Effects of Aided Language Input Intensity on AAC Use

By

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Abstract

Aided forms of augmentative and alternative communication (AAC) enable individuals with significant disabilities to interact with people in their environment and be active participants in their lives. However, the provision of an AAC system is not enough and requires both general and focused systematic instruction to build language and communication skills in those who rely on aided forms of AAC. While interventions are often comprised of multiple strategies, aided language input is known to be of paramount importance. Prior research related to aided language input has varied considerably in how frequently it has been provided to participants.

Three school-aged boys participated in the study (*M*age = 8.5; age range = 6.8-10.8 years). One participant had a diagnosis of autism spectrum disorder, one had a diagnosis of Down syndrome, and one participant had diagnoses of autism spectrum disorder, Down syndrome, and an intellectual disability. Two of the three participants came from monolingual households, and one participant came from a bilingual household where English and Spanish were spoken.

Information was collected during pre-intervention using parent questionnaires, Rowland's Communication Matrix (Rowland & Fried, 2010), and modified standardized testing using the Test of Auditory Comprehension of Language 4th edition (Carrow-Woolfolk, 2014). Information was collected during intervention sessions through direct observation of AAC device use, number of different words used, as well as overall changes to communication. To determine effect sizes and statistical significance, Actual and Linear Interpolated values and a randomization test were calculated for (a) AAC use by participants, (b) number of different words used by participants, and (c) overall use of AAC/speech/sign. Post-intervention

information was collected via parent questionnaire using Rowland's Communication Matrix and re-administration of Test of Auditory Comprehension of Language 4th edition.

Utilizing an alternating treatments design consisting of low-intensity and high-intensity conditions, this study investigated the effects that aided language input had on (a) the number of device activations produced by the participants, (b) the number of different words/pre-stored messages used by the participants, and (c) concurrent changes in communication and language.

There were no statistically significant differences between the low and high intensity conditions on the number of device activations, the number of different words used, or on communication through all modalities. However, progress was made for each participant. This progress was different for each participant. One participant had improved scores on the receptive language test the Test of Auditory Comprehension of Language 4th edition. Another participant had an increasing trend in how much they used their device as well as an increasing trend in how many different words they utilized, while another participant demonstrated an increased number of words produced verbally, increased mean length of utterance in words, and by improved scores on parent report measures. These findings provide further evidence of the overall benefits that aided language input provides to children who use AAC and the different effects of aided language input on participants with different communication skills and profiles. Clinical implications and future research directions are provided.

Keywords: Augmentative and alternative communication; Aided language input; Assistive technology; Communication; Complex communication needs

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Introduction

Language acquisition in children developing typically is a miraculous process. They rapidly acquire new words, learn the syntactic and grammatical rules of their language without explicit instruction, and generate novel messages in a seemingly effortless manner. Likewise, language acquisition in populations with language disorders is just as remarkable. When provided with appropriate supports, evidence-based strategies, and intervention with appropriate frequency and intensity, children with communication disorders make progress and improve their production of speech and/or in their command of language.

In comparison to the aforementioned groups, the language acquisition process in children with complex communication needs (also referred to as students with significant support needs, extensive support needs, significant and/or multiple disabilities) is perhaps the least understood, yet no less impressive. This group of students may have some speech production capabilities but cannot depend on it as a functional method of communication with familiar and unfamiliar communication partners. Children and adults who present with such challenges in communicating ideas, thoughts, wants, and needs in an effective and efficient manner through the speech modality are referred to as having complex communication needs (CCN) (Beukelman & Mirenda, 2013). Individuals with CCN are comprised of those who have multiple disabilities, severe manifestations of a syndrome/disability type (i.e., Rett Syndrome, cerebral palsy, childhood apraxia of speech) as well as those who have acquired communicative disorders (i.e., via intrauterine stroke, traumatic brain injury, etc.). Due to the difficulties in communicating, individuals with CCN often rely on, or would benefit greatly from access to augmentative and alternative forms of communication (AAC). Some of the individuals requiring AAC rely on it temporarily, as in the case of childhood apraxia, whereas others require AAC for the duration of

their lifetime (e.g., cerebral palsy). Different forms of AAC exist and may be categorized as being unaided forms of AAC (requiring no external equipment, such as sign language or use of gestures), or aided forms of AAC (requiring external equipment). Available aided AAC systems range from low-tech devices such as communication boards, Picture Exchange Communication Systems, and communication notebooks, to high-tech options such as electronic speech generating devices (SGDs). People with CCN are often multi-modal communicators, meaning that they utilize a variety of modes to achieve effective communication. Many individuals who use AAC will rely on their aided AAC systems for conveying the bulk of information and unaided forms of AAC (sign, gesture and body language) for clarification or to supplement their message further. While incorporation of aided AAC systems into speech and language therapy is necessary to promote language development for students with CCN and allow active participation in the variety of settings that they need to communicate in, the very use of AAC does create a different language learning experience for these students as well as unique demands on memory and other cognitive skills (von Tetzchner, 2018).

Literature Review

This review of the literature begins with a discussion of language development in children developing typically, which is followed by what is known about the language development in children who use AAC. Research specific to language input for children who use AAC is covered, including participants in research investigating language input through augmented means, the efficacy of language input through augmented means, common expressive language outcomes in AAC intervention research, common instructional components of AAC intervention research, and dosage of language input in AAC intervention research.

Language Development in Children Developing Typically

Speech and language development is a complex process that requires the recruitment of many interrelated cognitive processes. While many often think of the use of speech when they hear the term "communication," children actually begin developing communication skills prior to communicating using speech. These prelinguistic forms of communication, such as pointing, are utilized to convey meaning to communication partners (Goldin-Meadow, 2014). A child's prelinguistic communication skill development is followed closely by lexical development (i.e., word learning) with most children producing words at roughly one year of age (Childers & Tomasello, 2002; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Overall, young children understand and produce nouns earlier than verbs, despite understanding verb meanings and passive sentences (Childers & Tomasello, 2002; Goldin-Meadow, Seligman, & Gelman, 1976; Goldwin-Meadow, 2014; Huttenlocher et al., 1991). After amassing a vocabulary of roughly 50-100 words, children developing typically begin to acquire morphemes and syntax which allows for additional meaning within messages to be conveyed (Rescorla & Mirak, 1997). The average mean length of utterance in morphemes corresponds to their age, roughly up though age 4 (Brown, 1973). Although direct instruction is often not necessary for helping this group of children develop their language skills across domains, access to language input is believed to be a critical driver of language development, irrespective of theoretical framework applied (Abbeduto & Boudreau, 2004; Poll, 2011).

