session followed the explicit instruction intervention protocol, and the other session followed the incidental teaching intervention protocol (both described in the Intervention Condition section). Authors used a random number generator to randomize the order that the interventions were provided within a week. Within each intervention session, one word list (i.e. 10 words) was taught to the participant.

After targeting a single wordlist, interventionists used probing condition procedures to evaluate the child's knowledge of the taught words. The child had to show 70% mastery of the targeted wordlist twice to move onto a new wordlist. Wordlists were probed immediately after intervention and, if criterion was met, probed again at the beginning of the following intervention session. If a child did not meet criterion on a single word list 5 weeks in a row, that list was discontinued, and a new wordlist was used. All intervention sessions were video recorded on a computer.

Probe Assessment Procedures

In probe assessments, children sat at a desk or on the ground across from the first author. The first author showed a black and white image of each target word to the participant, and the child was prompted to name that word on the AAC device. Participants were given 10 seconds of wait time to begin to formulate a response. Without initiation of a response within 10 seconds, participants were re-prompted to name the picture and given another 10 seconds of time to formulate a response. If the child did not produce a response after both prompts, the response was recorded as “no response” and incorrect. Synonyms or similar words of target words (e.g. producing “rat” rather than “mouse”) were re-prompted (e.g. “can you tell me another word for this?”). A second inaccurate response was recorded as incorrect. Any independently self-corrected responses were counted as correct. Total number of correct responses in probes is the dependent variable in this study.

Intervention Condition

In both intervention conditions, the target word was modeled four times and the child was prompted to imitate four times. All models were produced both verbally and on the AAC device. In both interventions, if a child imitated a word inaccurately, the interventionist said, “good try; this word is ______” and provided an additional model of the target word according to modeling procedures within that intervention protocol.

Explicit Instruction Protocol. Intervention sessions in this condition lasted approximately 30 minutes. This protocol was developed to include components of explicit instruction interventions (e.g. Beck & McKeown, 2007; Coyne et al., 2007; Lund & Douglas, 2016) at a linguistically appropriate level for early language learners. This intervention included three phases: (1) introduction to word, (2) direct retrieval practice, and (3) expressive practice. In Phase (1), the interventionist showed the color picture that represents the target word to the child and modeled production of the word. While producing the word on the AAC device, the interventionist used navigation description to label each icon that must be touched to navigate to the target word (e.g. "to say the word mouse, first touch the dog, then the pets, then the mouse"). Then, the interventionist prompted the child to imitate the production on the AAC device and provided navigation description to support the participant's production. This introduction was completed with all 10 words in the wordlist. Navigation description was used in the explicit instruction protocol because explicit instruction typically includes instruction about pronunciation of a target word (Beck & McKeown, 2007; Coyne et al., 2007). However, CAAC produce target words by moving their hand to select words on the AAC device rather than moving their articulators to produce a word verbally. Thus, navigation description was implemented as an alternative to pronunciation instruction to support learning the motor movements necessary to produce a target word.

In Phase (2), which included direct retrieval practice, all 10 colored images that represented target words were placed in front of the child. The interventionist said, "point to _______," and named one of the 10 target words in random order. This procedure continued with all target words. If the child pointed to the incorrect picture, the interventionist provided feedback by saying, "this one is the _______," and pointed to the correct picture. At the end of this phase, the interventionist prompted participants to point to any pictures that were inaccurately identified. This procedure continued until the participant correctly pointed to all pictures. This direct retrieval practice was included as a deep processing activity, which is commonly included in explicit instruction (Beck & McKeown, 2007; Coyne et al., 2007)

In Phase (3), the interventionist presented one picture of a target word (e.g. mouse) at a time. The interventionist modeled production of the target word three times and prompted the child to imitate three times. In all models and imitations, the interventionist provided navigational description. For all targeted nouns, the interventionist presented a toy that represented the target word (e.g. a toy stuffed mouse) and described the noun to support word learning (e.g. a mouse is an animal with a long tail). The child played with the toy briefly. For all targeted verbs, the interventionist described the action, used a baby doll to act out the action, and if possible, prompted the child to act out the action. Description of the target word was included because explicit instruction typically includes description of the target word's definition (Beck & McKeown, 2007; Coyne et al., 2007). This process was repeated with all 10 target words.

Incidental Teaching Condition. Intervention sessions in this condition lasted approximately 20 minutes. This condition did not include any phases; rather, this condition included naturalistic play with the target word and follow-in labeling, which is a common strategy used in incidental teaching (e.g. Lund & Douglas, 2016). In this condition, the interventionist placed two colored pictures (representing two of the target words) in front of the participant. The interventionist provided wait time for the participant to demonstrate interest in one of the pictures and draw the interventionist's attention towards that picture (e.g. hold up one picture to show to interventionist). If the participant did not show interest in one of the pictures within 10 seconds of wait time, then the interventionist interacted with one of the pictures without inviting the child to join until the participant showed interest in one of the pictures. If the participant interacted with the picture but did not initiate communication with the communication partner, the interventionist imitated the child's play until the child initiated interaction with the interventionist. In no instances did a participant refrain from initiating interaction with the interventionist about a picture. This procedure has been considered a follow-in labeling approach previously in the literature (e.g. Lund & Douglas, 2016; Kaiser & Roberts, 2013).

Once interaction was initiated, the interventionist modeled production of the target word and prompted the child to imitate. Then, if targeting a noun from the wordlist, the interventionist engaged the child in natural play with the picture and toy that represent the target word (e.g. if the target word is, "spoon," the interventionist and child pretended to eat with the spoon). If targeting a verb from the wordlist, the interventionist talked about the action on the picture, used a doll to complete the action, and prompted the participant to either complete the action or have the doll complete the action. Throughout this natural play, the interventionist modeled production of the word three more times and prompted the child to imitate three more times. Navigational description was not used in the incidental teaching protocol, for specific instruction about production of a word is unique to explicit instruction (Beck & McKeown, 2007; Coyne et al., 2007). This procedure proceeded with all 10 target words.

Reliability

Scoring and Interobserver agreement

All probes were scored by the interventionist (a graduate student clinician). A trained second scorer (an undergraduate student in communication sciences and disorders) scored 93% of probes for Child 1, 100% of probes for Child 2, and 93% of probes for Child 3. Participants received one point for an accurate response and zero points for an inaccurate response or no response. Scorers then divided the number of accurate responses by total number of words in wordlist and multiplying by 100. Both scorers individually calculated probing accuracy and then compared results to assess for agreement. Agreement was calculated by dividing total number of agreed upon probing results by total number of probes and multiplying by 100. Agreement reached 100% for Child 1 and Child 2 and 93% for Child 3. Thus, original scoring was used in all analyses.

Fidelity

Fidelity was assessed in 100% of intervention sessions for all participants. To assess for fidelity, either the first author or a trained undergraduate student in communication sciences and disorders compared actual intervention procedures against the intervention protocol. Fidelity was calculated by dividing total number of protocol steps that were followed in intervention by the total number of protocol steps and multiplying by 100. Fidelity for each participant in each intervention condition was above 98%.

Results

The purpose of the study was to compare the total number of words learned across 3 participants in two different intervention conditions: (a) explicit instruction and (b) incidental teaching. See Figures 1, 2, and 3 for each participant's results.

Baseline Condition

During baseline probing, children demonstrated ability to name some words in the wordlists. Recall that wordlists were modified to ensure that participants knew no more than two words prior to intervention. In the explicit instruction intervention, Child 1 knew two words in the first list, two words in the second list, and four words in the third list. Child 1 acquired words quickly, and she appeared to teach herself the location of new target words based on past intervention instruction. By the end of the study, authors were unable to provide a balanced wordlist in which Child 1 knew two or less words. Thus, she began the third wordlist knowing four of the 10 words. In the incidental teaching intervention, Child 1 knew two words in the first list and zero words in the second list. Child 2 knew one word in the first explicit instruction intervention wordlist and zero words on all other wordlists in both interventions. In both the explicit instruction and incidental teaching interventions, Child 3 knew zero words in the first list and one word on the second. Because wordlists were modified to ensure that children knew two or less words prior to intervention, wordlists used in intervention differ from the original wordlists in the appendices.

Intervention Condition

All children missed the incidental teaching intervention session in week 1 and the explicit instruction intervention session in week 6 because school was closed on those days. Individual absences are reported for each child in sections below. It should be noted that all children were absent at least 1 time for an explicit instruction intervention session, and none of the children were absent for an incidental teaching intervention session. Thus, all children received more incidental teaching intervention sessions than explicit instruction intervention sessions.

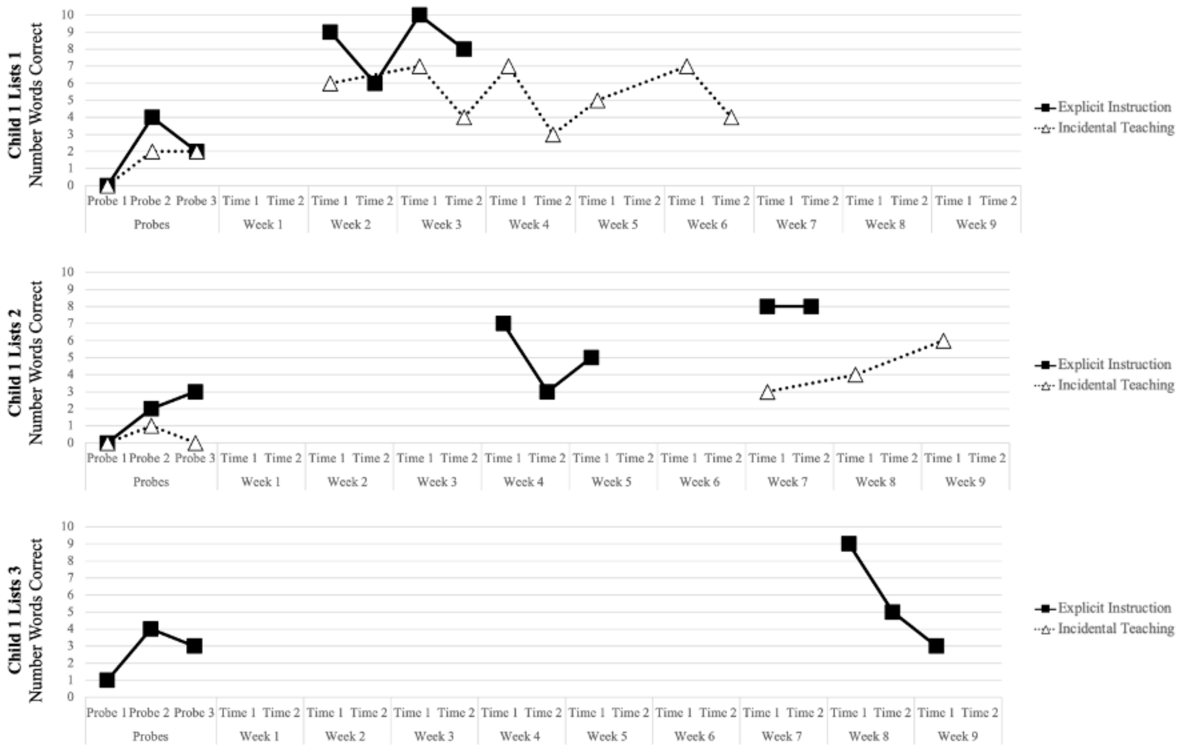
All participants' responses to both interventions are displayed in Figures below. Both authors and a blinded third viewer of the data individually concluded that all children learned more words in the explicit instruction intervention than the incidental teaching intervention. This is confirmed by one demonstration of more words learned in the explicit instruction intervention than the incidental teaching intervention and at least two replications of this pattern for each child.

Participants learned an average of 10.79 words in the explicit instruction intervention and 5.78 words in the incidental teaching intervention. Thus, even though all participants received fewer explicit instruction intervention sessions than incidental teaching intervention sessions, they still learned an average of 5.01 more words in the explicit instruction intervention than in the incidental teaching intervention. To calculate these averages, authors identified the number of words within a wordlist that were produced correctly two or three times in baseline probing. Authors subtracted this number from the total number of words produced accurately in probing after each intervention session that targeted that wordlist. This procedure identified the total number of words that were learned in each intervention session. These results were added together and divided by the total number of times that that wordlist was targeted in intervention. This procedure was completed for all wordlists targeted. The results for the explicit instruction intervention were added together, and the results for the incidental teaching intervention were added together. Results for each individual child are described below.

Child 1

Figure 1 displays Child 1's response to both interventions across multiple wordlists. Child 1 was absent for the explicit instruction intervention session in week 1 but was present for all other sessions. Thus, she received seven explicit instruction sessions and eight incidental teaching sessions. In the explicit instruction intervention, Child 1 met criterion for the first wordlist in week 3 and the second word list in week 7. She learned the third word list in the final two weeks of therapy. In the incidental teaching intervention, Child 1 never met criterion on the first wordlist, so this list was abandoned after 5 intervention sessions (per intervention protocol). She learned the second list in the final three weeks of therapy but did not meet criterion on this list, either. Across all nine weeks, Child 1 learned an average of 14.67 words in the explicit instruction intervention and an average of 8.73 words in the incidental teaching intervention. To quantify comparisons across lists and effectiveness estimates, a regression analysis was conducted with a single-level model where the difference in baseline versus treatment was dummy coded, such that β_0 represents baseline level and β_1 reveals the change in level between baseline and treatment. For direct instruction with the first word list, $\beta_0 = 2.00$ (p = .12) and $\beta_1 = 6.25$ ($p = .007$) and for incidental teaching, $\beta_0 = 1.33$ ($p = .16$) and $\beta_1 = 4.04$ ($p = .003$). For direct instruction with the second word list, $\beta_0 = 1.67$ ($p = .19$) and $\beta_1 = 4.53$ ($p = .02$) and for incidental teaching, $\beta_0 = .333$ ($p = .64$) and $\beta_1 = 4.00$ ($p = .013$). Only direct instruction occurred with a third word list, and for that list $\beta_0 = 2.67$ ($p =.128$) and $\beta_1 = 3.00$ ($p = .20$), so change was not significant. Because β_1 represents change from baseline to intervention for two of these sets of words, these results support the increased effectiveness of direct instruction were they could be compared.

Figure 1
Child 1's performance by intervention type.



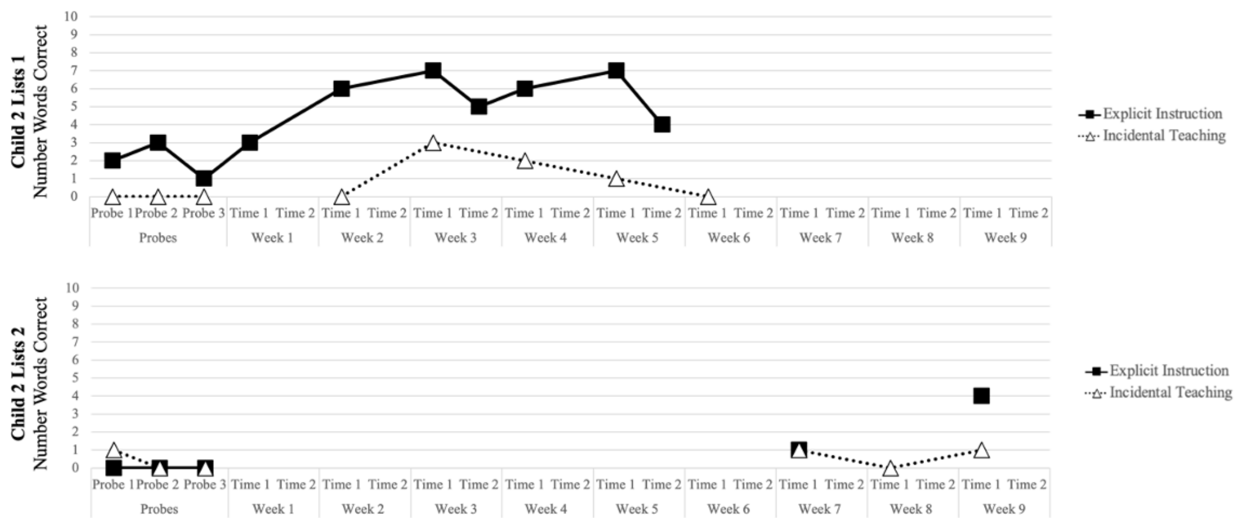
Child 2

Figure 2 displays Child 2's response to both interventions across multiple wordlists. Child 2 was absent for the explicit instruction session in week 8 but was present for all other sessions. Thus, she received seven explicit instruction intervention sessions and eight incidental teaching sessions. Child 2 did not meet criterion on any word lists across both interventions, so wordlists were abandoned after being targeted for five weeks in a row or at completion of the study. Across all nine weeks (i.e. two sets of wordlists), Child 2 learned an average of 7.30 words in the explicit instruction intervention and an average of 1.87 words in the incidental teaching intervention. Again, to quantify comparisons across lists and effectiveness estimates, a regression analysis was conducted with a single-level model where the difference in baseline versus treatment was dummy coded. For direct instruction with the first word list, β_0 = 2.00 (*p* =

.039) and β_1 = 3.43 (p = .008) and for incidental teaching, β_0 = 0 (p = 1.00) and β_1 = 1.20 (p = .17). For direct instruction with the second word list, β_0 = 0 (p = 1.00) and β_1 = 2.50 (p = .11) and for incidental teaching, β_0 = .333 (p = .37) and β_1 = .333 (p = .52). Again for this participant, results from the first list confirm the increased effectiveness of direct instruction as compared to incidental teaching.

Figure 2

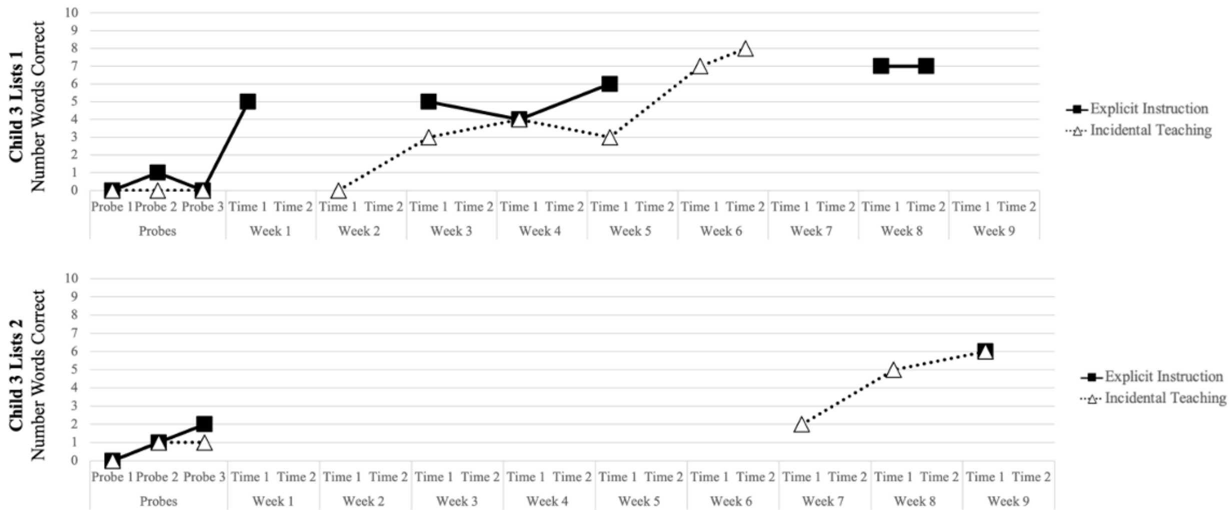
Child 2's performance by intervention type.



Child 3

Figure 3 displays Child 3's response to both interventions across multiple wordlists. Child 3 was absent for the explicit instruction intervention session in weeks 3 and 7 but was present for all other sessions. Thus, he received six explicit instruction intervention sessions and eight incidental teaching sessions. In the explicit instruction intervention, Child 3 met criterion for the first wordlist in week 8 and learned the second wordlist for the last intervention session. In the incidental teaching intervention, Child 3 met criterion for the first wordlist in week 6 and learned the second wordlist for the final three weeks of intervention. Child 3 learned an average of 10.40 words in the explicit instruction intervention and an average of 6.73 words in the incidental teaching intervention.

Figure 3
Child 3's performance by intervention type.



It should be noted that Child 3 likely learned one more word in the first list of the explicit instruction intervention than Figure 3 reveals. Child 3 learned the word, "sandwich," within the first few weeks of intervention. Upon presentation of the color picture of "sandwich" during intervention, Child 3 would produce the word on the AAC device prior to the interventionist modeling the word. However, during baseline probing and probing after each intervention session, he perceived the black and white picture of "sandwich" to resemble "cake" and, thus, produced the word, "cake," consistently for this probe. This errored response was recorded as inaccurate even though he demonstrated knowledge of the word during the intervention session. Thus, based on observational data, he likely learned one more word in the first list in the explicit instruction intervention than is represented in Figure 3.

Furthermore, it should be noted that Figure 3 reveals that Child 3 learned the same/similar number of words in both interventions. However, Child 3 received two fewer intervention sessions in the explicit instruction intervention in comparison to the incidental teaching intervention. These results indicate that he learned words more efficiently in the explicit instruction intervention in comparison to the incidental teaching intervention. A regression analysis baseline versus treatment dummy coded reveal that, for direct instruction with the first word list, $\beta_0 = .333$ ($p = .61$) and $\beta_1 = 5.33$ ($p < .001$) and for incidental teaching, $\beta_0 = 0$ ($p = 1.00$) and $\beta_1 = 4.17$ ($p = .049$). For direct instruction with the second word list, $\beta_0 = 1.00$ ($p = .23$) and $\beta_1 = 5.00$ ($p = .049$) and for incidental teaching, $\beta_0 = .667$ ($p = .49$) and $\beta_1 = 3.67$ ($p = .042$). Again for this participant, these results confirm the increased effectiveness of direct instruction as compared to incidental teaching.

Post-Hoc Analysis

Following the planned analysis, authors were curious about how many nouns and verbs each child learned. Because differing amounts of nouns and verbs were in each word list, authors calculated percent of nouns learned and percent of verbs learned to allow for comparison between the word classes. To calculate percent of nouns learned, authors subtracted the number of nouns within a wordlist that the child knew in probes prior to intervention from the total number of nouns taught within a session. This yielded the number of unknown nouns taught within a session. Authors then identified the number of nouns produced accurately in probes after the intervention session and subtracted any nouns that were known prior to intervention. This yielded the number of unknown nouns learned within a session. Authors divided the number of unknown nouns taught by the number of unknown nouns learned to yield the percent of nouns learned within a single intervention session. This was completed for all intervention sessions. Percentages were averaged together to yield a total average percent of nouns learned. The same procedure was used to calculate a total average percent of verbs learned. Child 1 learned 68.66% of nouns taught and 49.99% of verbs taught. Child 2 learned 34.66% of nouns taught and 13.33% of verbs taught, and Child 3 learned 50.71% of nouns taught and 31.54% of verbs taught. Thus, all children learned more nouns than verbs.

Overall Impression

The overall impression from the resulting data is that participants with intellectual and developmental disabilities learned words on their AAC device in both interventions. However, Child 1 and Child 2 learned more words in fewer sessions in the explicit instruction condition, and Child 3 learned the same number of words in both interventions with less sessions in the explicit instruction intervention. These data suggest that the explicit instruction intervention yields more efficient word learning for this population. The extent that children experienced success in the naturalistic, incidental teaching intervention differed across participants. For example, Child 3 learned more words in the incidental teaching intervention in comparison to Child 2, who learned almost no words in that intervention.

Discussion

The purpose of this study was to compare the effects of a naturalistic, incidental teaching intervention to a structured, explicit instruction intervention on word learning with early language learners who speak using robust, high-tech AAC. Participants learned words in both conditions. However, all three participants learned vocabulary words more efficiently (i.e. learned words in less time) when taught using the structured, explicit instruction intervention approach across multiple wordlists. This finding aligns with current literature indicating that a structured vocabulary intervention yields better vocabulary outcomes than a naturalistic vocabulary intervention for verbal children with or at risk for vocabulary deficits (Coyne et al., 2007; Lund & Douglas, 2016). Additionally, in a post-hoc analysis, data revealed that all children learned more nouns than verbs across both interventions. These findings suggest that CAAC may learn nouns more easily or more quickly than verbs, which is consistent with the literature for verbal early language learners (e.g. Nelson, 1973; Sanford University, n.d.). This finding may have implications for order of word acquisition for CAAC, a topic which should be further investigated in the literature.

Upon initial inspection of Figure 3, which reveals Child 3's word learning outcomes from both the explicit instruction and the incidental teaching interventions, Child 3 seemingly performed relatively equally in both intervention types. On wordlists 1, Child 3 learned 8 words in the incidental teaching intervention and 7 words in the explicit instruction intervention. On wordlists 2, Child 3 learned 6 words in both interventions. However, readers should consider multiple factors before interpreting these results. First, Child 3 learned the word, "sandwich," in the explicit instruction condition within the first few weeks of intervention; upon presentation of the picture of sandwich during intervention, he would produce the word on the AAC device before the interventionist modeled the word weekly. However, when presented with the black and white picture of sandwich during probing, Child 3 consistently produced the word, "cake," rather than "sandwich," yielding an incorrect score. It is likely that Child 3 learned the word sandwich in the explicit instruction intervention (totaling 8 words learned in that intervention) but mistook the probe picture for cake rather than a sandwich. Thus, Child 3 likely learned 8 words in both interventions on wordlists 1. Second, Child 3 learned words more quickly in the explicit instruction intervention than the incidental teaching intervention. On wordlists 2, Child 3 learned 6 words across three consecutive incidental teaching sessions, and he learned 6 words in one explicit instruction session. Additionally, on wordlists 1, he learned 8 words in 5 consecutive incidental teaching sessions, and he learned 7 (likely 8) words in five nonconsecutive explicit instruction sessions. Thus, although Child 3 learned the same/similar amounts of words in both interventions, the explicit instruction intervention yielded more efficient word learning for Child 3, which is especially important for CAAC who are substantially behind their verbal peers in vocabulary acquisition (Andzik et al., 2018; Erickson & Geist, 2016).

Child 1 demonstrated a unique and unexpected word learning phenomenon that seemingly facilitated the word learning process: once she learned the location of an entire category (e.g. animals), she taught herself the location of other target vocabulary words within that category. For example, in the first wordlist, Child 1 learned the words “bear” and “elephant.” The second list that Child 1 learned included the target word, “cat.” Child 1 did not demonstrate knowledge of the word, “cat,” when probed prior to all intervention. However, after learning her first wordlist that included the words “bear” and “elephant,” Child 1 searched in the animals section of the device until she found the word cat, and she produced that word meaningfully twice in probes prior to any teaching. Thus, Child 1 used her knowledge of the location animals (i.e. elephant and bear) and her knowledge of categories (animals) to search for and locate a new word in that same category: cat. None of the other children demonstrated this skill. Child 1 has a higher nonverbal IQ than the other two participants, and she is bilingual. It is possible that either of these two factors (or both) could have influenced her ability to self-teach new words. Future research should evaluate whether children can use their knowledge of categories and categorical organization on AAC devices to find new words on the device, and these investigations and should identify variables that influence this phenomenon.

The results across all children in this study reveal that children with deficits in cognition, including children with intellectual disability (i.e. nonverbal IQ below 70: Child 2 and Child 3), can learn to produce meaningful words on robust, high-tech AAC devices efficiently. Regardless of nonverbal IQ, all children made substantial gains in word learning across seven or eight weeks of intervention in the explicit instruction intervention (ranging from an average of 7.30 words to 14.67 words). All participants used LAMP Words for Life™ without any edits to the application itself, meaning that there was no simplification of or movement of the words available on the device. This finding has implications for clinical practice. It is possible that edits to a high-tech AAC device (e.g. hiding vocabulary words or reducing the number of words available on the device) are unnecessary for many CAAC with and without intellectual disabilities. With explicit instruction that includes navigational description, it is possible that many CAAC can learn early words on their AAC device while still having access to morphological markers and thousands of vocabulary words. Access to these important linguistic components opens the possibility for CAAC to independently explore and potentially learn these linguistic components (similar to Child 1's self-taught word learning in this study), which supports progress in language development through AAC (Binger et al., 2020).

Clinical Relevance

Results from this study provide practicing professionals with a feasible intervention (i.e. explicit instruction) that can be implemented immediately in practice for CAAC who are in the early word learning stage of language development. The explicit instruction intervention was completed within approximately 30 minutes weekly for each participant by a single interventionist in the school setting. Materials needed to complete this intervention are limited: pictures of target words and some toys that represent these target words. Thus, intervention procedures can be immediately extracted from this paper and implemented into practice with relatively little preparation.

Additionally, although this study included only three participants, the participants represent diverse social factors that expand the population to whom the results are relevant. Participants included children with and without intellectual disabilities (i.e. IQ above and below 70) and included monolingual and bilingual (English-Spanish) language learners. Participants' household incomes included a wide range. Participants present with a variety of diagnoses, one of whom is deaf or hard of hearing in addition to her primary diagnosis of Down syndrome, and participants' ages range from 5;11 – 8;7. Practicing speech-language pathologists can apply these results to a wide range of children because this participant pool is diverse across multiple factors.

Limitations and Future Directions

This study has multiple limitations that impact the conclusions that can be drawn from the results. First, this study excluded children with acquired disabilities and children with autism spectrum disorder who speak using AAC. Thus, these studies should be repeated with these populations to determine which intervention approach yields the most efficient word learning with robust AAC devices.

Second, this study only included children who speak using LAMP Words for Life™. However, there are many other robust language representations available that CAAC use to communicate. Thus, this study should be repeated with children who use various types of robust, high-tech AAC devices to determine whether the results are applicable across all types of language representations. Third, although the participants represented a variety of social factors (e.g. various nonverbal IQs, various household incomes), all three participants were either white and Hispanic or white and not Hispanic. It is important that this work be repeated with children from other races to determine applicability across cultures.

Conclusion

The purpose of this study was to compare the effects of an explicit instruction intervention (Beck & McKeown, 2007; Coyne et al., 2007) and an incidental teaching intervention (Daugherty et al., 2001; Valdez-Menchaca & Whitehurst, 1988) with early language learning CAAC who use robust, high-tech AAC devices. Results indicate the explicit instruction intervention yielded better vocabulary outcomes for all participants across multiple wordlists. Thus, these preliminary data suggest that the explicit instruction intervention is the superior vocabulary intervention for this population.

Acknowledgements

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Data Availability Statement

Data sets from this project can be obtained upon reason able request to authors.

Author Contributions

Both authors contributed equally to conceptualization and methodology of this project. Courtney Trevino was the lead contributor for investigation, data curation, formal analysis, and writing. Emily Lund was the lead contributor for reviewing/editing writing and resources, and Emily Lund supported completion of investigation, data curation, and formal analysis.

EVALUATING CHILDREN WHO SPEAK USING AAC'S TAXONOMIC KNOWLEDGE AND THE IMPACT OF AN AAC DEVICE ON THEIR TAXONOMIC KNOWLEDGE

Authors: Courtney Trevino & Emily Lund

Abstract

Purpose: This study evaluates children who speak using AAC's (CAAC) taxonomic knowledge and the impact of an AAC device on their taxonomic knowledge.

Method: This study included seven groups of children: CAAC with intellectual disability (CAAC-ID; *n* = 9), CAAC without intellectual disability (CAAC; *n* = 9), age-matched group for CAAC-ID (AM-ID; *n* = 9), age-matched group for CAAC (AM; *n* = 9), vocabulary-matched group for CAAC-ID (VM-ID; *n* = 9), vocabulary-match group for CAAC (VM; *n* = 9), and IQ-matched group for CAAC-ID (IQ-M; *n* = 6). Participants completed a standardized receptive vocabulary test, nonverbal IQ test, and two experimental tasks. The experimental tasks included a (a) closed-ended taxonomic sorting task and (b) taxonomic picture selection task in which children identified pictures that match with named superordinate, basic, and subordinate terms.

Results: In task (a), age-matched groups consistently performed best, followed by CAAC groups, vocabulary-matched groups, and then the IQ-match group. In task (b), age-matched groups consistently performed best, followed by vocabulary-matched groups, CAAC groups, and then the IQ-match group. Throughout both tasks, CAAC-ID and IQ-M performed more poorly than other groups, but CAAC-ID consistently outperformed IQ-M.

Conclusions: Results suggest that CAAC present with deficits in taxonomic knowledge in tasks that do not include language, and they present with disordered taxonomic knowledge in tasks that include language. Taxonomic deficits/disorder may be contributing to poor word learning outcomes for this population. The fact that CAAC-ID consistently outperformed IQ-M suggests that AAC device use may support development of taxonomic knowledge.

As typically developing, verbal children progress through language development milestones, they develop an understanding of taxonomy, or the hierarchical classification of words based on shared properties and relations between words (e.g. animals, dog, German Shepard; Waxman & Hatch, 1992). Verbal children use their taxonomic knowledge to support word learning (Waxman & Kosowski, 1990; Wojcik, 2018) and to store learned words (for review, see Wojcik, 2018). This process ultimately yields ability to effectively communicate. Children who speak using augmentative or alternative communication (AAC) experience a unique language development process. First, these children surrounded by verbal speech, but they speak using AAC; they receive less input in their symbol system (i.e. AAC symbols) than verbal children do in their symbol system (i.e. verbal words; Barker et al., 2013). Second, they produce words by navigating through a visual, rigid, taxonomically organized system. These two unique components of language development through AAC may influence CAAC's taxonomic knowledge, which could have a trickledown effect on word learning, word storage, and general communicative effectiveness. The purpose of this study is to evaluate CAAC's taxonomic knowledge and the impact that an AAC device has on their taxonomic knowledge.

Typical Word Learning and Taxonomic Development

Typically developing children progress through a predictable sequence of language development milestones (e.g. Bloom, 2002). One of the earliest expressive language skills that children develop in this predictable sequence is acquisition of vocabulary words (Bloom, 2002). As children learn words and expand their vocabularies, they must have effective methods to store these vocabulary words. Effective word storage yields efficient word retrieval during interaction, which is necessary to produce meaningful, novel utterances in a time efficient manner (Wojcik, 2018). Children store vocabulary words in their lexical semantic networks. A lexical-semantic network is a cognitive system that stores words by relating them to other words (Sheng & McGregor, 2010; Lund & Dinsmoor, 2016). Specifically, a lexical semantic network stores words by intertwining words' referents, their taxonomic belonging, and their relations to other words, including taxonomic relations (Wojcik, 2018). Thus, children use taxonomy to store vocabulary words in their lexical semantic networks.

Taxonomy is the classification of words into hierarchical categories/levels based on shared properties between referents and referents' relations to one another. Words are commonly classified into the following three hierarchical levels: superordinate (e.g. animals), basic (e.g. dog), and subordinate (e.g. German Shepard; Lund & Dinsmoor, 2016; Waxman & Hatch, 1992). Words at differing hierarchical levels may have relations to one another (e.g. German Shepard is a type of dog). These taxonomic relations provide parameters for the meaning of words. Specifically, relations help define what is and what is not a referent for a word (e.g. what is and is not a dog; Bloom, 2002), which is a concept that children must grasp when learning words.

Development of taxonomic knowledge begins in early childhood as children learn words from their parents' verbal input (Booth & Waxman, 2002; Booth & Waxman, 2009). As vocabulary knowledge grows with age, children's understanding of taxonomic relations matures. Mervis and Crisafi (1982) revealed that children develop knowledge of basic-level relations first (by two years and six months [2;6] of age). They then develop an understanding of superordinate-level relations (around age 4;0), followed by subordinate-level relations (by age 5;6; Mervis & Crisafi, 1982).