Children Who Use AAC

To date, the language development process in populations with communication disorders is still not fully understood (Schwartz, 2015). This is especially true for children who rely on or

would benefit from AAC. In comparison to peers developing typically, children who are non-verbal communicators often have deficits in both expressive and receptive language, across semantic, pragmatic, phonological, morphological, and syntactic domains of language (Binger, Maguire-Marshall, & Kent-Walsh, 2011; Smith, 2015; Soto & Dukhovny, 2008).

Based upon language samples, it is difficult to determine with specificity what linguistic skills a person who uses AAC has, as it is not uncommon for them to rely on predominantly single symbol utterances (Smith, 2015). Even experienced AAC users who generate multi-symbol utterances produce sentences that are telegraphic in nature, are missing morphological markers, and/or have atypical word order (Blockberger & Sutton, 2003; Bruno & Trembath, 2006). While this does not decrease the importance of language use as a measure of linguistic competence, it most certainly makes it more difficult to interpret (Bedrosian, 2008). Smith (2015) outlined three possible scenarios that may explain why children with CCN do not achieve higher language skills.

> (A) They may not have access to the full range of conventional learning mechanisms to support the development of spoken language. (B) Use of aided communication may place additional pressure on conventional learning mechanisms, creating tensions between developmental demands and capacities and (C) Novel learning mechanisms may be required in order to develop and use aided communication. (p.223)

It may be the case that all three of these differences are true in children who are non-verbal communicators. Conversely, these three scenarios may be in play to varying amounts in different etiologies of CCN, which may account for the wide variability of outcomes. Much remains to be discovered about language acquisition in children who use AAC. What is known is

that language outcomes are a result of a combination of factors, including those intrinsic and extrinsic to the child (Adamson, Bakeman, Suma, & Robins, 2017; Brady, Thiemann-Bourque, Fleming, & Matthews, 2013; Romski, Sevcik, & Adamson, 1997) .

Intrinsic factors. Personal characteristics enhancing responsivity to communication instruction and language intervention are considered to be intrinsic factors, referred to by some as a child's 'innate endowment' (Smith, 2015). A child's innate endowment is comprised of many interrelated components, including, but not limited to: speech comprehension, fast mapping ability, attention skills, memory and working memory, adaptive skills, problem solving skills, play skills, and non-verbal intelligence (Brady et al., 2013; Murray & Goldbart, 2011; Sevcik, 2006; Smith, 2015; Wilkinson, 2007). Others have described the intrinsic variables at play in PWUAAC as belonging to one of six factors, or domains, including: awareness, communicative intent, world knowledge, memory, symbolic representation, and metacognitive skills (Rowland & Schweigert, 2003).

Regrettably, in the past and in the present many children and adults have been precluded from being considered "candidates" for AAC based on intellectual functioning or presumed intelligence (Calculator, 1997). Most certainly, there exists a complex relationship between cognition and language and communication skills, with disagreement on the extent to which cognition influences language and communication skills, and vice versa (Perlovsky & Sakai, 2014). Importantly, it is known that cognitive development and linguistic development may not occur in tandem in individuals with language disorders (National Joint Committee for the Communication Needs of Persons with Severe Disabilities, 2002). Murray and Goldbart (2011) discussed research specific to how cognition intersects with the use of AAC. While overall, they noted few studies investigated intrinsic factors, they concluded that AAC creates unique

demands on memory that may actually be beneficial in the long term for PWUAAC. For example, a device with a dynamic screen display requires that an individual not only memorize the sequence of selections necessary to generate an intended message, but also requires holding the message in working memory until the entirety of the message has been uttered. It is worth mentioning that the influence of vocabulary organization on a device may be a barrier to effective and efficient device use. How big of an obstacle an unintuitive organization scheme is to a PWUAAC may be dependent on the severity level of their intellectual disability.

Another intrinsic factor is the motoric ability to produce speech or make vocalizations. Some motor skill issues preventing speech production for PWUAAC are diagnosis specific and generally remain static over the course of the person's life, such as in anarthria or dysarthria for individuals with cerebral palsy. Likewise, for children with childhood apraxia of speech, their speech production abilities improve over time, eventually to the point where AAC is no longer needed. Speech production capabilities, even in the case where it is highly unintelligible or a single vowel production, may create opportunities for the PWUAAC to engage in a larger amount of communicative interactions with their communicative partners. In turn, this increases the amount of exposure they have to verbal language. It is important to note that the ability to vocalize does not in and of itself establish the opportunity for the PWUAAC to interact with a communication partner. Rather, a vocalization needs to occur within a meaningful context, where the intent behind the vocalization is readily interpreted by the communication partner and augmented by facial expression and gesture as needed. While these intrinsic characteristics influence how readily language is acquired and refined, extrinsic factors are equally as important.

Extrinsic factors. Beyond the differences that may exist within individuals, numerous factors outside of individuals also play a significant role in language development. These include opportunities for language learning and device specific characteristics. The life experiences of individuals who have CCN are often much different than the life experiences of children developing typically. As children developing typically mature, they explore their surrounding environments and experiment with their speech sound production system. This exploration of the environment creates opportunities for communication partners to provide language input by labeling actions/items in the environment, thus helping facilitate progress from prelinguistic communication to more developed levels of communication. However, children with CCN have less access to the verbal input and contingent responsivity than their peers developing typically (Smith, 2015). In other words, children with CCN may vocalize less frequently, in turn creating less opportunities for their communication partners to respond to. Over time this can translate to less speech directed to them and their other communicative attempts may not be acknowledged by their communication partner as the communicative attempts may not be conventional (Beck, Stoner, & Dennis, 2009; Solomon-Rice & Soto, 2014). When partners do not respond according to the message transmitted (i.e., not acknowledging a message or interpreting a message incorrectly), the number of opportunities to get feedback (i.e., response from communication partners) and additional language input are decreased (Clarke, Soto, & Nelson, 2017). As a function of decreased language input, responses by communication partners, and lower quality recasts, children with CCN may have less word knowledge overall and a smaller vocabulary.

Another extrinsic factor influencing language development in PWUAAC is symbolic representation. On many AAC systems, symbols/icons are used to represent words/phrases.

However, while the intent of these symbols/icons is to reduce the difficulty of learning new words, they may potentially cause confusion about what symbols/icons represent. For example, on many dedicated aided AAC devices, verbs are presented with a picture of a person doing the action (i.e., 'throwing' is depicted by a person throwing a ball (Binger & Light, 2007b; Smith, 2015). This combination of visuals within one symbol has the potential of sending a mixed message to a child learning to use AAC who are also in the process of developing an internal schemata of different word classes (i.e., man, ball, and throw). This necessitates that practitioners rectify the input/output asymmetry and make sure they teach what the symbols/icons represent through repeated exposure via device modeling in meaningful tasks (Light, 1997; Smith & Grove, 2003). This is especially true for low-tech forms of aided AAC, where there is no speech output when a symbol is selected. This feature can make learning a symbol referent more challenging given that there is less feedback given to the PWUAAC. Likewise, high-tech aided AAC systems that have speech generation when a symbol is selected are not enough by themselves, requiring additional language input that is obtained in interactions where the PWUAAC are provided with contextually rich information and demonstrations of symbol use.

While the incorporation of a device creates a different experience for learning and using language, intervention techniques and strategies can help the person who uses AAC become more linguistically competent in their aided AAC system. Many of the recommended intervention strategies for PWUAAC are similar to those recommended for children developing typically and for children that are language delayed who are verbal communicators, with the most important being language input. In contrast to the adequacy of verbal input alone in encouraging language development in children who are verbal communicators, interventionists

and communication partners must augment their messages via the use of the aided AAC systems in order to stimulate language development for children who use AAC.

Language Input Techniques in AAC Research

The process of speech and language learning in children is well known to be influenced by the amount of words children hear, otherwise known as language input, with higher levels of input being associated with improved language outcomes (Hart & Risley, 2003; Huttenlocher et al., 1991; Shneidman, Arroyo, Levine, & Goldwin-Meadow, 2013). The critical role that language input plays in language development is well documented across typically developing (Gaskell & Ellis, 2009) and populations with language disorders (Brady, Herynk, & Fleming, 2010; Rice, Oetting, Marquis, Bode, & et al., 1994; Storkel, Komesidou, Fleming, & Romine, 2017). Researchers have also investigated how language input may be most effectively provided to people who use aided forms of AAC, now generally referred to as Aided Language Input (ALI). As technology has improved over time, language input techniques using AAC systems have also changed.

Initial AAC interventions implementing aided language input were employed with students who used low-tech aided AAC systems (communication boards) and were termed Aided Language Stimulation (Goossens, 1989). To use Aided Language Stimulation (ALgS), clinicians selected a graphic symbol and delivered verbal input simultaneously, thereby providing input verbally and visually as to what the symbol represented (Drager et al., 2006). The ALgS approach to language input was followed shortly thereafter by the System of Augmented Language, or SAL (Romski & Sevcik, 1988). As opposed to ALS, the SAL method required a SGD.

Another approach using aided input is referred to as Aided Language Modeling (Drager et al., 2006) The three components of Aided Language Modeling (ALM) included: using a finger to point to a referent in the environment, pointing to a graphic symbol of the referent on a device, and providing a spoken model of the referent. Although these various approaches have slight differences in how aided input is used, they all provide linguistically richer messages provided to the PWUAAC by their partners (Loncke et al., 2006).

Today, ALI and aided AAC modeling are analogous, referring to the construction or co-construction of a message by the communication partner, where they generate a message on the AAC system that reflects the message semantically that they have generated verbally (Binger & Light, 2007a). This can be accomplished asynchronously, after the message was provided verbally, or while the message is being generated verbally. The amount of language that is produced using the AAC system when ALI is implemented is dependent on what the intervention targets are. For example, for one person it may involve only producing the main content words ("he kicked the ball", selects [He + Ball]), where for other more linguistically developed individuals, ALI may consist of generating each part of the sentence, including morphological features.

Similar to how various methods have been used to augment language for PWUAAC, the manner in which ALI methods support language development via AAC also takes a variety of forms. Wood, Lasker, Siegel-Causey, Beukelman, and Ball (1998) proposed a framework for understanding how ALI accomplishes the goal of promoting language development comprised of four components, including: (1) message augmentation, (2) creating a link between verbal language and referents, (3) supporting message retention by decreasing demands on the AAC user's memory by using previously generated messages as a visual support, and (4) identifying

viable options for choice making/responding to verbal prompts. As a function of the importance that language input has on the outcomes of PWUAAC, many have examined the efficacy of interventions using ALI as a main intervention component. In the following sections, the results, discussions, and recommendations of multiple meta-analyses and systematic reviews of studies pertaining to ALI will be summarized and organized based on the information known about the populations, expressive outcomes, instructional components, and the intensity (dosage) of ALI.

Participants in AAC research. Just as the profiles of PWUAAC are diverse and the need for AAC occurs across all ages, participants within interventions focused on using ALI with aided AAC communicators have been comprised of a heterogenous group of individuals across the lifespan. Interestingly, although the prevalence of disorders negatively impacting the use of speech as a primary mode of communication increases with age (Beukelman & Mirenda, 2013), the majority of the literature specific to ALI has included school aged and preschool aged children as participants (Biggs et al., 2018; O'Neill et al., 2018; Sennott et al., 2016). What else do we know about the participants who have contributed to the literature specific to ALI?

While people with CCNs are a low incidence group, the most frequently occurring primary diagnoses of child and adult participants include autism, intellectual/developmental disabilities, childhood apraxia of speech, cerebral palsy, and Down syndrome (Allen et al., 2017; Gevarter & Zamora, 2018; O'Neill et al., 2018). People with primary diagnoses less frequently documented in the literature include orthopedic health impairment and specified disabilities such as Prader-Willi syndrome (Gevarter & Zamora, 2018). Additionally, other less represented groups of PWUAAC in the research literature include adolescents and adults, including those with specific diagnoses, such as autism (Holyfield, Drager, Kremkow, & Light, 2017).