The Relationship Between Word Learning, Taxonomy, and Lexical Semantic Networks

Children use their taxonomic knowledge to support language development, specifically supporting word learning (e.g. Waxman & Kosowski, 1990; Wojcik, 2018), word storage, and word retrieval from their lexical semantic network (for review, see Wojcik, 2018). Thus, it is logical that children with language disorders may also present with atypical taxonomic knowledge. Multiple studies have found deficits related to lexical semantic organization and/or taxonomic knowledge in people with language differences or disorders (e.g. Lund & Dinsmoor, 2016; McGregor & Waxman, 1998). For example, McGregor and Waxman (1998) completed a taxonomic naming task with typically developing children and children with language disorders, specifically word finding deficits (as identified by scoring significantly lower than the typically developing group on noun naming, verb naming, and a story retell word retrieval task). Children from both groups demonstrated ability to name words in different hierarchical levels. However, children with word finding deficits demonstrated decreased ability to name subordinate-level terms. Additionally, when unsure of an accurate response, children with language deficits responded with, “I don’t know,” significantly more often than the typically developing group. Typically developing children produced other words that, although incorrect, had some relation to the target word. Authors concluded that children with word finding deficits presented with deficiencies in word storage in their lexical semantic networks.

Lund and Dinsmoor (2016) conducted a taxonomic sorting task and a taxonomic naming task with children with cochlear implants, age-matched peers, and vocabulary matched peers. Age-matched peers consistently performed best on all sorting tasks, followed by children with cochlear implants and then vocabulary-matched peers. Group differences were not significant, but medium effect sizes were found, suggesting that the study was underpowered. In the taxonomic naming task, children with cochlear implants performed significantly worse on naming superordinate-level terms in comparison to their age-matched peers. Results suggest that children with cochlear implants who present with poorer expressive vocabulary skills in comparison to their peers also demonstrate deficits in taxonomic knowledge and use of taxonomic knowledge to name pictures.

The previous two studies identify two unique groups who present with language disorders and deficits in taxonomic knowledge. These two groups include (1) children with an organic language disorder (i.e. language disorder is the primary diagnosis; McGregor & Waxman, 1998) and (2) children with a language differences/disorders as a result of limited access to language input (i.e. children who are deaf or hard of hearing; de Hoog et al., 2016; Lund & Dinsmoor, 2016). These two studies reveal that both disordered language (McGregor & Waxman, 1998) and reduced language input can impact taxonomic knowledge (Lund & Dinsmoor, 2016), which can have a trickledown effect on word storage in the lexical semantic network (Wojcik, 2018).

CAAC and Semantic Organization of AAC Devices

Children who experience limitations with verbal speech, oftentimes secondary to an intellectual or developmental disability (e.g. Down syndrome, cerebral palsy, rare genetic disorders), can either supplement or substitute verbal speech with an AAC device. Many children use high-tech AAC, or a tablet-like device with an app that displays the individual words and morphemes of a language. Children who speak using AAC (CAAC) select these words and morphemes to form novel utterances that communicate their messages, and the device speaks the message aloud. Because these AAC apps store thousands of words, app creators must adopt an organizational system that allows CAAC to efficiently locate words.

Many different AAC apps exist, and each of these apps store language and morphological markers uniquely. Most apps rely on taxonomic relations to store vocabulary words (e.g.

Assistiveware, n.d.; PRC-Saltillo, n.d.; Tobii Dynavox, n.d.). For example, on the LAMP Words for Life™ app, if a child wants to say, “monkey,” the child would select the symbol, “come” on the home screen, which displays a dog icon (representing the superordinate term, “animals”). Then, the child would then choose from intermediate-level taxonomic options: pets, zoo, insects, birds, water, baby animals, woods, and dinosaurs. The child must select the category, “zoo,” to find the symbol for basic-level term, “monkey.” To find the word “monkey” on the Proloquo2go app, a child must select the symbol “things,” and then select the superordinate-level term, “animals.” The child would then find the basic-level term, “monkey.” Because apps use taxonomic relations to organize words on the AAC device, CAAC must use their understanding of taxonomic relations to locate and speak words on the AAC device.

Implications of Visual, Taxonomically Organized AAC Systems

The fact that CAAC speak using AAC devices that visually display and organize vocabulary words differentiates CAAC’s expressive and receptive language development and taxonomic development from verbal speakers in multiple ways. First, verbal speakers use their mouth, not a preorganized, visual language system, to say words. Verbal speakers use taxonomic relations to store and retrieve words (Wojcik, 2018), but they do not need to visually navigate those relations on a device to say the word aloud. Thus, their taxonomic knowledge of a word may have some error, but verbal children can still say the word aloud. Alternatively, CAAC must physically navigate through taxonomic relations on the AAC device to produce a desired word (e.g. first dog, then zoo, then monkey). If children cannot complete this taxonomic navigation process, they cannot say their desired word aloud. Thus, CAAC may need to develop a greater understanding of taxonomic relations than verbal speakers to learn and say words, potentially slowing the expressive language development process.

Second, because CAAC navigate through these taxonomic pathways to say words, they likely gain more explicit experience in using taxonomic relations during word production than verbal children do. However, these taxonomic relations are extremely rigid and follow predesigned pathways. This rigidity may limit CAAC's knowledge of flexible taxonomic relations between words. For example, because the "monkey" symbol is in the zoo folder, the child may only taxonomically associate monkeys with zoos. However, verbal children may have other intermediate-level taxonomic categories for monkeys, such as "rainforest animals," that they have developed through various expressive and receptive experiences with the word. It is possible that the entrenched pathways on the AAC devices reduce CAAC's broader understanding of taxonomic relations between words. Third, because CAAC follow these predesigned taxonomic pathways to produce words and these pathways may influence their taxonomic knowledge of words, AAC device use may even differentiate the way that CAAC store words in their lexical semantic network. Thus, CAAC could rely on the sematic organization of their AAC device to retrieve words that they desire to say, although there is no literature at this time to support or refute this.

Fourth, when adults say novel words to verbal children, adults are saying words in the child's symbol system: verbal words. Verbal children progress through the word learning process and begin to use verbal speech to say these words (e.g. Bloom, 2002). However, CAAC do not receive the same amount of input in their symbol system: AAC symbols (Barker et al., 2013). CAAC are surrounded by verbal speech, but they are unable to produce verbal speech. Although some interventions involve modeling language on an AAC device (for review, see O'Neill et al., 2018), children still do not receive the same amount of AAC symbol input (i.e. augmented input) as their verbal peers receive in verbal speech (Barker et al., 2013). The fact that CAAC receive less input in their form of communication but are still expected to develop that form of language is unique to this population. For example, we do not expect children to communicate using sign language when they primarily only hear verbal input. It is possible that this discrepancy in input impacts the word learning process (as was observed in Lund and Dinsmoor's [2016] investigation, wherein children with cochlear implants receive less clear input than children with typical hearing), which in turn could impact their taxonomic knowledge and formation of their lexical semantic network.

In conclusion, these differences could have a trickle-down effect on CAAC's language development. It is possible that these associations impose on the development of taxonomic knowledge in a way that hinders comprehensive development of taxonomy. If true, these differences could have long-term effects in lexical-semantic organization and, ultimately, word retrieval and communication effectiveness. Thus, it is vital to gain an understanding of CAAC's taxonomic knowledge and their lexical semantic networks to consider the impact that AAC devices may have on word learning, storage, and retrieval.

AAC and Taxonomic Relations

Few early investigations have explored the relationship between taxonomic relations and AAC. None of these studies have explicitly investigated CAAC's taxonomic knowledge; rather, the purpose of these investigations was to optimize AAC device organization or identify methods of evaluating taxonomic knowledge. Gervater (2015) compared four autistic children's ability to use two different non-robust organizational displays: taxonomic and thematic (both created by investigators). Taxonomic organizational displays are organized using common hierarchical levels (e.g. find "dog" by clicking on an "animals" folder). Thematic organizational systems organize icons by themes (e.g. find "balloons" by clicking on a "birthday party" folder).

Participants made more accurate requests using the thematic organizational display; authors concluded that autistic CAAC may prefer thematic organization displays over taxonomic displays (Gervater, 2015). However, the thematic display used actual photographs of items/locations in the child's home, and the taxonomic display used computer generated images. This difference may have influenced results. Additionally, the organization of these systems do not mirror typical AAC device organization, which may impact the applicability of these results.

Additionally, Wilkinson and Rosinquist (2006) evaluated a method of assessing taxonomic knowledge in autistic people with intellectual disability. Twenty-two autistic people with limited verbal skills (i.e. potential future users of AAC) with a cooccurring intellectual disability were split into two groups: a minimal training group and an extensive training group. Both groups completed the same computerized sorting task with different amount of instruction on task completion and operational features of the computerized program. Analysis of accuracy percentages between groups suggests that the group that received additional training performed better than the group with less training. A second experiment evaluated the extensive training group's ability to generalize the task to other categories. Results varied with accuracy ranges between 53-90%. Results suggest that autistic people with intellectual disabilities demonstrate some understanding of taxonomic relations at the basic and subordinate level; additionally, results suggest that this population may benefit from additional instructional support prior to sorting tasks (Wilkinson & Rosenquist, 2006).

All other studies that investigate taxonomy and AAC include typically developing participants. Light and colleagues (2004) investigated verbal children's ability to learn the location of words on four different AAC device organizational systems: taxonomic, thematic, scene display, and semantic compaction. Scene displays provide a picture of an event or activity, and words are said aloud by clicking on images in the picture. Semantic compaction uniquely uses multi-meaning icons, meaning that a single icon (i.e. symbol picture) is meant to represent more than one concept. For example, if one were to say the word, “have,” one would click on the icon of the hand near money, for that icon represents money and the concept of *having* money. It should be noted that these systems also use taxonomic organization to store many nouns, as described in the monkey example in the LAMP Words for Life™ app. Results revealed that children in all conditions learned vocabulary word locations but that children learned significantly fewer words on the semantic compaction condition in comparison to the three other conditions (Light et al., 2004). It should be noted that the semantic compaction app that was used in this study is an old app that is typically not used anymore. Thus, applicability may be limited.

Similarly, Traylor (2004) evaluated 20 typically developing three-year-old’s ability to use their thematic and taxonomic knowledge to find target words on AAC devices that were generated by investigators. Results suggest children may be able to find words better on a taxonomically organized device (Traylor, 2004). These findings contradict findings from Gervater’s (2015) study, but Gervater’s use of two different types of images for device icons may account for these differences. Finally, Fallon and colleagues (2003) evaluated the open-ended sorting skills of 20 typically developing 4- and 5-year-old children. Results suggest that children sort thematically more than taxonomically in open ended tasks; authors concluded that CAAC could benefit from thematic organizational systems (Fallon et al., 2003). However, open-ended sorting is a different skill than locating words on an AAC device, so applicability may be limited.

In conclusion, only two of these studies included CAAC participants; the rest of these studies included verbal participants. One study investigated a method of evaluating taxonomic knowledge in autistic people who do not use AAC yet, and the rest of these studies aimed to inform AAC device organization. Results were inconclusive. Light and colleagues' (2004) study suggests that children can learn to say words on any device organization with training. Traylor's (2004) study suggests that children find words faster on a taxonomically organized device, which contradicts Gervater's (2015) findings that favor thematic organization. In summation, results about optimal device organization for CAAC are inconclusive.

Although it is an extremely important topic of investigation, perhaps optimal AAC device organization is not the first research question that need be asked. The impact that an AAC device and the unique experience of language development through AAC has on CAAC's taxonomic knowledge is unknown. An understanding of CAAC's taxonomic knowledge and whether this knowledge has been influenced by the device itself can inform the way that CAAC store words in their lexical semantic networks. These results, in combination with an understanding of the word storage and retrieval process, can inform optimal AAC device organization (i.e. identification of linguistic features on devices that support word storage with this population). Furthermore, results can lead to future investigations about intervention strategies that support word storage, word finding from the lexical semantic network, and word finding on an optimally organized AAC device itself, all of which are vital for efficient communication for CAAC.

Purpose

Researchers have identified that typically developing children's taxonomic knowledge influences word learning (Waxman & Kosowski, 1990) and word storage (Wojcik, 2018). However, CAAC's taxonomic knowledge has yet to be investigated. CAAC's unique language development experience could differentiate their taxonomic development and knowledge from their verbal peers. This differentiation could ultimately impact their word learning and lexical semantic organization, both of which impact effective communication.

An investigation into CAAC's taxonomic understanding may lead to testable hypotheses about intervention techniques and optimal device organization for this population, ultimately aiming to improve CAAC's expressive language outcomes. The purpose of this study is to evaluate CAAC's taxonomic knowledge and the impact that AAC has on their taxonomic knowledge. The following research questions will be addressed:

1. Do CAAC use general taxonomic knowledge to sort pictures as accurately as their age-matched, vocabulary-matched, and IQ-matched verbal peers?
2. Does communicating using an AAC device influence CAAC's taxonomic knowledge?
    a. Do CAAC form unique, AAC device-specific superordinate categories that their verbal age-matched, vocabulary matched, and IQ-matched peers do not form?
    b. Do CAAC rely on AAC device icons to sort images of familiar words into superordinate categories?
    c. Do CAAC demonstrate deficits in sorting images that are not programmed into their device in comparison to their verbal age-matched, vocabulary-matched, and IQ-matched peers?
3. Do CAAC demonstrate deficits in categorizing pictures into named taxonomic categories (rather than pictured categories) at the superordinate, basic, and subordinate levels in comparison to their age-matched, vocabulary-matched, and IQ-matched peers?

Methods

The Texas Christian University institutional review board approved this study (IRB#2023-57).

Participants

All children were recruited through advertisements in school districts, private practice therapy centers, and on social media. Sixty total children participated in this study; all children fell into one of seven groups: CAAC with intellectual disability (CAAC-ID; $n = 9$), CAAC without intellectual disability (CAAC; $n = 9$), age-match for CAAC-ID (AM-ID; $n = 9$), age-match for CAAC (AM; $n = 9$), receptive vocabulary match for CAAC-ID (VM-ID; $n = 9$), receptive vocabulary match for CAAC (VM; $n = 9$), and overall nonverbal IQ match for CAAC-ID ($n = 6$). Nonverbal IQ was measured using the Leiter International Performance Scale – Third Edition (Roid et al., 2013), and intellectual disability was defined as having a nonverbal IQ score below 70. All participants in age-matched and vocabulary-matched groups were typically developing, and all participants in all three matched groups (including IQ-M) were verbal speakers.

CAAC participants were between the ages of 3;4 and 11;5 and spoke using LAMP Words for Life™ app for at least three months. Participants demonstrated ability to produce fewer than 75 meaningful words on their AAC devices, ensuring that CAAC participants were in the early stages of language development through AAC. Potential participants were excluded if they had or were suspected of having an autism diagnosis because this diagnosis may impact the way that children process language (e.g. ASHA, n.d.c; Herringshaw et al., 2016), ultimately impacting results.

Each CAAC had one age-matched participant and one vocabulary-matched participant match. Each age-matched participant's age was within one month of their CAAC matched participant at the time of data collection. Each vocabulary-matched participant's raw score on the Receptive One-Word Picture Vocabulary Test – Fourth Edition (ROWPVT-4; Martin &

Brownell, 2010) was within six points of their CAAC matched participant. Potential age-matched and vocabulary-matched participants were excluded if they had a diagnosed intellectual or developmental disability, autism, and/or if they receive any special education services to ensure that CAAC's results were compared to that of typically developing peers.

Finally, 6 participants served as an IQ-match for the CAAC-ID participants. Two other IQ match participants were recruited (totaling 8), but they did not complete testing and so could not be included in analysis. CAAC-ID's nonverbal IQ scores ranged between 31 – 69. All nonverbal IQ scores of the IQ-M group fell within that range (ranging from 43 – 67). Potential IQ match participants were excluded if they had an autism diagnosis or if they spoke using AAC. See Table 1 for relevant participant information.

Table 1
Participant Data by Groups.

Characteristic	CAAC-ID	AM-ID	VM-ID	IQ-M	CAAC	AM	VM
Age	95.89	96.11	40.56[a]	67.00	73.44	73.11	42.67[b]
ROWPVT Raw	44.11	113.63[a]	45.56	32.00	55.00	90.67[b]	55.11
ROWPVT Standard	62.11[b]	119.00[a]	104.00[a]	69.50	85.11[a]	115.22[b]	110.00[b]
Nonverbal IQ	54.56[b]	115.11[a]	99.63[a]	54.00	82.88[a]	104.00[b]	101.63[b]

Note. ROWPVT = Receptive One-Word Picture Vocabulary Test – Fourth Edition; ROWPVT Raw = raw score on the ROWPVT-4 test; ROWPVT Standard = standard score on the ROWPVT-4 test; all numbers represent group mean

[a] indicates that group mean is significantly different than that of the CAAC-ID group
[b] indicates that group mean is statistically significantly different than that of the CAAC group

Procedure

All children completed the ROWPVT-4, Leiter International Performance Scale – Third Edition, and the experimental tasks described below. The first author or trained research assistants administered all tests and tasks. Two undergraduate students in communication sciences and disorders assessed for fidelity to the data collection procedures by checklist; fidelity was at 100%.

Taxonomic Sorting Task

To answer research questions 1 and 2 (including 2a, 2b, and 2c), participants completed taxonomic sorting tasks that were adapted from Lund and Dinsmoor (2016) and Waxman and Gelman (1986). In each sorting task, three buckets were placed in front of the child, and each bucket was labeled with a picture that represented a category. Twelve picture cards that represented basic-level terms were sorted into the three categories within a single sorting task (four picture cards per category). Two typically developing, verbal children who were not otherwise participating in the study validated that all category and basic-term pictures accurately represented target terminology through a confrontational naming task.

The evaluator provided directions for the task by saying, “there are labels on the front of each of these buckets. We’re going to make groups of pictures of the same kind. I’m going to give you a picture, and you’ll put it in bucket that is the same kind. I’ll do the first two, and you’ll do the rest. This picture goes in this bucket because these are the same kind.” The evaluator would show the picture card to the child and then put the picture in the correct bucket according to category. The evaluator then provided a second example, which always belonged to a different category than the first example. The evaluator then handed picture cards to the participant one-by-one and prompted the child to sort each card as needed. The evaluator did not provide feedback about accuracy to participants. All picture cards were shuffled to randomize order prior to beginning the sorting task. The order in which the sorting tasks were completed was counterbalanced.

To answer research question 1, participants completed two sorting tasks of common categories: shapes and color (Task 1). The categories for the shape sorting task were squares, circles, and triangles. Picture cards revealed these shapes in different sizes and colors/prints. The categories for the color sorting task were red, yellow, and blue. Picture cards revealed these colors in nonsense designs, such as a blue squiggly line and red polka dots.

To answer research question 2a, participants completed a sorting task using images from the LAMP Words for Life app (Task 2a). Category images were icons that are on the front/home page of LAMP Words for Life™: the rainbow with clouds, the hand with the pointer finger pointing upwards (and a string tied around the finger), and the blue shoe. The picture cards that were used for sorting displayed images from the LAMP Words for Life™ app that can be found by touching one of the category terms (rainbow, hand, or shoe). Images intended to be sorted into the rainbow category include the orange, Canadian cent, pencil, and scissors. Images intended to be sorted into the shoe category include the person sliding down the slide, person swimming, stick figure rock climbing, and person fishing. Images intended to be sorted into the hand/finger category include the umbrella, sunglasses, person pushing the wheelchair, and glove catching a ball.

To answer research question 2b, participants completed two sorting tasks. Both tasks required participants to sort images into the same categories: animals, food, and body parts. One task included images from the LAMP Words for Life app (Task 2b Device), and the other task included realistic images taken from the internet (Task 2b Internet). Category images from the internet included a picture of different animals, a picture of different types of foods, and an image of a girl. Category images used for the LAMP Words for Life™ sorting task include an apple to represent food, a dog to represent animals, and pictures of Mr. Potato Head body parts to represent body parts. These three LAMP Words for Life™ category images are the images on the home screen that must be touched to navigate to the picture card images. Picture card images intended to be sorted into the food category include grapes, cheese, bread, and corn. Images intended to be sorted into the animal category include butterfly, cow, rabbit, and giraffe, and images intended to be sorted into the body parts category include knee, hand, eye, and ear.

To answer research question 2c, participants sorted images of terms that are not programmed on their AAC devices (Task 2c); all images were retrieved from the internet. The categories included desserts, musical instruments, and toys. Images intended to be sorted into the desserts category include cake pop, popsicle, snow cone, and ice cream sandwich. Images intended to be sorted into the musical instruments category include trumpet, xylophone, flute, and saxophone, and images intended to be sorted into the toys category include dollhouse, barbies, slinky, and robot.

Scoring. Participants were given 1 point for accurately sorting a picture card and 0 points for inaccurately sorting a picture card. Points were summed for each individual sorting task; participants could earn up to 10 total points per sorting task. An undergraduate student in communication sciences and disorders scored this task, and a second undergraduate student double scored 33% of participant responses. Interobserver agreement was calculated by summing the total number of discrepancies, subtracting the total number of discrepancies from the total number of opportunities, and dividing that number from the total number of opportunities. Agreement was at 95% for sorting tasks that answered research questions 1 and 2c, and agreement was 100% for both sorting tasks that answer question 2b.

Taxonomic Picture Selection Task

To answer research question 3, participants completed a picture selection task (Task 3), which was adapted from Lund and Dinsmoor (2016) and McGregor and Waxman (1998). To complete this task, evaluators laid a group of 12 pictures cards within reach of the participant. The group of pictures included three sets of four cards, each set belonging to one superordinate category (e.g. transportation, plants, food). Two of the four cards belonged to one basic-level category (e.g. cars), and the other two cards belonged to another basic-level category within the same superordinate category (e.g. boats). Task 3 was completed twice using two different groups of 12 cards, totaling 24 picture cards. Two verbal children validated that all picture cards represented target terminology through a confrontational naming task. See Table 2 for all subordinate, basic, and superordinate labels used for this task.

Table 2
Labels for Terms in Taxonomic Picture Selection Task.

Group	Picture	Superordinate Label	Basic Label	Subordinate Label
Group 1	Convertibles	Transportation	Cars	Convertibles
	Vans	Transportation	Cars	Vans
	Canoes	Transportation	Boats	Canoes
	Ships	Transportation	Boats	Ships
	Roses	Plants	Flowers	Roses
	Daisies	Plants	Flowers	Daisies
	Palms	Plants	Trees	Palms
	Oaks	Plants	Trees	Oaks
	Macaroni and cheese	Food	Pasta	Macaroni and cheese
	Spaghetti	Food	Pasta	Spaghetti
	Peanut butter and jelly	Food	Sandwiches	Peanut butter and jelly
	Grilled cheese	Food	Sandwiches	Grilled cheese
Group 2	Parrots	Animals	Birds	Parrots
	Pigeons	Animals	Birds	Pigeons
	Grasshoppers	Animals	Bugs	Grasshoppers
	Spiders	Animals	Bugs	Spiders
	Jeans	Clothes	Pants	Jeans
	Leggings	Clothes	Pants	Leggings
	Long sleeves	Clothes	Shirts	Long sleeves
	Tank tops	Clothes	Shirts	Tank tops
	Chocolate chip	Treats or desserts	Cookies	Chocolate chip
	Oreos	Treats or desserts	Cookies	Oreos
	Skittles	Treats or desserts	Candy	Skittles
	Starbursts	Treats or desserts	Candy	Starbursts

Note. Adapted from Lund and Dinsmoor (2016) and McGregor and Waxman (1998).

Once 12 cards were laid out within reach of the participant, the evaluator said, “I'm going to say a word, and you're going to give me all of the pictures that go with that word. You can give me the same picture more than one time, and you can give me more than one picture at a time. I'll do the first two you do the rest. Give me boats.” The evaluator held out her hand and placed the picture cards representing the words “canoe” and “ship” in her hand. The evaluator placed those cards back in their locations and then said, “give me canoe.” The evaluator placed the picture card representing the word canoe in her own hand and then placed the card back in its location. The evaluator then said, “now it's your turn. Give me _______.” The evaluator named the remaining 11 subordinate level terms, five basic level terms, and all three superordinate level terms. Terms were named in a randomized order. Participants were expected to provide the evaluator with all pictures that represented a single term (e.g. Give the picture card of the daisy and the rose when the evaluator said, “give me flowers”). After completing this task with the first group of 12 picture cards, all of those picture cards were removed and replaced with the other group of 12 picture cards, and the exact same procedures were followed to complete task 3 with the other picture cards.

Scoring. Participants received an accuracy score at each taxonomic level: superordinate, basic, and subordinate. A single picture card accurately provided to the evaluator was worth one point. If a picture card should have been handed to the evaluator but it was not, the participant received 0 points. If an inaccurate picture card was handed to the evaluator, the participant received -1 point (never receiving less than 0 points for a single prompt). Participants could earn a total of 12 points at the superordinate level, 10 points at the basic level, and 11 points at the subordinate level. An undergraduate communication sciences and disorders student scored this task. A second undergraduate student in communication sciences and disorders double scored 33% of participant responses. Interobserver agreement was calculated by summing the total number of discrepancies, subtracting the total number of discrepancies from the total number of opportunities, and dividing that number from the total number of opportunities. Agreement was at 95% for superordinate and subordinate scores and above 90% for basic scores.

Results

Research Question 1

The first research question addressed whether CAAC sort as accurately as their age-matched, vocabulary-matched, and IQ-matched peers and was answered with results from Task 1. Task 1 responses can yield a total of 20 possible points. Authors ran a one-sample *t*-test to determine whether participants performed differently than chance response (chance level calculated at 6.66 points given, across the two sorting tasks, a closed set of three possible sorting options for each card). Results revealed that all groups performed differently than chance response, indicating that all groups, on average, demonstrate ability to sort. The *p*-values for the CAAC-ID, CAAC, VM-ID, and the IQ-M groups were all at or below .02. The *p*-value for the remaining groups could not be calculated because all participants in these groups performed at mastery (i.e., earned 20 points), yielding no variability, but the fact that all group members performed at mastery indicates that they performed differently from chance response.

Authors planned a one-way Analysis of Variance (ANOVA) to identify group differences. Results from the first sorting task are pictured in Figure 1, and Table 3 reveals means and standard deviations for this and all other sorting tasks. Influential outliers were removed. Evaluation of assumptions revealed violations to normality and homogeneity of variances. Thus, group comparisons including groups who demonstrated mastery of this task (both age-matched groups and the VM-ID) were removed and addressed through Chi Square analysis.

Figure 1

Sorting Accuracy by group for Task 1.

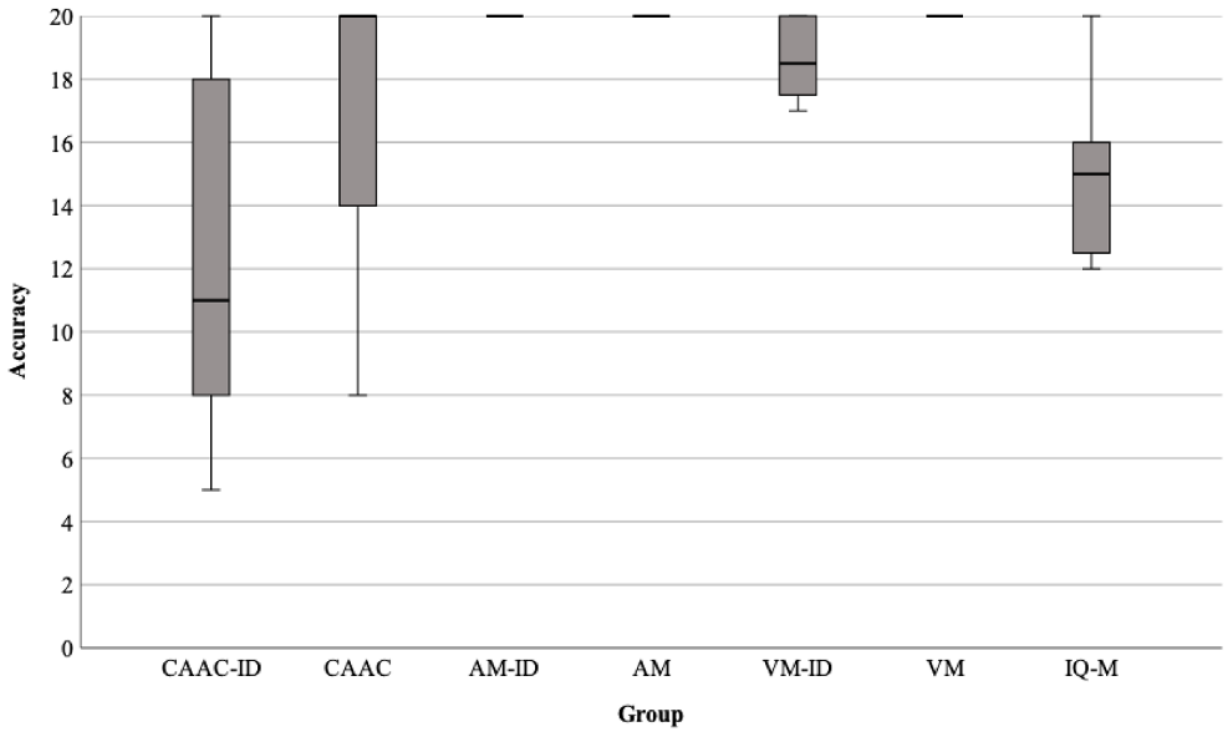


Table 3
Mean and Standard Deviations Per Analysis.

Task	Group: With CWCNS	Mean ± SD	Group Without CWCNS	Mean ± SD
Task 1	CAAC-ID	12.56 ± 6.13	CAAC-ID	12.56 ± 6.13
	AM-ID	20.00 ± 0.00	AM-ID	20.00 ± 0.00
	VM-ID	18.00 ± 2.67	VM-ID	18.00 ± 2.67
	IQ-M	14.14 ± 4.10	IQ-M	14.14 ± 4.10
	CAAC	16.44 ± 4.56	CAAC	16.44 ± 4.56
	AM	20.00 ± 0.00	AM	20.00 ± 0.00
	VM	20.00 ± 0.00	VM	20.00 ± 0.00
Task 2a	CAAC-ID	3.44 ± 2.01	CAAC-ID	3.43 ± 2.30
	AM-ID	3.22 ± 2.22	AM-ID	3.22 ± 2.22
	VM-ID	3.78 ± 1.72	VM-ID	3.88 ± 1.81
	IQ-M	4.17 ± 1.47	IQ-M	4.17 ± 1.47
	CAAC	3.78 ± 2.44	CAAC	4.13 ± 2.36
	AM	4.11 ± 1.45	AM	4.11 ± 1.45
	VM	3.22 ± 1.20	VM	3.13 ± 1.25
Task 2b: Device	CAAC-ID	5.00 ± 2.35	CAAC-ID	5.29 ± 2.63
	AM-ID	10.00 ± 0.00	AM-ID	10.00 ± 0.00
	VM-ID	3.56 ± 2.30	VM-ID	3.50 ± 2.45
	IQ-M	2.50 ± 1.22	IQ-M	2.50 ± 1.22
	CAAC	7.22 ± 3.27	CAAC	8.00 ± 2.45
	AM	9.38 ± 1.41	AM	9.38 ± 1.41
	VM	6.33 ± 3.04	VM	6.63 ±3.11
Task 2b: Internet	CAAC-ID	5.89 ± 3.02	CAAC-ID	6.71 ± 2.93
	AM-ID	10.00 ± 0.00	AM-ID	10.00 ± 0.00
	VM-ID	6.00 ± 3.39	VM-ID	6.38 ± 3.42
	IQ-M	3.83 ± .75	IQ-M	3.83 ± .75
	CAAC	7.11 ± 3.06	CAAC	7.50 ± 3.02
	AM	10.00 ± 0.00	AM	10.00 ± 0.00
	VM	6.89 ± 2.98	VM	7.25 ± 2.96
Task 2c	CAAC-ID	5.00 ± 2.29	CAAC-ID	5.29 ± 2.56
	AM-ID	10.00 ± 0.00	AM-ID	10.00 ± 0.00
	VM-ID	5.22 ± 2.39	VM-ID	5.50 ± 2.39
	IQ-M	4.17 ± 1.83	IQ-M	4.17 ± 1.83
	CAAC	7.11 ± 3.10	CAAC	7.88 ± 2.23
	AM	10.00 ± 0.00	AM	10.00 ± 0.00
	VM	5.89 ± 2.15	VM	6.13 ± 2.17
Task 3: Superordinate	CAAC-ID	4.44 ± 1.51	CAAC-ID	4.44 ± 1.51
	AM-ID	21.63 ± 3.02	AM-ID	21.63 ± 3.02
	VM-ID	5.78 ± 3.73	VM-ID	5.78 ± 3.73
	IQ-M	2.83 ± 2.86	IQ-M	2.83 ± 2.86
	CAAC	8.11 ± 4.28	CAAC	8.11 ± 4.28
	AM	17.78 ± 7.03	AM	17.78 ± 7.03

	VM	7.25 ± 3.62	VM	7.25 ± 3.62
Task 3: Basic	CAAC-ID	6.89 ± 3.18	CAAC-ID	6.89 ± 3.18
	AM-ID	17.56 ± 2.07	AM-ID	17.56 ± 2.07
	VM-ID	10.00 ± 1.73	VM-ID	10.00 ± 1.73
	IQ-M	3.33 ± 2.50	IQ-M	3.33 ± 2.50
	CAAC	8.67 ± 2.40	CAAC	8.67 ± 2.40
	AM	15.56 ± 3.88	AM	15.56 ± 3.88
	VM	10.63 ± 3.20	VM	10.63 ± 3.20
Task 3: Subordinate	CAAC-ID	4.44 ± 3.36	CAAC-ID	4.44 ± 3.36
	AM-ID	21.00 ± 1.20	AM-ID	21.00 ± 1.20
	VM-ID	9.56 ± 2.24	VM-ID	9.56 ± 2.24
	IQ-M	3.17 ± 1.94	IQ-M	3.17 ± 1.94
	CAAC	7.22 ± 2.49	CAAC	7.22 ± 2.49
	AM	16.33 ± 4.61	AM	16.33 ± 4.61
	VM	11.63 ± 5.01	VM	11.63 ± 5.01

An ANOVA comparing the CAAC-ID group with the CAAC, VM-ID, and IQ-M results revealed a significant effect of group on sorting ability, $F(6, 51) = 6.40$, $p < .001$, $\omega^2 = .36$. Post Hoc tests with Bonferroni adjustment indicate significant differences between the CAAC-ID and VM-ID groups ($p = .047$, $d = 1.15$) but no significant differences between CAAC and CAAC-ID ($p = .452$). However, to estimate the magnitude of effect, because this is the first study of its kind with this population, Cohen's *d* (small = .2, medium = .5, and large = .8) was calculated to compare all groups. Results revealed a large effect size for the comparisons between CAAC-ID and CAAC ($d = .72$), CAAC-ID and AM-ID ($d = 1.72$), and CAAC and VM ($d = 1.10$). This finding suggests that the study may be underpowered and that these groups may perform differently on sorting tasks. No significant difference between CAAC-ID and their IQ-M peers ($p = 1.000$), and small effect size ($d = .30$) indicated no group difference.