Another group of individuals included in the literature specific to ALI are those who are communication partners but who do not rely on AAC themselves. Without question, the role of communication partners in supporting the use of AAC is substantial (Kent-Walsh & McNaughton, 2005). When untrained on the nuances of supporting a person who uses AAC, it is not uncommon for communication partners to dominate interactions, frequently interrupt, provide few opportunities for initiating communication, fail to respond to multi-modal communicative attempts, and focus more on the device rather than the person, thereby creating circumstances which negatively impact the language learning process for the person who uses AAC (Binger et al., 2011; Kent-Walsh & McNaughton, 2005). However, when systematic communication partner training on ALI is implemented, it has been documented to be effective for supporting PWUAAC across types of AAC systems used (i.e., high tech vs. low tech), across ages, for individuals with a variety of primary diagnostic labels, and across different domains of language (Kent-Walsh, Murza, Malani, & Binger, 2015).

Aided Language Input Effectiveness. Most recently, a number of systematic reviews and meta-analyses have been completed which pertain to the effectiveness of ALI interventions. Sennott, Light, and McNaughton (2016) reviewed research articles employing ALI in naturalistic settings. Out of the 17 studies which met their search criteria, 10 also met the criteria for best-evidence analysis which demonstrated conclusive evidence of effectiveness. Out of the 10 studies, 9 utilized a single case design and 1 implemented a group treatment design.

Examining the effects of ALI interventions on expressive and receptive language skills, Allen, Schlosser, Brock, and Shane (2017) found that a variety of types of effect size estimates were reported. The means of the effect size estimates were as follows: percentage of non-overlapping data points (PND) was 86.1, percentage exceeding the mean (PEM) was 88.7,

percentage of all non-overlapping data points (PAND) was 85.11, and when evaluating the effectiveness of post intervention outcomes (i.e. generalization), mean PND was 95.1 and the mean PEM was 95.8.

Others have explored the effects of AAC interventions in a broader sense. Logan, Iacono, and Trembath (2017) looked at the effects of aided AAC interventions for people with autism spectrum disorder (ASD), including those that used high-tech and low-tech forms of AAC. They found that out of the 26 single case research studies included in their systematic review, that 12.5% provided conclusive evidence, 12.5% were suggestive of effectiveness, and 75% were deemed to provide preponderate data. They concluded that most studies which failed to provide stronger evidence was due to an underreporting of information such as inter-observer agreement, measures of treatment integrity, and insufficient number of demonstrations of effect. The following year, Morin et al. (2018) also systematically reviewed single case research experiments including high-tech and low-tech forms of aided AAC and people with ASD as well as ID. After utilizing the criteria set forth by the What Works Clearinghouse, they reported their findings which were broken down by single case research design (including multiple baseline/multiple probe and alternating treatments design), they concluded that the available evidence from multiple baseline/multiple probe designs make the use of AAC an evidence-based practice. They did not report a large difference between interventions using low-tech vs. high-tech forms of aided AAC.

Biggs, Carter, and Gilson (2018) systematically reviewed interventions utilizing ALI for the purpose of comparing effects based on the specific ALI approach used. Out of the 48 single case research design studies included in their review, they found that the primary function of ALI differed across studies. These primary functions included: (1) ALI used to augment input, (2)

ALI to serve as prompts, and (3) ALI to serve as an instructional demonstration. They further categorized the studies as belonging to one of five groups, including those whose interventions consisted of: (a) ALI alone, (b) ALI with additional instructional components, (c) models as prompts with additional instructional components, (d) instructional demonstrations with additional instructional components, and (e) a combination of modeling approaches (i.e., two or more approaches to aided AAC modeling) and additional instructional components. The majority of interventions in their review used a combination of modeling approaches and additional instructional components (29.2%), followed by ALI and additional instructional components (25%), and models as prompts with additional instructional components (22.9%). In comparison, relatively few studies used ALI to serve as an instructional demonstration (12.5%) or used ALI as the sole intervention strategy (10.4%).

Utilizing visual analysis of the single case data, Biggs et al. (2018) concluded that while use of ALI was effective at improving expressive communication skills in the participants who use AAC, the effects of intervention are improved when additional instructional components are included. In other words, ALI is a critical aspect of improving communication and language skills in individuals who use AAC, but it should not be the only instructional strategy used. This was also found by Gevarter and Zamora (2018) in their systematic review of intervention packages used in AAC studies. Nearly 60% (n = 19) of the studies included in their review provided suggestive evidence or better of the effectiveness of the interventions, and roughly 40% (n = 13) were deemed to provide inconclusive evidence.

In addition to visual inspection of data, interventions utilizing ALI have yielded large effect sizes across ages groups, including toddlers (.90), preschool aged children (.83), elementary aged children (.87), and adolescents (.86), with moderate effect sizes (.37) found for

adults (O'Neill, Light, & Pope, 2018). See Tables 1 and 2 for additional information of effect sizes by disability category in meta analyses and systematic reviews. These large, positive effects across ages are important to note, as myths related to who may benefit from AAC intervention can be persistent, in some cases preventing people who require AAC from obtaining a robust language system. These findings most certainly support the argument that the age or diagnoses of individuals who have CCN should not be used as a criteria prohibiting access to AAC interventions (Romski & Sevcik, 2005).

Expressive Outcomes in Aided Language Input Research. Given that the ultimate goal of AAC intervention is to enable PWUAAC to achieve greater levels of participation with communication partners, it is not surprising that the overwhelming majority of literature on aided AAC interventions has been concerned with expressive language outcomes (Brady, Snell, & McLean, 2016). More specifically, pragmatic and semantic skills are the most frequently reported outcomes of intervention, with morphosyntactic skills less likely to be a primary outcome for the interventions (Allen et al., 2017; Biggs et al., 2018; Sennott et al., 2016).

Similarly, when communication partner training on ALI is the focus of the study, the most common measured outcomes are related to pragmatic and semantic outcomes, with the least measured outcomes related to morphosyntax (Kent-Walsh, Murza, et al., 2015). That said, the most frequently occurring function targeted in communication partner training studies related to ALI has been requesting (Logan et al., 2017; Morin et al., 2018).