To address differences between CAAC groups and groups that performed at mastery, authors converted dependent variables to a binary variable: children were scored according to whether they demonstrated mastery (20 points) or did not reach mastery (19 or fewer points). Authors performed a Chi-Square test to reveal significant associations between participant group and task mastery (suggesting difference in group performance). Because evaluation of assumptions revealed violation to the cell size assumption, Fisher's exact test was used to reveal differences for the following groups: CAAC-ID and AM-ID ($X^2(1, n = 18) = 14.40$, one-tailed exact significance < .001) and CAAC and AM ($X^2(1, n = 18) = 5.14$, one-tailed exact significance = .041). No significant differences were found between CAAC and VM groups ($X^2(1, n = 18) = 1.00$, one-tailed exact significance = .310). but a large effect size using the original variable's mean and standard deviation suggests the study might be underpowered to detect group difference between these groups.

After completing these analyses, authors reviewed each participant's score on this task to evaluate whether each participant could sort. Although groups, on average, all sorted at a better-than-chance level, the authors noted that some individual children did not appear to have above-chance sorting abilities. All participants who had a score of 8 and below were further analyzed relative to their overall sorting ability. If they scored at chance level or below (score of 4 or fewer) on all four of the other sorting tasks, authors deemed that that participant did not demonstrate sufficient sorting ability (i.e. has not yet developed the skill of sorting). This distinction is important for further task interpretation: interpretations of the other research questions relate to whether or not a child can, at a minimum, sort items into categories. Two CAAC-ID, one CAAC, one VM-ID, and one VM participant fit this criterion. The following analyses were conducted twice: once with all participants and once with children who could not sort removed from the data set.

Research Question 2

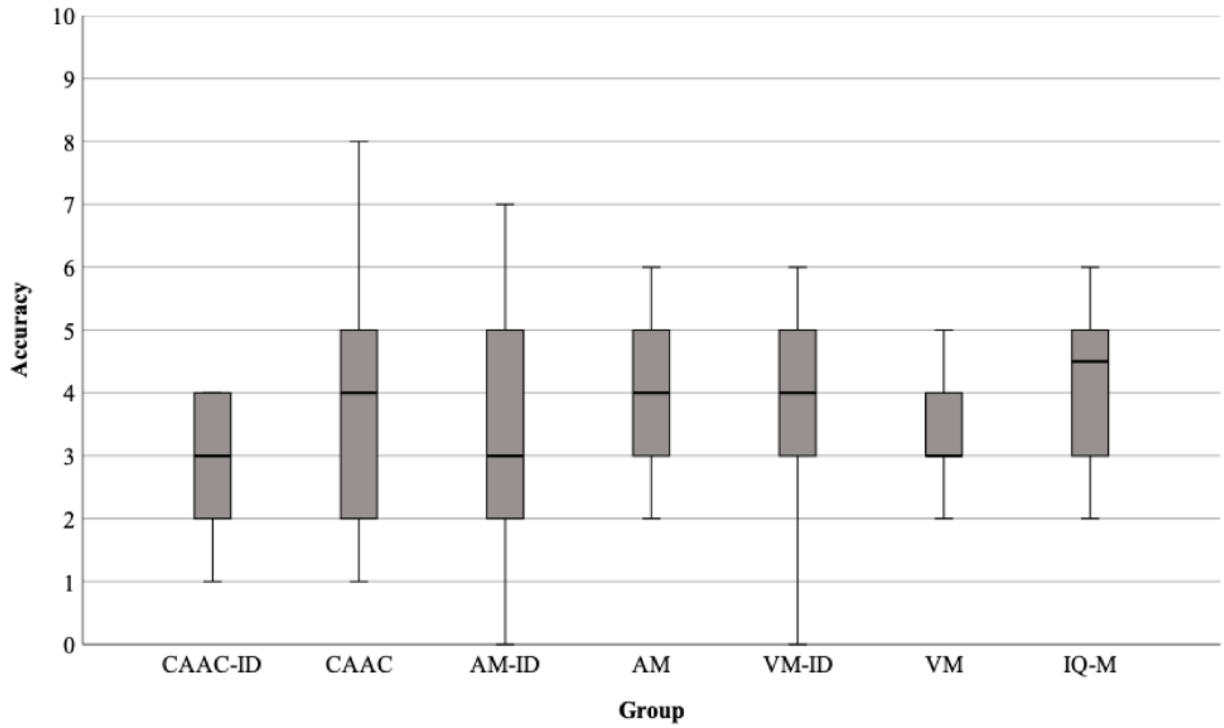
The second question addressed whether using an AAC device influences CAAC's taxonomic knowledge. This question was answered in three separate tasks that answered three separate sub-questions.

Research Question 2a

This question addressed whether CAAC form unique, device-specific superordinate categories that their matched, verbal peers do not form. Analyses were conducted using results from Task 2a (totaling 10 possible points). Authors ran a one-sample *t*-test to determine whether participants performed differently than chance response (chance level calculated at 3.33). Results revealed that none of the groups performed differently than chance response (all $p > .146$), suggesting that none of the groups, including CAAC and CAAC-ID, could sort device-specific categories.

Authors planned a one-way ANOVA to identify group differences. All assumptions were met. Results are pictured in Figure 2. An ANOVA comparing results from all groups revealed no significant differences between groups $F(6, 53) = .36$, $p <.899$, $\omega^2 = -.07$. Small to medium effect size across all comparisons (all $d < .41$) support ANOVA findings. Authors removed cases of children who could not sort from the data set and reran all analyses; differences in statistical significance were not observed.

Figure 2
Sorting accuracy by group for Task 2a.



Research Question 2b

Research question 2b addressed whether device icons influence CAAC's ability to sort familiar, generally-known categories. Results were calculated using sorting outcomes from Task 2b.

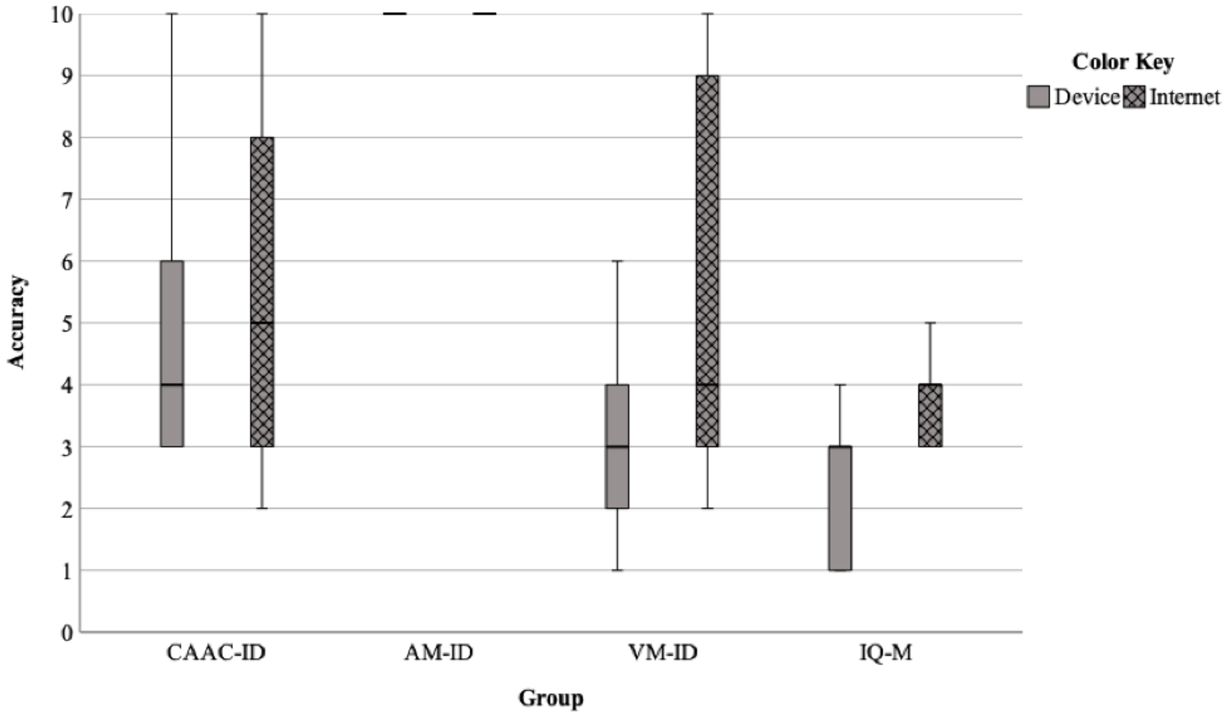
Device Icons. Authors ran a one-sample *t*-test to determine whether participants performed differently than chance response (chance level calculated at 3.33). CAAC-ID, VM-ID, and IQ-M groups did not sort differently than chance (p = .066, p = .779, and p = .156 respectively). The AM-ID group demonstrated mastery without variability, so a *p*-value was not calculated, but the fact that they performed at mastery indicates that they performed differently from chance response. All other groups performed differently than chance (all $p < .019$). These analyses were also completed using the data set that removed the five participants who cannot sort, and statistical significance or lack thereof remained consistent across groups.

Realistic Pictures. Authors completed the same analysis procedures with results from the sorting task with realistic pictures (i.e. pictures taken from the internet). Authors planned a one-sample *t*-test to determine whether participants performed differently than chance response (chance level calculated at 3.33). IQ-M did not perform differently from chance (p = .165). All other groups sorted significantly differently from chance (all p < .047). AM and AM-ID groups demonstrated mastery without variability, indicating that they performed differently from chance response. Results remained consistent when analyses excluded children who cannot sort.

Repeated Measures ANOVA. A two-way repeated measures ANOVA was run to compare the sorting accuracy of different groups related to the CAAC group that did have intellectual disability (CAAC-ID, AM-ID, VM-ID, and IQ-M) with different pictures (device icons and internet pictures). Results are pictured in Figure 3. Influential outliers were removed. Mastery demonstrated by the AM-ID group yielded violations to normality, so their results are removed from the ANOVA and addressed through a Chi-Square analysis. Mauchly's test of sphericity indicated that the assumption of sphericity was met for the two-way interaction, $X^2(5) = 3.98$, $p = .565$, was violated for main effect of group, $X^2(5) = 14.47$, p=.016, and could not be calculated for main effect of picture because there were only two groups. Two Epsilon (Σ) were < .75 and one was > .75 according to Greenhouse and Geisser (1959) calculation. Thus, an average of Greenhouse and Geisser and Huynh-Feldt was used to correct the two-way repeated measures ANOVA (Field, 2018).

Figure 3

Sorting accuracy by group and picture type for Task 2b.



The interaction effect between group and picture type was not statistically significantly different, $F(2.10, 10.50) = 1.01$, $p = .409$, partial $\eta^2 = .168$. The main effect of picture was also not statistically significant, $F(1.00, 5.00) = 2.17$, $p = .200$, partial $\eta^2 = .303$, but the main effect of group was statistically significant, $F(1.95, 9.76) = 13.81$, $p = .001$, partial $\eta^2 = .734$. However, for groups with variable performance, even though a main effect was detected, no significant difference between individual groups was found given the Bonferroni adjustment.

Cohen's *d* calculations revealed a large effect size for comparisons with device pictures between CAAC-ID and CAAC ($d = .78$), CAAC-ID and AM-ID ($d = 3.01$), and CAAC-ID and IQ-M ($d = 1.34$), suggesting that these groups may perform differently with this skill and that the study was underpowered to detect difference. A medium effect size was found for the comparison between CAAC-ID and VM-ID ($d = .62$). Analyses performed using the data set without children who cannot sort revealed a large effect size for the comparison between CAAC-ID and VM-ID (*d* = .70), suggesting that these groups may perform differently when children who cannot sort are excluded. Large effect sizes were revealed for the comparisons with internet pictures between CAAC-ID and AM-ID (*d* = 1.93) and CAAC-ID and IQ-M (*d* = .94), suggesting that these groups may perform differently. Medium to small effect sizes were found for comparisons between CAAC-ID and CAAC (*d* = .40) and CAAC-ID and VM-ID (*d* = .04). Results using the data set without children who cannot sort did not reveal any differences.

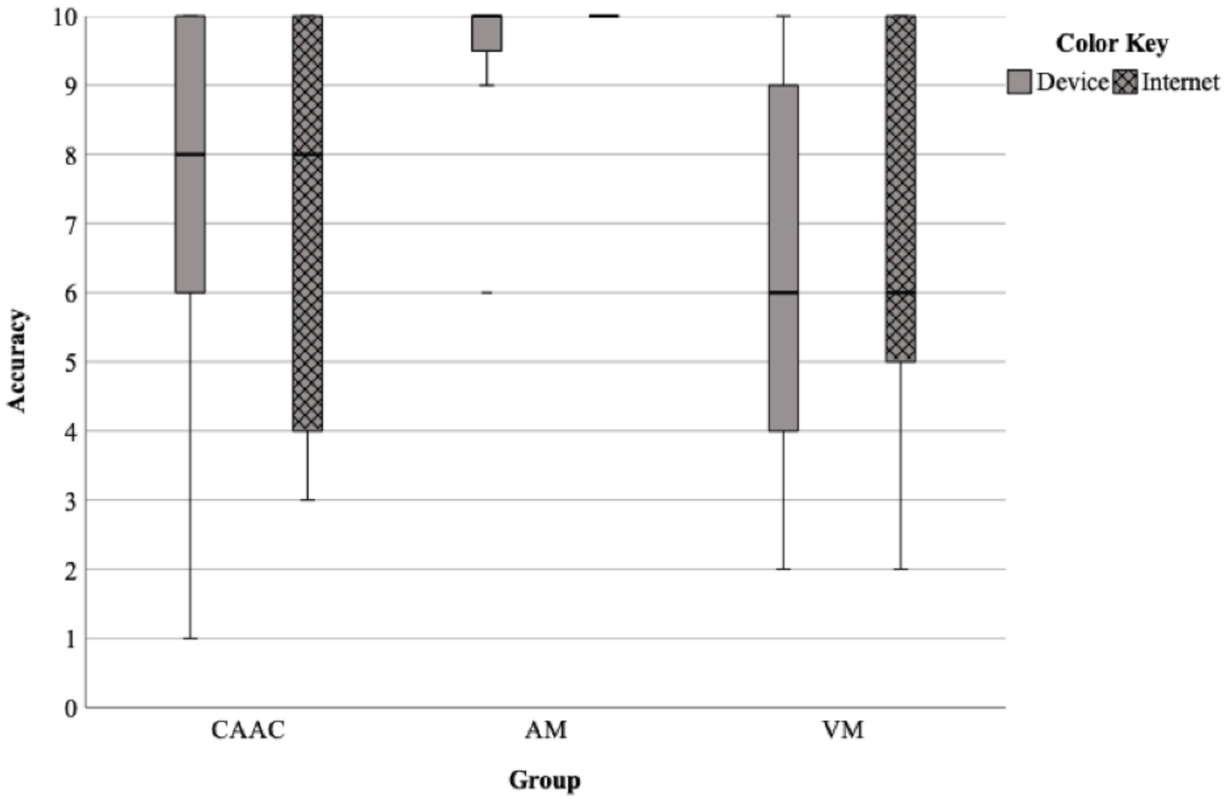
Differences within-group between picture type were also calculated. Effect sizes were medium to small for CAAC-ID (*d* = .33), uncalculated for the AM-ID (no variability), and large for the VM-ID group (*d* = .84) and the IQ-M group (*d* = 1.31), suggesting that the last two groups performed better on internet images than device images. Results using the data without children who cannot sort yielded a medium effect size within the CAAC-ID group (*d* = .51), suggesting that this group may perform better with internet images, as well.

Chi-Square analyses evaluated group differences with the AM-ID group because they reached mastery. To conduct Chi-Square analyses for all remaining sorting tasks, authors converted dependent variables to a binary variable: children were scored according to whether they demonstrated mastery (10 points) or did not reach mastery (9 or fewer points). Fisher's exact test was used to report significance to correct for violations to the cell size assumption for all sorting tasks. Chi-Square analyses revealed a statistically significant association between group and task mastery for the CAAC-ID and AM-ID groups when sorting device pictures, ($X^2(1, n = 18) = 10.89$, one-tailed exact significance = .002), and when sorting realistic, internet pictures, ($X^2(1, n=18) = 11.46$, one-tailed exact significance = .001). Results suggest group difference in performance. Significance in repeated measures ANOVA and Chi-Square analyses were consistent when children who cannot sort were excluded.

Another two-way repeated measures ANOVA was run to compare the sorting accuracy of different groups related to the CAAC group that did not have intellectual disability (CAAC, AM, and VM) with different pictures (device icons and internet pictures). Results are pictured in Figure 4. Influential outliers were removed. Near mastery demonstrated by the AM group yielded violations to normality, so their results were removed from the ANOVA and addressed through a Chi-Square analysis. Mauchly's test of sphericity indicated that the assumption of sphericity was met for the two-way interaction, $X^2(2) = 4.87$, $p = .09$ and main effect of group, $X^2(2) = .85$, $p = .61$, but could not be calculated for main effect of picture because there were only two groups. Thus, an average of Greenhouse and Geisser and Huynh-Feldt was used to correct the two-way repeated measures ANOVA (Field, 2018).

Figure 4

Sorting accuracy by group and picture type for Task 2b.



The interaction effect between group and picture type was not significantly different, $F(1.29, 9.00) = 1.08$, $p = .349$, partial $\eta^2 = .134$. The main effect of picture was not statistically significant, $F(1.00, 7.00) = .96$, $p = .361$, partial $\eta^2 = .120$, nor was the main effect of group, $F(1.74, 12.15) = 1.77$, $p = .210$, partial $\eta^2 = .202$.

Cohen's *d* calculations revealed a large effect size for the comparison with device pictures between CAAC and AM ($d = .86$), suggesting that these groups may perform differently. A small effect size was observed for CAAC and VM ($d = .28$). Analyses performed using the data set without children who cannot revealed a medium effect size for the comparison between CAAC and VM ($d = .49$). Cohen's *d* calculations revealed a large effect size for the comparison with realistic, internet pictures between CAAC and AM ($d = 1.34$), suggesting that these groups may perform differently with this skill. A small effect size was found for the comparison between CAAC and VM (d = .07). Analyses performed using the data set without children who cannot sort revealed consistent findings. Differences within-group between picture type were also calculated. Medium to small effect sizes were observed for CAAC (d = .03), AM (d = .52), and VM (d = .19). Results using the data without children who cannot sort yielded consistent findings.