Instructional components. To achieve the desired outcomes of AAC therapy, SLPs need to employ techniques or strategies. In a broad sense, the intervention strategies or instructional components could be broken into two groups, those related to facilitating language acquisition

and use, and those related to encouraging participation or otherwise directing student behavior. See Table 3 for brief descriptions of the intervention components.

Table 1. *Summary of Findings of Meta-Analyses on Aided Language Input Effectiveness*

Authors	Individuals who use AAC by ages/grades (total number and percentage)	Primary Disability categories (total number and percentage)	Focus of review	Effect size type	Effect size (ages)	Effect size (disability category)
(O'Neill et al., 2018)	Toddler: 6 (4.5%) Pre-K: 47 (38.5%) Elem: 58 (47.5 %) Adolescent: 4 (3.2%) Adult: 7 (5.7%)	ASD: 34 (28.1%) IDD:20 (16.5%) CAS: 6(5%) CP: 21(17.4%) DS: 19(15.7%) DD: 10(8.2%) Other: 11(9.1%)	Intervention effectiveness involving Aided AAC language input	Tau-U	Toddler: .90 Pre-K: .83 Elem: .87 Adolescent: .86 Adult: .37	ASD: .74 IDD: .75 CAS: .97 CP: .86 DS: .90 DD: .94 Other: .88
(Kent-Walsh, Binger, & Buchanan, 2015)	Pre-K (<5 yrs): 15 (28.3 %) Elem: (6-12 yrs): 35 (66%) Adolescent (12-17 yrs): 1 (1.8%) Adult (>18 yrs): 2 (3.7%)	ASD: 17 (32%) IDD: 17 (32%) CP: 9 (16.9% CAS: 2 (3.7%) MD: 4 (7.5%) Other: 4 (7.5%)	Effectiveness of Communication partner instruction	Improvement rate difference	Pre-K: .90 Elem: .83 Adolescent: .00 Adult: .83	ASD: .69 IDD: .86 CP: .88 CAS: 1.0 MD: .92 Other: 1.0

ASD: Autism spectrum disorder, CAS: Childhood apraxia of speech, CP: Cerebral palsy, DS: Down syndrome, IDD: Intellectual/developmental disability, DD: Developmental Delay, MD: Multiple Disabilities. Percentages reported reflect the proportion of individuals within the studies included in the meta-analysis. Errors in percentages due to rounding to second decimal place.

Table 2. *Summary of Findings from Systematic Reviews on Aided Language Input Effectiveness*

Authors	Focus of Review	Effect size type or Criteria for Evaluation	Effect size or Findings
(Allen et al., 2017)	Effectiveness of ALI for people with DD and CAS on expressive and receptive vocabulary and syntax	Single subject designs: PND, PEM, PAND Group research: Eta squared, partial eta squared, and modified visual analysis	Mean PND = 86.1 Mean PEM = 88.7 Mean PAND = 85.11 Post intervention outcomes: Mean PND = 95.1 Mean PEM = 95.8 Group research: Adequate in research quality
(Gevarter & Zamora, 2018)	Assess quality of evidence of Aided AAC interventions conducted in naturalistic settings	Quality indicators for single subject research (Kratochwill et al., 2010) & PND	Certainty of evidence: 21% conclusive, 37% suggestive, 42% preponderant. PND: mean = 91
(Logan et al., 2017)	Determine if AAC interventions for people with ASD are effective in teaching a variety of communication functions	Best Evidence Analysis (Slavin, 1986)	12.5% Conclusive 75% Preponderant 12.5% Suggestive
(Morin et al., 2018)	Determine if the social-communication interventions involving AAC meet evidence-based standards	What Works Clearinghouse Design Standards	Meets criteria for evidence-based practice
(Sennott et al., 2016)	Effectiveness of ALI in naturalistic interventions for various domains of language	PND	Average PND across domains = 90.6
(Simacek et al., 2018)	Evaluate aspects of treatment interventions	Appraisal of treatment dosage	Cumulative intervention intensity range = 150 - 3060

DD: Developmental disabilities; CAS: Childhood apraxia of speech; MD: Mean difference; PAND: Percentage of all non-overlapping data; PEM: Percentage exceeding the mean; PND: Percentage of non-overlapping data; SCRD: Single case research designs; IOA = Inter-observer agreement

Table 3. *Frequently Occurring Instructional Components in Addition to Aided Language Input*

Intervention component	Percentage of Studies
Expectant delay: Questions provided with rising intonation at the end of the question, communication partner communicates non-verbally that they are awaiting a response (with raised eyebrows).	71%
Contingent responding: Communication partner acknowledges behavior or symbol/phrase selected and responds according to the message's content.	57%
Open-ended questions: Questions directed to person who uses AAC that have no inherent "right" or "wrong" answer.	46%
Direct prompting: Visual or verbal prompting for the person to use their device.	42.8%
Expansion/recasting: Communication partner restates the original message in a syntactically and/or semantically different sentence, incorporating new information.	21%

Adapted from (O'Neill et al., 2018).

In addition to ALI, a variety of facilitative language strategies exist that serve slightly different purposes. For example, contingent responsivity helps a person who uses AAC establish a link between the meaning of a word/symbol with a specific referent. For nonverbal communication acts, when communication partners respond to the gesture, sign approximation, or vocalization/approximation where the purpose is known, or the message is easily interpreted,

it can provide an opportunity for the communication partner to model on the device the message that reflects what the person was trying to say. In other words, it creates an opportunity to show the person how to communicate on their device the same message but in a modality that may be comprehensible to unfamiliar communication partners. Lastly, recasting and expansion as instructional components compliment ALI and enhance the communicative interaction between a PWUAAC and their communication partner as well as increase the richness of the linguistic input (Clarke et al., 2017; von Tetzchner, 2018). For example, recasting and expansion can help increase the completeness of a communication message by including additional information and can help the communication partner clarify a message in instances where a single symbol message is selected, or when telegraphic messages are produced by the PWUAAC. Additionally, recasting and expansion create an environment to teach new sentence forms, grammatical forms, and vocabulary (Clarke et al., 2017). Furthermore, recasting and expansion can create a more natural interaction by allowing both parties to contribute information as opposed to an interrogative role assumed by the communication partner with the PWUAAC becoming a "respondent" to the line of questioning.