Chi-Square analyses did not reveal a significant association between group and task mastery for the CAAC and AM groups with device pictures ($X^2(1, n = 18) = 2.00$, one-tailed exact significance = .173) nor with internet pictures ($X^2(1, n=18) = 2.10$, one-tailed exact significance = .167). However, the large effect sizes suggest that these groups do perform differently. No changes were observed when children who cannot sort were excluded.

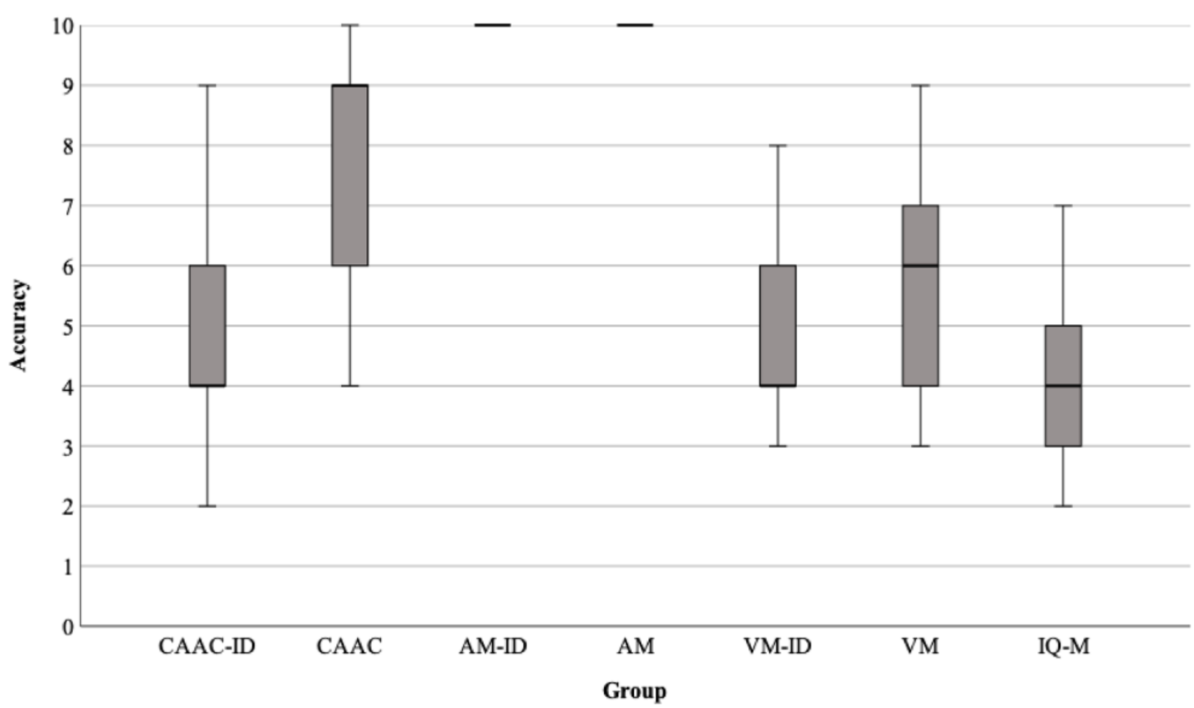
Research Question 2c

Research question 2c addressed CAAC's ability to sort words that are not on their AAC devices (meaning they have limited expressive interaction with these words expressively) in comparison to their age-matched, vocabulary-matched, and IQ-matched peers. Results were calculated using sorting outcomes from Task 2c. Authors ran a one-sample t-test to determine whether participants performed differently than chance response (chance level calculated at 3.33). CAAC-ID and IQ-M groups did not sort differently than chance (p = .061 and p = .317 respectively). CAAC, VM-ID, and VM groups sorted differently than chance (all $p < .046$), and both age-matched groups demonstrated mastery without variability, indicating that they performed differently from chance response.

Authors planned a one-way ANOVA to identify group differences. Results are pictured in Figure 5. Influential outliers were removed. Mastery demonstrated by the AM-ID and AM groups yielded violations to normality, and homogeneity of variance was violated. Because both the AM-ID and AM groups performed at ceiling, their results are removed from the ANOVA and addressed through a Chi-Square analysis. ANOVA results comparing the CAAC-ID group to CAAC, VM-ID, VM, and IQ-M groups revealed a significant effect of group on sorting ability, $F(6, 49) = 9.14$, $p < .001$, $\omega^2 = .47$. However, for groups with variable performance, even though a main effect was detected, no significant difference between individual groups was found given the Bonferroni adjustment. Cohen's *d* calculations revealed a large effect size for the comparison between CAAC-ID and CAAC ($d = .77$), CAAC-ID and AM-ID ($d = 3.09$) and CAAC and AM ($d = 1.32$), suggesting that these groups may perform differently and that the study was underpowered to detect difference. Medium to small effect sizes were found for comparisons between CAAC-ID and VM-ID ($d = .09$), CAAC and VM ($d = .46$), and CAAC-ID and IQ-M ($d = .40$).

Figure 5

Sorting accuracy by group for Task 2c.



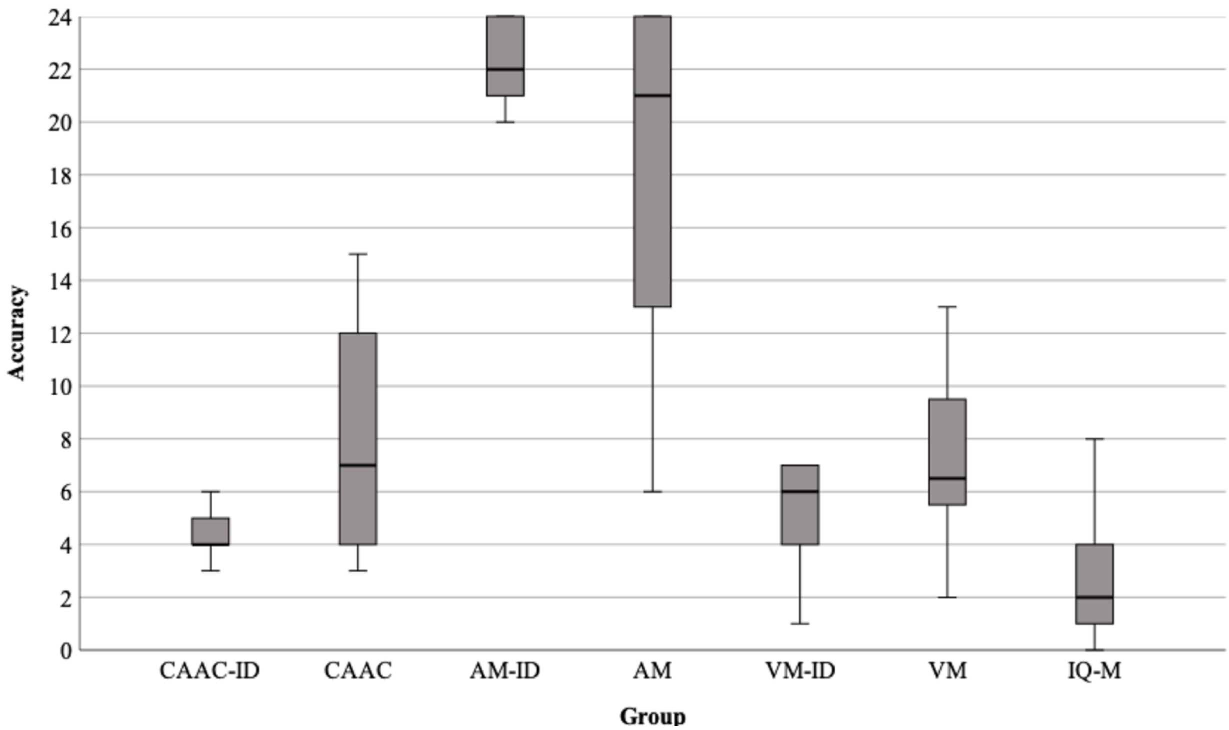
Chi-Square analyses evaluated group differences with groups that reached mastery (AM and AM-ID groups). Chi Square analyses revealed statistically significant differences between CAAC-ID and AM-ID (X^2(1, n=18) = 11.46, one-tailed exact significance < .001) and between CAAC and AM (X^2(1, n=18) = 5.56, one-tailed exact significance = .028). Authors removed cases of children who cannot sort from the data set and reran all analyses; differences in statistical significance were not observed. However, the effect size for the comparison between the CAAC and VM changed from small/medium (d = .46) to large (d = .80), suggesting that these groups may also perform differently when only considering children who can sort.

Research Question 3

Research question 3 addressed whether CAAC's taxonomic knowledge differs from that of age-matched, vocabulary-matched, and IQ-matched peers when categories are represented by a spoken word (rather than a picture). Results were calculated using outcomes from Task 3. Authors planned a one-way ANOVA to assess for differences between groups in identifying items that belong to a named superordinate-level term. Results are pictured in Figure 6. Influential outliers were removed, and the assumption of homogeneity of variance was violated. Thus, results are reported using a Welch Test, which is an adjusted F-test. All other assumptions were met. ANOVA results revealed a significant effect of group on the outcome variable, F(6, 21.19) = 35.79, p <.001, ω^2 = .71. Post Hoc tests with Bonferroni adjustment indicate significant differences between the CAAC-ID and AM-ID group (p <.001, d = 7.20) and the CAAC and AM group (p <.001, d = 1.66). Large effect sizes were observed for the comparisons between CAAC-ID and CAAC (d = 1.14) and CAAC-ID and IQ-M (d = .70), suggesting that this study may be underpowered to detect differences between these groups. Medium to small effect sizes were observed for comparison between CAAC-ID and VM-ID (d = .47) and CAAC and VM (d = .22).

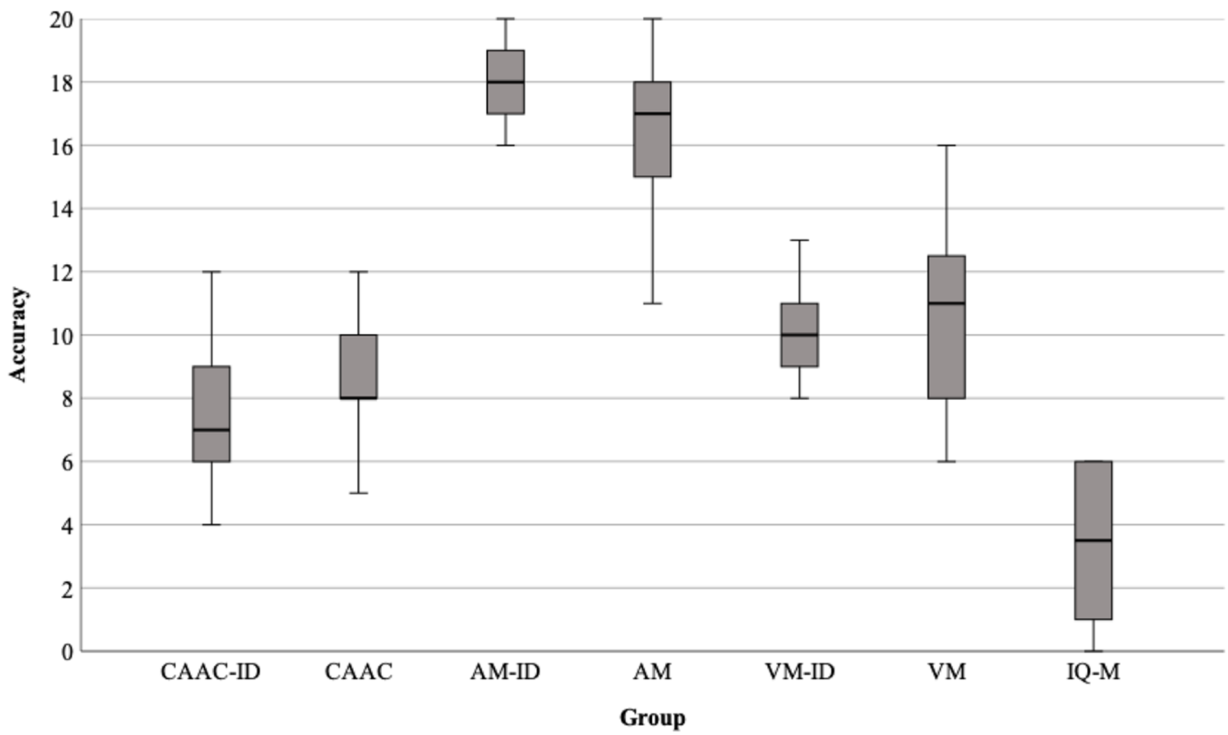
Figure 6

Response accuracy by group for Task 3 at the superordinate level.



Authors then planned a one-way ANOVA to assess for differences between groups in identifying items that belong to a named basic-level term. Results are pictured in Figure 7. All assumptions were met. ANOVA results revealed a significant effect of group on the outcome variable, $F(6, 52) = 24.04$, $p < .001$, $\omega^2 = .70$. Post Hoc tests with Bonferroni adjustment indicate significant differences between CAAC-ID and AM-ID (p <.001, d = 3.98) and CAAC and AM (p <.001, d = 2.14). Large effect sizes were observed for the comparisons between CAAC-ID and VM-ID (d = 1.21) and CAAC-ID and IQ-M (d = 1.24), suggesting that this study was underpowered to detect these group differences. Medium to large effect sizes were observed for the comparison between CAAC-ID and CAAC (d = .63) and CAAC and VM (d = .69), suggesting that these groups may also perform differently at the basic taxonomic level.

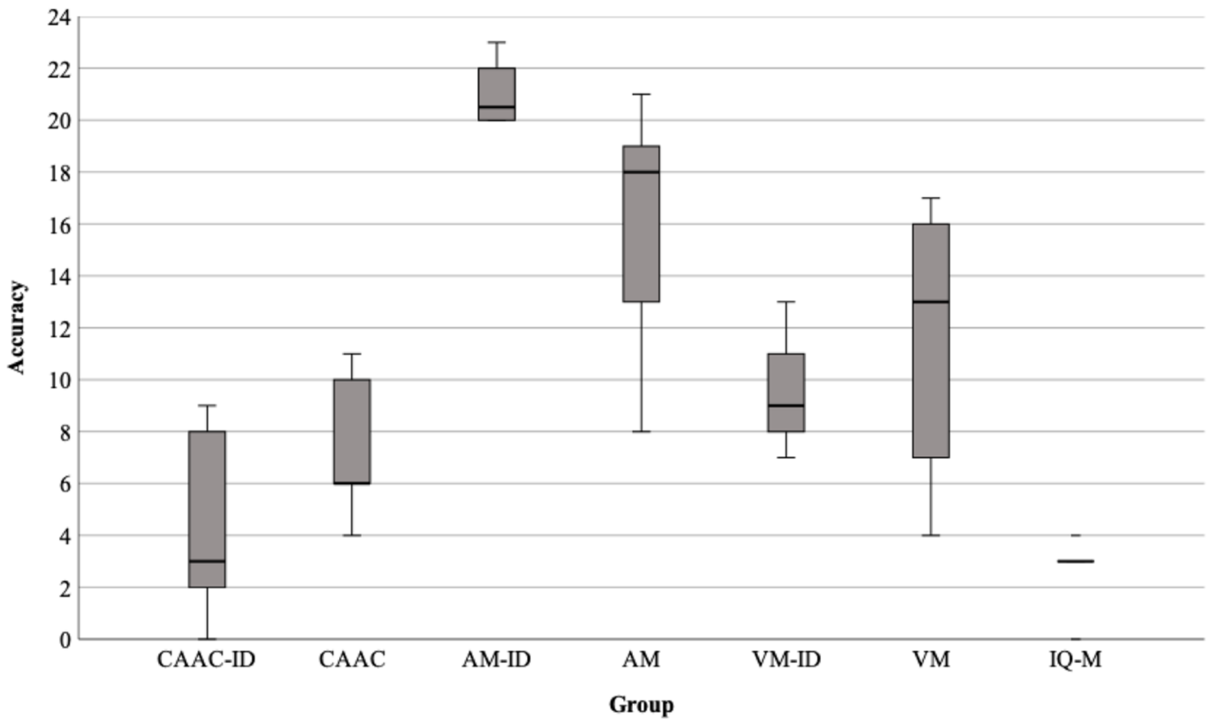
Figure 7
Response accuracy by group for Task 3 at the basic level.



Finally, authors planned a one-way ANOVA to assess for differences between groups in identifying items that belong to a named subordinate-level term. Results are pictured in Figure 8. Influential outliers were removed, and homogeneity of variance was violated. Thus, results are reported using a Welch Test, which is an adjusted *F*-test. All other assumptions were met. ANOVA results revealed a significant effect of group on the outcome variable, $F(6, 21.67) = 92.38$, $p <.001$, $\omega^2 = .75$. Post Hoc tests with Bonferroni adjustment indicate significant differences between CAAC-ID and AM-ID ($p <.001$, $d = 6.56$), CAAC and AM ($p <.001$, $d = 2.46$), and CAAC-ID and VM-ID ($p = .039$, $d = 1.79$). Large effect sizes were observed for the comparisons between CAAC-ID and CAAC ($d = .94$) and CAAC and VM ($d = 1.11$), suggesting that this study was underpowered to detect these differences. A medium to small effect size was observed for the comparison between CAAC-ID and IQ-M ($d = .47$).

Figure 8

Response accuracy by group for Task 3 at the subordinate level.