Instructional components that are frequently used to promote participation and direct student behavior include expectant delay and prompting. Systematic use of these components is known to enhance language intervention (Finke et al., 2017; Gevarter & Zamora, 2018; Kozleski, 1991). Expectant delay provides an opportunity for the person using AAC to process the message that was provided to them and generate a response or answer to their communication partner. The amount of wait time that is appropriate for an individual varies from person to person, with some people requiring wait time of 30 to 45 seconds, and others requiring substantially less time, such as 5 to 10 seconds. It is not uncommon for communication partners

to inadvertently provide too little time to the PWUAAC and quickly proceed to using direct verbal prompts, interrupting the processing of language provided to the PWUAAC and independent generation of a message. As mentioned previously, most interventions use a variety of strategies, see Table 3 for a percentage breakdown of commonly used instructional components in most AAC interventions.

Interventions for adolescents and adults on the autism spectrum who use AAC tend to differ in the intervention components. Holyfield et al. (2017) found that while most interventions consisted of multiple components, the most frequently used strategies were prompting and contingent responsivity. Other less frequently reported components were unspecified instruction, video modeling, communication support strategies, and partner strategy instruction.

When training communication partners to use ALI, the training packages consisted of description and discussion of the strategy, a comprehension check of the communication partner via verbal rehearsal of the rationale for why the strategy is helpful, demonstration/modeling of the strategy, and opportunities for guided feedback (Kent-Walsh, Murza, et al., 2015). While the main instructional components of intervention may differ slightly based on the age, diagnosis, and participant group (e.g., PWUAAC vs. communication partner), it is important to consider how frequently the components are provided to the individuals of interest.

Dosage of aided language input. In addition to the specific intervention strategies employed by speech language pathologists and other communication partners, other therapy related variables influencing the outcomes of therapy include how frequently intervention occurs (dose frequency), the activities used during therapy (dose form), the length of intervention (total intervention duration), and the amount that the specific strategies are being implemented during

the sessions (Warren, Fey, & Yoder, 2007). These aforementioned therapeutic variables all contribute to cumulative intervention intensity (dose X dose frequency X total intervention duration = cumulative intervention intensity).

Just as the PWUAAC are unique in terms of their areas of need, level of communicative competence, and in the amount, they possess the intrinsic variables, aspects of service delivery for these individuals should be also be unique. It is known that for certain populations of people who receive speech language services that frequent and intense therapy is needed, such as in the case of childhood apraxia of speech (ASHA, 2007). For PWUAAC, it is generally accepted that AAC intervention should adopt an immersion approach, where language input is provided throughout the day, in a variety of activities, and in different environments (Dodd & Gorey, 2014). However, it is unknown what constitutes the optimal amount of ALI, as interventions focusing on the use of AAC have implemented ALI with much variability in dosage. Regrettably, a sizable number of studies in the area of AAC possess an insufficient amount of information for ALI dosage to even be determined. Research has reported ALI frequency ranging from 50% of opportunities to 100% of opportunities (Allen et al., 2017; Simacek, Pennington, Reichle, & Parker-McGowan, 2018; Snell et al., 2010), and others reporting a range of less than 1 model per minute and up to 5 models per minute (O'Neill et al., 2018). While these examples of aided language input may not seem to vary widely, it is necessary to investigate aided language input intensity for the optimal intensity to be identified. While manipulating how much aided language input was utilized in each session, overall this study may be considered a “low intensity” language intervention when considering the overall dosage of aided language input, the dose frequency, and the total intervention duration.

Purpose and Specific Aims

Prior inquiry into aided language input efficacy has demonstrated it is effective on a variety of language related outcomes including semantics, morphology, syntactic, and pragmatic language skill areas. However, these research studies have varied in the intensity with which aided language input was utilized as an independent variable. Differential effects of language input provided to people with CCN who use AAC remains unknown. Due to the wide variability in aided language input intensity reported in prior studies, it is advised that additional research is conducted focusing on manipulation of ALI dosage (Romski & Sevcik, 2018; Sennott, Light, & McNaughton, 2016; Simacek, Pennington, Reichle, & Parker-McGowan, 2018). Currently it is unknown if the intensity in ALI provision would yield similar outcomes across domains of language and if there is a point of diminishing returns. It is known that more may not always be better in language interventions (Woynaroski, Fey, Warren, & Yoder, 2016). The purpose of this study was to examine the effects of ALI on the use of AAC devices and overall communication/language by addressing three aims.

Specific Aims

1. Does ALI provided at different intensities affect device use?
2. Does ALI provided at different intensities affect the number of different words/pre-stored messages generated by a person who uses AAC?
3. Are there concurrent changes in communication and/or language utilized by participants following intervention?

Methods

This study was conducted to address the three specific aims by using an alternating treatments design. A total of 3 individuals participated in the study. Sessions were 45 minutes in length and occurred two times per week within the Schiefelbusch Speech-Language-Hearing Clinic. During each session, the participant and the principal investigator engaged in play with an age appropriate board game, card game, and/or other play-based activities. Two conditions were alternated from session to session in a random order (see Appendix A). The two conditions included: (a) the low intensity condition: where the principal investigator used aided language input in roughly 1/3 (33%) of opportunities or a maximum number of 90 AAC models and (2) the high intensity condition: where the principal investigator modeled the use of the device in roughly 3/3 (99%) of opportunities or a maximum of 270 device models. Across both conditions, an opportunity was defined as a verbal message produced by the interventionist. In other words, for each message spoken by the interventionist, there was an opportunity for aided language input to occur. Each condition constituted 1/2 of the sessions (5 sessions = low-intensity, 5 sessions = high-intensity). Data on the frequency that participants activated their device in the 45-minute session was collected across both conditions (research Aim 1), as well as the number of different words/pre-stored messages that are used during each session across all conditions (research Aim 2). Additionally, data on use of speech and use of sign were collected in each session in both conditions (research aim 3) and pre and post communication and language measures were explored.

Recruitment

Subsequent to approval from the Institutional Review Board at the University of Kansas, participants were recruited by directly contacting families of people who use AAC who met the inclusionary criteria to participate in the study. Families were contacted via email (Appendix B) and/or by letter (Appendix C). Additionally, flyers were posted within the Schiefelbusch Speech-Language-Hearing Clinic for recruitment purposes (Appendix D). See Appendix E for consent form. Participants who met the inclusionary criteria were also recruited through a local school district by Clinical Faculty at the University of Kansas.

Participants

Participants in this study met the following inclusionary criteria: (a) were between the ages of 6-11, (b) currently used/possessed a high-tech speech generating AAC device, (c) had a comprehensive AAC assessment, (d) possessed normal or corrected hearing and vision, and (e) accessed their device through direct selection or eye-gaze. Individuals who accessed their AAC systems to communicate via switch access were excluded. The intervention procedures for this study required dual operation of an AAC system by the interventionist and the participant. Accessing a device via switch access would have introduced problems with achieving the desired number of device models per session in both conditions, as using a switch to make activations requires more time, even for very competent device users, in comparison to direct selection. Exclusion of individuals using low-tech aided AAC systems (i.e., paper-based) was to control for the amount of feedback given to each participant apart from the feedback provided by the interventionist. In other words, individuals have devices that generate speech, receive immediate

feedback of the word/message the symbol, whereas people who do not have an AAC system with speech generation would not have the same amount and types of feedback.

Participant Charlie. Charlie was 7 years; 11 months old child at the start of the study. Charlie's primary diagnosis was Down syndrome. Charlie utilized a Tobii - Dynavox Indi with Snap and Core First software. Charlie accessed his device via direct selection with either left hand or right hand without assistance or the use of a stylus. Charlie's AAC evaluation was completed in 2017. At the time the assessment center completed the comprehensive AAC assessment, they recommended that Charlie be fitted with the Tobii - Dynavox Indi with Snap and Core First software. At the start of the study, Charlie used his device for roughly 1.5 years. At school, Charlie's communication goal was related to increasing his expressive language by using pictures, words/verbal approximations, and signs/gestures to express wants/needs, answer yes/no questions, and to make protests. Charlie received 60 minutes of speech/language services per week at school. Charlie received additional private therapy once per week that was one hour in duration, where his goals focused on independent device use, production of core vocabulary words, multi-modal communication, and the use of his device for various communication functions. Charlie's parents reported that at home his device was not utilized often, and that Charlie typically communicated through sign and gesture. See Table 4 for Charlie's pre-intervention scores on the MacArthur-Bates Communication Development Inventory: Words and Gestures.

Table 4. *MB-CDI Pre-intervention Results: Charlie*

Pre-Intervention MB-CDI Results: Charlie	
Section	Percentage
Phrases Understood	78.5 (22/28)
Words Understood	64 (255/396)
Words Produced (via sign, AAC, speech)	53 (343/396)
Early Gestures	72 (13/18)
Later Gestures	42 (19/45)
Total Gestures	51 (32/63)

On the TACL-4, Charlie scored 12 on the vocabulary subtest, 2 on the morpheme subtest, and 8 on the syntax subtest. See Table 10 for all participants' scores on the TACL-4. On the Communication Matrix, Charlie's primary level of communication was 4, or conventional communication and his higher level of communication was 6, or abstract symbols. The primary level of communication was determined by selecting the communication level that showed the greatest mastery. The higher level of communication was determined by selecting the level immediately following the primary level of communication which had the highest percentage of mastery. He had a total score of 110 or 69% on the Communication Matrix. See Table 5 for a breakdown of the percentage of items at each level mastered or surpassed.

Table 5. *Pre-Intervention Communication Matrix Results: Charlie*

Pre-Intervention Communication Matrix Results: Charlie	
Communication Level	% Mastered or Surpassed
1 Pre-Intentional	100
2 Intentional	100
3 Unconventional	100
4 Conventional	100
5 Concrete	47
6 Abstract	88
7 Language	0

Participant Frank. Frank was 10 years; 10 months at the start of the study with the diagnoses of Down Syndrome, autism spectrum disorder, and intellectual disability. Frank utilized a Prentke Romich Company Accent 1000 with Language Acquisition through Motor Planning (LAMP) software and a keyguard. Frank's AAC evaluation was completed in 2014. At the time the assessment center completed the comprehensive AAC assessment, they recommended that Frank be fitted with a PRC Accent 1000 device with LAMP software and a keyguard. At the start of the study, Frank had used the device for roughly 4.5 years. At school, Frank's communication goal was related to using core words to request and/or comment. Frank received 60 minutes per week with his school speech-language pathologist. Frank also received

a private individual therapy session once per week that was one hour in duration. Frank's private therapy goals related to the use of core vocabulary words, using his device for functions of communication other than requesting, and producing utterances comprised of 3 or more selections. Frank's mother reported that they regularly use his device at home. See Table 6 for Frank's pre-intervention scores on the MacArthur-Bates Communication Development Inventory: Words and Gestures.

Table 6. *MB-CDI Pre-intervention Results: Frank*

Pre-Intervention MB-CDI Results: Frank	
Section	Percentage
Phrases Understood	60.7 (17/28)
Words Understood	50.5 (200/396)
Words Produced (via sign, AAC, speech)	3.5 (14/396)
Early Gestures	55.5 (10/18)
Later Gestures	17.7 (8/45)
Total Gestures	28.5 (18/45)

On the TACL-4, a measure of receptive language skills in the vocabulary, morphology, and syntax domains, Frank scored a 6 in the vocabulary subtest, a 3 in the morpheme subtest, and a 6 in the syntax subtest. See Table 10 for Frank's performance on the TACL-4. On the Communication Matrix, Frank earned a total score of 73 or 46%. On the Communication Matrix, Frank's primary level of communication was 3, or unconventional communication and his higher level of communication was 6, or abstract symbols. The primary level of communication was

determined by selecting the communication level that showed the greatest mastery. The higher level of communication was determined by selecting the level immediately following the primary level of communication which had the highest percentage of mastery. See Table 7 for a breakdown of the percentage of items at each level mastered or surpassed.