Discussion

The purpose of this study was to evaluate the taxonomic knowledge of CAAC in comparison to peers who do not use devices to communicate. Participants completed three tasks: (1) a sorting task to evaluate participants' ability to sort, (2) multiple sorting tasks that evaluated participants' taxonomic knowledge and the impact of an AAC device on their taxonomic knowledge, and (3) a picture selection task that evaluated participants' ability to apply language to their taxonomic knowledge. Results compared CAAC's outcomes to those of their age-matched, vocabulary-matched, and IQ-matched peers.

Sorting Tasks

Age-matched groups consistently performed best on all sorting tasks, typically followed by the CAAC groups, then the vocabulary-matched groups, and finally the IQ-matched group.

The progression of performance from age-matched to CAAC to vocabulary-matched groups is consistent with other findings that evaluate taxonomic knowledge of children with language disorders in comparison to age-matched and vocabulary-matched peers (Lund & Dinsmoor, 2016). These results reveal that early language learners who speak using AAC likely demonstrate deficits in their taxonomic knowledge as compared to their age-matched peers who are developing typically.

Results suggest that intellectual disability influenced participants' sorting abilities, which is consistent other studies (e.g. Megalakaki & Yazbek, 2013). On sorting tasks 2c and 2b with device pictures, the CAAC group outperformed the CAAC-ID group (differences yielded large effect sizes). Additionally, other than Task 1, the IQ-M group never performed differently than chance response. Both findings suggest that intellectual disability impacts taxonomic knowledge for all children, regardless of device use. Although CAAC-ID demonstrated deficits in taxonomic sorting, they did outperform their IQ-M group on Task 2b with realistic pictures and Task 2c (d = 1.35 and d = .50 respectively when children who cannot sort were excluded). The fact that CAAC are expected to navigate through taxonomic categories in their AAC devices to locate and say words provides with them repeated taxonomic practice, which may account for these differences. Thus, AAC device use may support taxonomic development in children with intellectual disability, which would in turn support language development (Wojcik, 2018).

On Task 2a, the fact that no groups sorted differently than chance and none sorted differently from each other suggests that CAAC have not developed taxonomic categories that are unique to their AAC devices. CAAC navigate these systems daily. It is, perhaps, concerning that their sorting relevant to their AAC devices does not look different from and better than children who have never seen these AAC devices before. If CAAC do not know that the pencil and scissors should be sorted into the rainbow category (because one can find the words “pencil” and “scissors” by selecting the rainbow icon), then it is likely that CAAC do not know where these words are located on their devices. It is possible that the fact that they have not developed these device-specific categories is contributing to their persistence as an early language learner. Children cannot learn to say new words if they cannot physically find them on the device.

In conclusion, results do not suggest that CAAC’s taxonomic knowledge of concepts represented by pictures is dependent on an AAC device. Participants demonstrated some sorting ability with pictures and words that are not on their AAC devices, and they lacked development of categories specific to their devices. Rather, results suggest that AAC devices influence and facilitate CAAC's taxonomic knowledge, especially children with intellectual and developmental disability. Taxonomic development is an important step in early language development; taxonomy supports children as they learn new words (Waxman & Kosowski, 1990), store these learned words, and retrieve them for communication (Wojcik, 2018). Not only must CAAC progress through these steps when communicating, but they must also navigate through taxonomic sequences to physically find these words on their devices. Thus, a firm grasp on taxonomic relations is especially important for this population to become effective, efficient communicators.

Taxonomic Picture Selection Task

Task 3 evaluated CAAC’s ability to identify items that belong to a category when that category is named aloud (versus shown in a picture in the sorting task). Therefore, this task relied more heavily on language than did the previous sorting tasks. Age-matched groups outperformed all other groups on this task at all three levels (superordinate, basic, and subordinate). Both vocabulary-matched groups surpassed the CAAC groups and performed second best on all tasks (except CAAC and VM at the superordinate level), followed by CAAC groups and then the IQ-matched group. Thus, when children were required to categorize by spoken word rather than picture, vocabulary-matched peers consistently outperformed CAAC, although group performances were consistently close for the superordinate and basic-level tasks.

Similar to the sorting task, IQ-matched peers consistently had the lowest mean accuracy score. The fact that CAAC-ID and IQ-M consistently presented with the lowest accuracy score supports the conclusion that intellectual disability substantially impacts taxonomic knowledge, which is a finding that is supported in the literature (Megalakaki & Yazbek, 2013). Thus, the addition of language to the taxonomic task did not change the overall effect of intellectual disability on sorting. However, similar to sorting tasks, CAAC-ID did consistently outperform the IQ-M group, suggesting that AAC devices may support development of taxonomic skills in children with intellectual disability.

Comparisons between CAAC groups and vocabulary-matched groups yielded larger differences at the subordinate level than did at the superordinate and basic levels. This suggests that CAAC, who have a language disorder, demonstrated more difficulty with words at the subordinate level than other levels. McGregor and Waxman (1998) observed the same pattern in verbal children with word finding deficits. It is likely that subordinate-level terms are exceptionally difficult for children with language disorders, including CAAC, to learn.

The fact that CAAC groups performed more poorly than age-matched groups on these language-based taxonomic tasks was expected and shows delay in development of taxonomy, which is consistent with study findings and the literature (e.g. Lund & Dinsmoor, 2016). However, the fact that, CAAC performed more poorly than children who have the same vocabulary size as them suggests that CAAC's taxonomic knowledge is disordered, not just delayed, when the taxonomic task involves language. This differs from the picture sorting task results (a more cognitive and less language-based task), which suggested that CAAC are delayed but not disordered.

Overall results indicate that CAAC can categorize groups with visual supports similarly to their vocabulary-matched and IQ-matched peers (Tasks 1 and 2), suggesting that receptive vocabulary size and cognition play a large role in sorting ability. However, when they must rely on language to categorize (Task 3), their categorization skills are poorer than that their vocabulary-matched peers, suggesting that vocabulary size is less of a contributing factor when the task involves language. It is likely that CAAC's expressive language disorder is impacting their language-based categorization skills, for this has been found in other populations with language disorders (Lund & Dinsmoor, 2016; McGregor & Waxman, 1998). Because taxonomy supports vocabulary knowledge, and CAAC present with vocabulary deficits and disordered taxonomic knowledge in language-based tasks, it is possible that this taxonomic disorder is contributing to CAAC's vocabulary deficits. Thus, CAAC may benefit from direct taxonomic instruction as it relates to word knowledge.

Clinical Implications

The results of this study may have implications for AAC device design and clinical interventions. CAAC-ID, VM-ID, and IQ-M all performed at chance level in Task 2b when sorting pictures taken from the device, but CAAC-ID and VM-ID performed above chance level when sorting pictures (same categories) taken from the internet. It is possible that this discrepancy is related to the type of images presented in these tasks. LAMP Words for Life™ images that represent superordinate categories (i.e. "animals") are basic-level images (i.e. a picture of a single dog). On the contrary, internet images that represented superordinate categories are more directly relevant to the superordinate-level term (i.e. a picture of many different animals). Thus, sorting with internet images requires participants to match basic-level terms to superordinate categories, but sorting with device images requires participants to match basic-level terms with superordinate categories that are labeled through a basic-level image, which is a more complex task.

AAC device icon images may impact CAAC's ability to use their taxonomic knowledge to find words on their devices. However, AAC device making companies are given a near impossible task: ensure thousands of words are represented by appropriate pictures, organized using a logical word storage methodology, and can be retrieved in a time efficient manner. Optimal organization of words on an AAC device is a complex question with contradictory study outcomes (e.g. Light et al., 2004; Traylor 2004). AAC devices have limited landscape. If a device presents a logical superordinate category for every noun on the system, the device would need to display so many categories that efficiency in locating words on the device would be compromised. Thus, the answer to the problem may lie in clinical interventions rather than optimization of device organization.

CAAC with and without intellectual disability are expected to use taxonomic knowledge to locate words on their AAC devices, but they present with deficits in taxonomic knowledge. CAAC may benefit from additional instruction on taxonomic relations within an AAC device. Trevino and Lund (in preparation) found that explicit instruction on navigating device categories to find/learn words on an AAC device yielded better vocabulary outcomes for CAAC with and without intellectual disability, which supports this hypothesis.

Limitations and Future Directions

Various study limitations have led to future research directions. The ceiling effect demonstrated by both age matched groups on sorting tasks violated ANOVA assumptions and, thus, limited conclusions that can be drawn using this comparison. Therefore, those outcome variables were transformed into binary variables, and a Chi-Square analysis was used for group comparisons that included a group that reached mastery. Although transforming the variable and performing a different statistical analysis compensated for the ceiling effect, the nature of a binary variable is one such that subtle differences are lost, which could impact granularity of results. Because categorization using taxonomic knowledge is a developmental skill, it is expected that age-matched peers would present at ceiling level with these tasks. However, a larger sample size would give a more precise range of CAAC's performance on taxonomic skills and provide more power to capture differences in performance using binary variables. Additionally, future studies that include these comparisons can include younger children whose age-matched peers are not expected to have mastered this skill, which will allow for variability in results and prevent violations to ANOVA assumptions.

Additionally, children with autism were excluded from the study, for they may process language differently than children without autism (ASHA, n.d.c; Herringshaw et al., 2016). Unique language processing could have an impact on taxonomic knowledge and word storage, which could yield differences in study outcomes. Authors plan to repeat this study with autistic children who speak using AAC. Furthermore, taxonomic knowledge of CAAC who have surpassed the early stages of language development through AAC has yet to be studied. This limits authors' ability to determine the extent that being an early language learner influences outcome variables (for there is no data from a more linguistically advanced group to which results can be compared). Authors plan to repeat this study with CAAC who have surpassed the early stages of language development to evaluate differences and similarities between groups.

Furthermore, the lack of statistical significance but consistency in large effect sizes suggests that the study was underpowered. It is possible that subtle differences in taxonomic knowledge between groups were not captured. Future studies should consider larger sample sizes (and power analyses using the findings from this study) to ensure that the study is fully powered.

Finally, this study should be repeated with children who speak using other types of high-tech AAC devices. These devices use different types of pictures to represent words and categories, and they use different organizational structures to store words. It is important to evaluate the way that other types of AAC devices influence taxonomic knowledge and whether other device organizations yield differing effects on the CAAC's taxonomic knowledge.

Conclusions

Findings suggest that CAAC with and without intellectual disability present with deficits in taxonomic knowledge in comparison to their same-age peers. CAAC’s taxonomic outcomes shift from delayed to disordered when categorization tasks involve language (i.e. words rather than pictures only). These deficits and disorders in taxonomic knowledge could be contributing to CAAC’s vocabulary deficits, compromising their ability to learn, store, and retrieve words and physically find words on their AAC devices. Future studies should investigate methods to support taxonomic knowledge in an effort to facilitate the early word learning process.

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CHAPTER V: CONCLUSION

Children who experience limitations with verbal speech can speak using an alternative method of communication: augmentative or alternative communication (AAC). Access to AAC provides this population with a promising opportunity to learn to effectively communicate. However, despite access to AAC devices, children who speak using AAC (CAAC) present with substantial limitations in their expressive language outcomes (Andzik et al., 2018; Erickson & Geist, 2016). More specifically, the majority (approximately 60-70%) of CAAC are stuck in the early word learning phase of language development through AAC (Andzik et al., 2018; Erickson & Geist, 2016), meaning that they produce fewer than 50 meaningful words on their AAC devices (Andzik et al., 2018). Early word learning is one of the first steps in language development through AAC and, without proficiency, CAAC cannot become independent, proficient communicators (Binger et al. 2020). Thus, the topic of early word learning is of extreme relevance and importance to this population.

The overarching purpose of this dissertation manuscript is to investigate the impact of measurement, input, and AAC devices on early word learning for CAAC. The results from all three manuscripts contribute to this overarching purpose. The purpose of the first study in this dissertation manuscript was to identify a language sample elicitation strategy that yielded valid language samples for children who speak using AAC (CAAC). The purpose of the second study was to compare two different vocabulary input approaches to determine the approach that yielded more vocabulary words learned for CAAC. The purpose of the third study was to evaluate the taxonomic knowledge of CAAC and the way that an AAC device may influence their taxonomic knowledge.

Dissertation Manuscripts and Clinical Relevance

In the first article, authors compared various language sample elicitation strategies to identify the tool that appears to have concurrent validity with other measures of CAAC's early language productions. Multiple tools exist that evaluate early developing expressive language, and many of these tools can be used with CAAC (e.g. Fenson et al., 2007; Rowland, 2004, Brady et al., 2018, Kovach, 2009). However, none of these tools yield a sample of the child's expressive language skills, particularly one that could be sensitive to short-term changes in functional communication. Unlike other evaluation methods, language samples can be analyzed to evaluate nuances in communicative abilities and can capture small change in expressive language productions (Schuele, 2010; McCauley & Swisher, 1984). Thus, they are exceptionally important when evaluating early developing expressive language, which oftentimes includes granular changes that may not be captured in other types of assessments (McCauley & Swisher, 1984).

Research indicates that a play-based elicitation strategy is most appropriate for early language learners (Heilmann, 2010), but various play-based strategies exist. These strategies had yet to be compared for this population. Thus, authors elicited three language samples from all 10 CAAC participants using three different elicitation strategies: a generic play-based method, the Communication and Symbolic Behavior Scales (CSBS; Wetherby & Prizant, 2003), and automatic data logging. Authors hypothesized that the CSBS would yield the most valid language sample because it includes standardized elicitation procedures that are designed for early language learners. Results from language samples were correlated with Communication Matrix (Rowland, 2004) results to determine the elicitation strategy that yielded the most valid language sample.

Results revealed that the generic play-based elicitation strategy correlated most closely with Communication Matrix results. Results also revealed that, although it did correlate as well with the Communication Matrix, the CSBS elicited the most communicative acts, suggesting that this elicitation method can be used to evaluate the limits of CAAC's expressive language abilities. Automatic data logging lacked communicative context, which is important when evaluating early language productions, and, thus, was determined to be an ineffective tool for this population.

Although some studies had investigated language sampling with people who speak using AAC (e.g. Kovacs & Hill, 2017; Savaldi-Harussi and Soto, 2016), none of these studies included early language learners. Results from this study provide researchers and clinicians with a valid tool that can be used to evaluate expressive language productions as CAAC learn new words in early language development. Practitioners can use these findings to assess their clients, which will support therapeutic decision making for this population.

Once a valid evaluation tool was identified to measure early AAC productions, authors proceeded to investigate methods of teaching early words to CAAC. In the second article, authors compared two approaches to input in early word learning for CAAC: a naturalistic input intervention (i.e. incidental teaching) and a structured input intervention (i.e. explicit instruction). Both instructional methods are common, effective vocabulary interventions for verbal children (e.g. Beck & McKeown, 2007; Valdez-Menchaca & Whitehurst, 1998). A growing body of literature suggests that the structured approach yields better vocabulary outcomes for verbal children with or at risk for vocabulary deficits (Coyne et al., 2007; Lund & Douglas, 2016). However, vocabulary intervention articles for CAAC, who present with vocabulary deficits (e.g. Erickson & Geist, 2016), investigate early word learning strategies that use naturalistic strategies

(Drager et al., 2006; Harris & Reichle, 2004; Hall, 2014; and Romski et al., 2010). Because the structured approach to intervention yielded better vocabulary outcomes for children with other disabilities or who are at risk for vocabulary deficits (Coyne et al., 2007; Lund & Douglas, 2016), authors hypothesized that the structured intervention approach would yield more words learned for CAAC.

An adapted alternating treatments single-subject design was used to compare the structured and naturalistic approaches to early word learning interventions. Results revealed that the structured intervention approach yielded more efficient word learning (i.e. more words learned in less sessions) for all three CAAC participants. This finding is consistent with the literature for other children with or at risk for vocabulary deficits (Coyne et al., 2007; Lund & Douglas, 2016).

The structured intervention included explicit instruction about the navigational pathway to produce a target word, or the icons that must be selected to "find" a target word, on the AAC device. This unique component drew CAAC's attention to taxonomic categories entrenched within their AAC devices, which may have supported their ability to find (and maintain ability to find over time) the target word on their device. Results provided clinicians with an effective intervention input protocol that can be feasibly implemented in clinical settings with limited preparation. Practicing clinicians can use results from the first and second study of this dissertation to feasibly target and evaluate early word learning for CAAC.

Once effective word learning intervention procedures were identified, authors sought to understand the way that CAAC store these learned words. Extant literature suggests that verbal children use taxonomy to facilitate early word learning (Waxman & Kosowski, 1990), store these learned words, and efficiently retrieve words during conversation (Wojcik, 2018). Deficits in taxonomy have been observed in children with language disorders and differences (Lund & Dinsmoor, 2016; McGregor and Waxman, 1998), which, theoretically, could be contributing to their vocabulary deficits.

CAAC present with a language disorder (e.g. Andzik et al., 2018), and they receive limited input in their symbol system (Barker et al., 2013), both of which could contribute to deficits in taxonomic knowledge (Lund & Dinsmoor, 2016; McGregor and Waxman, 1998). It is possible that deficits in taxonomic knowledge could impact CAAC's ability to learn and store new words, contributing to their persistence in the early stages of language development through AAC. Thus, the third study in this dissertation evaluated CAAC’s taxonomic knowledge and the impact that an AAC device has on their taxonomic knowledge. Authors hypothesized that CAAC would present with taxonomic deficits in comparison to their typically developing age-matched peers.

CAAC's taxonomic knowledge was evaluated using picture sorting tasks and picture identification tasks. The latter required CAAC to apply language to their taxonomic knowledge. Results for CAAC with and without intellectual disability were compared to that of their age-matched and vocabulary-matched peers, and CAAC with intellectual disability’s results were compared to that of their IQ-matched peers. The IQ-matched group was included because CAAC not only face challenges with language, but they also face challenges with general learning (i.e. intellectual disability). Inclusion of an IQ-match group was necessary to parse out the effects of intellectual disability versus language knowledge versus age versus using an AAC device, providing a comprehensive understanding of the factors that influence taxonomic knowledge in CAAC.

Results revealed that CAAC present with deficits in taxonomic knowledge in comparison to their typically developing, age-matched peers. On sorting tasks (i.e. tasks that do not involve spoken language), CAAC groups typically outperformed their vocabulary-matched groups; CAAC without intellectual disability showed greater separation from vocabulary-matched peers than did CAAC with intellectual disability. However, on picture identification tasks, which involved the use of language when categorizing, vocabulary-matched groups typically outperformed CAAC groups. This finding suggests that CAAC present with a disorder (not just delay) in taxonomic knowledge when paired with language. Also, because this shift in performance is consistent with (and unique to) both CAAC groups, this finding also suggests that communicating using an AAC device influences this shift in performance. Perhaps CAAC are better at categorizing with visual supports (i.e. sorting task) because they navigate through taxonomic categories (represented by pictures) on their devices daily, but without the visual supports, their taxonomic deficits are more profound.

Additionally, CAAC without intellectual disability consistently outperformed CAAC with intellectual disability on all taxonomic tasks, and the IQ-matched group never performed above chance levels (except when demonstrating that they know how to sort). Authors concluded that intellectual disability impacts taxonomic knowledge, which is consistent with the literature (Megalakaki & Yazbek, 2013). However, the fact that CAAC with intellectual disability outperformed the IQ-matched group across all tasks suggests that AAC device use may support development of taxonomic knowledge, which could have a positive impact on CAAC's word learning, storage, and retrieval.

Overall, CAAC presented with deficits in taxonomic knowledge, especially CAAC with intellectual disability, but they are required to navigate through taxonomic categories (and memorize these taxonomic pathways) to learn new words on their AAC devices. Thus, these findings suggest that CAAC could benefit from instruction on taxonomy, especially as it relates to learning and finding words on their AAC devices. It is likely, then, that the navigational description component in the second study of this dissertation, which focused on teaching taxonomic pathways of the AAC device, provided participants with the taxonomic support that they needed to learn new words, contributing to study two's outcomes.

In conclusion, CAAC's persistence in the early word learning stages of language development through AAC (Andzik et al., 2018; Erickson & Geist, 2016) is a widespread problem that leads to lack of communicative proficiency and, ultimately, isolation for this population. Each of the studies in this dissertation manuscript investigated different aspects of early word learning for CAAC: measurement, intervention strategies, and cognitive-linguistic mechanisms that contribute to word learning. The results from all studies in this dissertation contribute to a body of work that, together, investigates clinically relevant and feasible solutions for this early word learning problem.

Future Directions

Results from each individual study and overarching conclusions drawn from all three studies together provide guidance and direction for future research. The second and third studies together reveal the role that taxonomy plays in early word learning with this population, and this topic has not yet been approached in the literature. This finding opens the door to an innovative line of work that investigates processes of word learning as they relate to taxonomy, which may be an important factor in language development for CAAC that has been overlooked thus far.

Future studies in this line of work will evaluate the way that CAAC use taxonomy to support word learning, ultimately aiming to facilitate the early word learning process for this population. For example, an early study in this line of work will evaluate whether CAAC can use taught taxonomic knowledge and device navigation to self-teach new words. That is, the purpose will be to determine whether CAAC can locate new, untaught words on an AAC device (e.g. cat) after being taught another word in the same taxonomic category and device location (e.g. dog). Authors observed this phenomenon in study two with one participant. If effective, this intervention method would have implications for word selection in intervention and could increase efficiency in the word learning process for CAAC.

Another early study in this line of work would investigate whether the structured intervention from study two facilitates formation of device-specific superordinate categories in CAAC. Should CAAC develop device-specific categories that support word learning and maintenance, CAAC may benefit from learning words in "themes" related to their AAC devices rather than common classroom themes, a third topic of investigation along this line of work. Again, if effective, these clinical strategies could facilitate the word learning process, which will help CAAC progress towards more advanced language productions (Binger et al., 2020).

Another line of work that will emerge from this dissertation manuscript is investigation of feasible evaluation and progress monitoring tools for this population. Early investigations will evaluate the extent to which the play-based elicitation strategy can measure change over time for different early communicative acts (e.g. AAC productions, gestures, vocalizations). A long-term goal in this line of work is to identify feasible, time efficient tools that practitioners can use to monitor early language progress in CAAC, as accurate and time-efficient progress monitoring is a requirement in both school and outpatient clinic settings.

In conclusion, with such limited language outcomes for CAAC (Andzik et al., 2018; Erickson & Geist, 2016), new, innovative approaches to early word learning are sorely needed.

The three articles in this dissertation manuscript set the foundation for two distinct lines of work that investigate solutions to this need. The first study revealed that practitioners' approach to measuring early language outcomes matters: some measurement tools may distort results for this population, which will impact assessment findings (and clinical decision making). The second study revealed that the type of input in vocabulary interventions matters: explicit vocabulary instruction, specifically with direct instruction about navigational pathways on the AAC device, yields better word learning for this population. Finally, the third study revealed that taxonomy and the device, together, matter: the device itself (along with other factors) draws on CAAC's understanding of taxonomy, and the device may even inform CAAC's understanding of taxonomy, yielding a potentially cyclical relationship. Outcomes from these studies and future lines of work will support CAAC in surpassing early stages of language development and progressing towards independent, effective communication.

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APPENDICES

Appendix A

Explicit Instruction Wordlists.

List 1	List 2	List 3	List 4	List 5
Dog	Pig	Bear	Cat	Ice Cream
Horse	Mouse	Elephant	Duck	Pizza
Banana	Cookie	Flower	Puzzle	Light
Grapes	Sandwich	Tree	Doll	Boot
Milk	Hat	Pants	Jacket	Glasses
Juice	Shoe	Shirt	iPad	School
Jump	Swim	Climb	Stand	Slide
Drink	Eat	Sing	Talk	Watch
Paint	Throw	Clap	Hit	Draw
Wipe	Catch	Break	Cut	Dance

Appendix B

Incidental Teaching Wordlists.

List 1	List 2	List 3	List 4	List 5
Cup	Car	Bus	Truck	Bath
Spoon	Bike	Train	Airplane	Star
Brush	Bowl	Bed	Door	Rain
Toothbrush	Fork	Chair	Stairs	Key
Foot	Arm	Scissors	Pillow	House
Nose	Ear	Crayon	Table	Pencil
Swing	Kick	Walk	Wash	Build
Read	Run	Ride	Give	Sit
Pull	Hug	Drop	Drive	Open
Push	Cry	Call	Fall	Kiss

VITAE

Courtney Trevino

EDUCATION

PhD in Health Sciences, emphasis in Speech-Language Pathology August 2021 – Present

- Texas Christian University
- Anticipated completion in May 2024
- *Dissertation: Evaluating the Impact of AAC on Taxonomy and Word Storage in Children who Speak using AAC; Advisor: Emily Lund*

Master of Science in Speech Language Pathology August 2015 – May 2017

- Texas Christian University

Bachelor of Science in Communication Sciences and Disorders August 2011 - May 2015

- Texas Christian University
- Minor in Child Development

CERTIFICATION AND LICENSURE

ASHA Certificate of Clinical Competency August 2018 – Present

Texas License-Speech-Language Pathology August 2018 – Present

RESEARCH

Publications

Trevino, C. T., & Lund, E. A. (2024). Determining an Effective Language Sample Elicitation Strategy for Early Language Learners Who Speak Using Augmentative and Alternative Communication. *American Journal of Speech-Language Pathology*, *33*(1), 203-219. https://doi.org/10.1044/2023_AJSLP-23-00148

Mattingly, J., Trevino, C., & Lund, E. (2023). Dance and the executive functioning skills of children: A scoping review. Featured in Bryl, K., Fontanesi, C., & Stewart, C. (2023). Abstracts from the 2022 Research and Thesis Poster Session of the 57th Annual American Dance Therapy Association Conference, Renewed Connections: Dance/Movement Therapy Fostering Community Healing, October 27 – 30, 2022. *American Journal of Dance Therapy*, *45, 109 – 121.*

Trevino, C., & Lund, E. (In preparation). Comparing Two Vocabulary Interventions for Children Who Speak Using AAC.

Trevino, C., & Lund, E. (In preparation). Evaluating Children Who Speak Using AAC's Taxonomic Knowledge and the Impact of an AAC Device on Their Taxonomic Knowledge.

Research Assistant in Childhood Hearing, Language, Literacy, and Deafness Lab August 2014 – Present

- Examiner: administered over 20 language and literacy assessments to typically developing children and children with hearing loss for NIDCD/NIH R01 (PI Werfel & Lund)
- Collected data for NIH/NIDCD R03 (PI Lund)
- Conducted data transcription and management for an ASHFoundation parent training study for children with hearing loss
- Managed and organized data from funded projects and other lab research projects
- Mentored undergraduate and graduate research assistants to accurately administer tests, score, and manage data in funded projects and other lab research projects (including my own research projects)

GRANTS

Awarded Grants

Harris College of Nursing and Health Sciences Student Research Grant. (2023). *Evaluating the Impact of AAC on Word Storage in Children who Speak using AAC*. Role: Principal Investigator.

Harris College of Nursing and Health Sciences Student Research Grant. (2023). *Evaluating Two Vocabulary Intervention Strategies for Early Language Learners who Speak using AAC*. Role: Principal Investigator.

National Institutes of Health Student Travel Grant – The Symposium on Research in Child Language Disorders. (2022).

Harris College of Nursing and Health Sciences Student Research Grant. (2022). *Determining an effective language sample elicitation protocol for early-stage language learners who speak using AAC*. Role: Principal Investigator.

Submitted But Not Funded

National Institutes of Health F31. (**Scored**, not funded; 2022). *Evaluating speech-language pathologists' clinical decisions for children who are deaf or hard-of-hearing.* Role: Principal Investigator.

Texas Speech-Language-Hearing Foundation. (Not funded; 2022). *Evaluating SLP's Practice Decisions for Children who Speak using AAC.* Role: Principal Investigator.

American-Speech-Language-Hearing Foundation Student Research Grant in Early Childhood Language Development. (Not funded; 2022). *The Effects of a Framework on Language-Based Decisions for Early Language Learners who Speak using AAC*. Role: Principal Investigator.

Council of Academic Programs in Communication Sciences and Disorders. (CAPCSD; not funded; 2021). *Determining the Most Effective Language Sample Elicitation Protocol for Early-Stage Language Learners Who Speak using AAC.* Role: Principal Investigator.

TEACHING EXPERIENCE

Teacher of Record

- COSD 30334 Language Development in Children, undergraduate course, Department of Communication Sciences and Disorders, Texas Christian University, Fall 2022

- COSD 30334 Language Development in Children Lab, undergraduate course, Department of Communication Sciences and Disorders, Texas Christian University, Fall 2022
- COSD 30373 Language Disorders in Children, undergraduate course, Department of Communication Sciences and Disorders, Texas Christian University, Spring 2023

Teaching Assistant

- COSD 30373 Language Disorders in Children, undergraduate course, Department of Communication Sciences and Disorders, Texas Christian University, Spring 2022

EMPLOYMENT

School Speech-Language Pathologist & AAC Team Lead August 2017 – August 2021

- Developed and executed district-wide procedures for AAC evaluations (evaluations, device trials, device selection, and supporting families in obtaining systems) and classroom intervention targeting language development through AAC for students ages 3 – 22; procedures still exist today
- Coached and mentored colleagues to become independent in AAC intervention and evaluations
- Collaborated with interprofessional team (e.g. physical therapists, occupational therapists, and more) to conduct evaluations and provide interprofessional services for children who speak using AAC
- Conducted speech therapy for students from ages 3-19 to develop language through AAC with various diagnoses, various access methods, and various speech generating devices

PEER REVIEWED CONFERENCE PRESENTATIONS

Trevino, C., & Lund, E. (2023, January). Language Sampling Early Language Learners who Speak Using AAC: Determining an Appropriate Elicitation Strategy. Poster presented at the annual convention of Assistive Technology Industry Association, Orlando, FL. *Recipient of Harris College of Nursing and Health Sciences Travel Grant* and *Texas Christian University Student Travel Grant.*

Trevino, C., Werfel, K. L., & Lund, E. (2022, June). The effect of neighborhood density on phoneme blending in children with hearing loss and children with typical hearing. Poster presented at the Symposium on Research in Child Language Disorders (SRCLD), Madison, WI. *Recipient of NIH Student Travel Award* and *Harris College of Nursing and Health Sciences Travel Grant.*

O'Lenick, D., & Trevino, C. (2019, November). Ethics and AAC. Presentation at the annual convention of the Speech-Language Hearing Association, Orlando, FL.

O'Lenick, D., & Trevino, C. (2019, February – March). Language through AAC IS Language through AAC. Presentation at the Texas Speech-Language-Hearing Association State Convention, Fort Worth, TX.

O'Lenick, D., & Trevino, C. (2019, February – March). Let's Talk Ethics and AAC. Presentation at the Texas Speech-Language-Hearing Association State Convention, Fort Worth, TX.

O'Lenick, D., & Trevino, C. (2018, February). The Fear of Commitment: Choosing an AAC System for your Client. Presentation at the Texas Speech-Language-Hearing Association State Convention, Houston, TX.

O'Lenick, D. & Trevino, C. (2018, February). Speaking AAC: Augmentative and Alternative

Communication Therapy Techniques. Presentation at the Texas Speech-Language-Hearing Association State Convention, Houston, TX.

O'Lenick, D. & Trevino, C. (2018, February). Ethics and Its Application to Augmentative and Alternative Communication. Presentation at the Texas Speech-Language-Hearing Association State Convention, Houston, TX.

INVITED PRESENTATIONS

Trevino, C., & Lund, E. (2024, April). Comparing two vocabulary interventions for children who speak using AAC. Poster presented at the Student Research Symposium, Fort Worth, TX. *Recipient of Harris College of Nursing and Health Sciences Second Place Award for doctoral student posters.*

Trevino, C. (2023, September). Teaching Vocabulary to Early Language Learners who Speak using AAC. Presentation at the Faculty Research Symposium, Fort Worth, TX.

Trevino, C., & Lund, E. (2023, April). Language Sampling Early Language Learners who Speak Using AAC: Determining an Appropriate Elicitation Strategy. Poster presented at the Student Research Symposium, Fort Worth, TX. *Recipient of Harris College of Nursing and Health Sciences Second Place Award for doctoral student posters.*

Trevino, C., (2022, September). What is the Best Way to Language Sample Expressive Language Produced through AAC? Presentation at the Faculty Research Symposium, Fort Worth, TX.

Trevino, C., Werfel, K. L., & Lund, E. (2022, April). The Effects Over Time of Word Form Characteristics on Early Literacy Skills of Children with Hearing Loss and Children with Normal Hearing. Poster presented at the Student Research Symposium, Fort Worth, TX.

Trevino, C. (2022, April). I Just Can't Find the Words. Three-Minute Thesis Competition: University-Level, Fort Worth, TX. *Third place winner of Texas Christian University Three-Minute Thesis Competition.*

Trevino, C. (2022, February). I Just Can't Find the Words. Three-Minute Thesis Competition: College-Level, Fort Worth, TX. *Second place winner of Harris College of Nursing and Health Sciences Three-Minute Thesis Competition.*

Trevino, C., & O'Lenick, D. (2020, August). AAC in the ISD. Presentation to Special Education Department at Weatherford Independent School District.

Trevino, C. (2019, August). Language through AAC in YOUR Classroom. Presentation to Special Education Department at Weatherford Independent School District.

O'Lenick, D., & Trevino, C. (2019, June). Language Rich Immersion. Presentation at the Texas Assistive Technology Network State Conference, Houston, TX.

O'Lenick, D., & Trevino, C. (2019, June). Getting to the Core of Core Vocabulary: Returning to the Research. Presentation at the Texas Assistive Technology Network State Conference, Houston, TX.

O'Lenick, D., & Trevino, C. (2019, June). Focusing on the "Communication" in Augmentative Communication. Presentation at the Texas Assistive Technology Network State Conference, Houston, TX.

O’Lenick, D., & Trevino, C. (2019, April). Language through AAC and So Much More. Presentation at Partners in Policy Marking, Austin, TX.

O’Lenick, D., & Trevino, C. (2018, September). Core Vocabulary. Presentation at Region XI Education Service Center, Fort Worth, TX.

PROFESSIONAL SERVICE

ASHA Member 2018 – Present

Texas Speech-Language and Hearing Association (TSHA) AAC Committee member 2019 – 2020

TSHA Co-Chair of Member Advocacy Committee 2018 –2019

TSHA Executive Board Graduate Student Representative 2015 – 2018

HONORS AND AWARDS

Harris College of Health Sciences Research Assistantship and Scholarship Award 2021 – Present

Texas Christian University STARS-Diversity Award 2021 – Present

Harris College of Health Sciences Student Research Symposium Second Place Award 2024

Harris College of Health Sciences Student Research Symposium Third Place Award 2023

Texas Christian University University-Level Three Minute Thesis Third Place Award 2022

Harris College of Health Sciences College-Level Three Minute Thesis Second Place Award 2022

Harris College of Nursing and Health Sciences Student Travel/Conference Grant 2022

Harris College of Nursing and Health Sciences Student Travel/Conference Grant 2022

Texas Christian University Graduate Student Travel Grant 2022

Texas Speech-Language and Hearing Association Young Leadership Award 2017

Texas Christian University Communication Sciences and Disorders Graduate Assistantship Award 2015

Texas Christian University’s Senior Legacy Award 2015

COMMUNITY SERVICE

Vice President, A Founding Executive Board Member for Nonprofit Organization 2018 – 2022

- Built the structure and foundation of the non-profit organization, including creation of bylaws, business structure, financial structure, marketing, and branding

Birdville Independent School District Bond Committee Member February – May 2022

Teacher in Children’s Ministry 2016 – 2018

Small Group Leader 2017 – 2018

Book Study Leader	2016 – 2017
Founder and Coordinator of A Chance to Dance: prom for individuals with IDD	2013 – 2015