Table 7. *Pre-Intervention Communication Matrix Results: Frank*

Pre-Intervention Communication Matrix Results: Frank	
Communication Level	% Mastered or Surpassed
1 Pre-Intentional	100
2 Intentional	100
3 Unconventional	100
4 Conventional	33
5 Concrete Symbols	6
6 Abstract Symbols	35
7 Language	0

Participant Dennis. Dennis was 6 years; 10 months old at the start of the study and had a diagnosis of autism spectrum disorder. Dennis utilized an iPad with Prentke Romich Company's Language Acquisition through Motor Planning software. Dennis's AAC evaluation was

completed in 2017. In comparison to the other two participants, Dennis's AAC system was not the one determined by the assessment center to best meet his current and future communication needs. At the time the assessment center completed the comprehensive AAC assessment, they recommended that Dennis be fitted with a NovaChat device with WordPower software. The funding request for this device was denied by his insurance company. Dennis acquired his current device from the school district he attends. Dennis accessed his device with his right hand via direct selection without any additional supports, such as keyguards or a stylus. At the start of the study, Dennis had his device for roughly 1.5 years. At school, Dennis's communication/language goals were related to following two step directions, increasing his vocabulary by labeling items, answering social WH questions, and making eye contact and smiling. Dennis received 60 minutes of speech/language services per week at school. Dennis's mother reported that their device had not been used at home, due to concerns of Dennis's father that the use of the device will negatively impact his speech production. See Table 8 for Dennis's pre-intervention scores on the MacArthur-Bates Communication Development Inventory: Words and Gestures.

Table 8. MB-CDI Pre-intervention Results: Dennis

Pre-Intervention MB-CDI Results: Dennis	
Section	Percentage
Phrases Understood	96.4 (27/28)
Words Understood	71.2 (282/396)
Words Produced (via sign, AAC, speech)	21.2 (84/396)
Early Gestures	83.3 (15/18)
Later Gestures	44.4 (20/45)
Total Gestures	55.5 (35/63)

On the TACL-4, Dennis earned a 19 in the vocabulary subtest, an 11 on the morpheme subtest, and an 11 on the syntax subtest. See Table 10 for information related to Dennis's performance on the TACL-4. On the Communication Matrix, Dennis's primary level of communication was 3, or unconventional communication and his higher level of communication was 4, or conventional communication. The primary level of communication was determined by selecting the communication level that showed the greatest mastery. The higher level of communication was determined by selecting the level immediately following the primary level of communication which had the highest percentage of mastery. He earned a total score of 97, or 61%. See Table 9 for a breakdown of the percentage of items at each level mastered or surpassed.

Table 9. *Pre-Intervention Communication Matrix Results: Dennis*

Pre-Intervention Communication Matrix Results: Dennis	
Communication Level	% Mastered or Surpassed
1 Pre-Intentional	100
2 Intentional	100
3 Unconventional	100
4 Conventional	73
5 Concrete Symbols	18
6 Abstract Symbols	12
7 Language	18

Table 10. *Pre-Intervention TACL-4 Performance: All participants*

Participant	Sub-test	Pre-Intervention
Charlie	Vocabulary	12
	Morphemes	2
	Syntax	8
Frank	Vocabulary	6
	Morphemes	3
	Syntax	6
Dennis	Vocabulary	19
	Morphemes	11
	Syntax	11

Context and Setting

All pre-intervention, intervention, and post-intervention sessions occurred at the Schiefelbusch Speech-Language-Hearing Clinic at the University of Kansas-Lawrence Campus. Individual therapy rooms were used for each session for every participant and therapy rooms consisted of tables to present materials, display the AAC device, and display intervention materials (e.g., games, toys, etc.). As needed, slant boards were used for the purpose of placing the AAC device in the visual field of participants. Intervention sessions consisted of a single participant and the primary interventionist. Sessions were recorded digitally onto a camera within the therapy room mounted on a tripod in addition to the recording equipment typically used for therapy sessions.

Procedures

The study involved family input, preintervention testing (described above), 10 intervention sessions, and post intervention testing. The methodological design for the intervention was alternating treatments. These alternating treatments consisted of 5 low-intensity and 5 high-intensity sessions. Each participant received a total of 10 intervention sessions. Sessions were held twice per week for each participant. Each participant received one intervention condition per day, a maximum of two intervention conditions per week. The order of conditions was randomly selected a priori for each participant, with the same condition occurring a maximum of 2 sessions in a row. See appendix A for the order of sessions for each participant.

Pre-intervention. Prior to initiation of the study, families were interviewed about how their child communicated and the purposes they used communication for. Parents were also asked what their child was interested in such as preferred topics, television shows, music, and recreational play activities. Additionally, the parents independently completed the MacArthur-Bates Communicative Development Inventory: Words and Gestures for the purpose of collecting information related to receptive/expressive language, speech sound production, adaptive and play behaviors, imitation skills, and the vocabulary size of their child. Parents also independently completed the paper format of the parent friendly version of Rowland's Communication Matrix (Rowland, 2011). The Communication Matrix collects information related to how individuals communicate for four communication function domains: refuse, obtain, request information, and socially. Completion of the Communication Matrix also provides the level of complexity with which an individual predominately communicates as well as higher levels that they are showing emergent skills. The levels range from 1-7, with Level 1 being pre-intentional communication

and Level 7 being communication through language (e.g., the combination of words/symbols). See Table 11 for listings of each assessment tool, when they were administered during the course of the study, and the type of information each assessment tool provided. Information collected during family interview from the MacArthur-Bates Communicative Development Inventory and the Communication Matrix were used descriptively as well as for the purpose of selecting communication functions and vocabulary to target that the participant did not already use. Lastly, the Test of Auditory Comprehension of Language fourth edition (TACL-4) was administered prior to the initiation of the intervention. The TACL-4 is a norm referenced test for children aged 3;0-12;11 that collects information on receptive language skills in the areas of vocabulary, morphology, and syntax. Information from the TACL-4 was used descriptively only to provide information on receptive vocabulary, receptive morphology, and receptive syntax as individuals with CCN were not a part of their norming sample when the test was developed. The test was adapted for use with participants so that they could indicate responses via eye gaze or for those who may require increased distance between response items. See Appendix F for an example of a modified TACL-4 stimulus card. The adapted test maintained the picture dimensions of the original test (3" x 4") but increased the space between pictures from less than an inch to 4.75 inches to help determine with greater specificity the person's response. To help increase the size between the pictures, the pictures were placed onto 11" x 17" pieces of paper. Two of the three participants, Charlie and Dennis, utilized the testing book from the original TACL-4, whereas Frank used the adapted test to ensure that his selections were clear indicators of his response as his hand would need to travel to locations on each stimulus card which were relatively far from other response choices. Each of the participants started at item #1 for each of the subtests. This was to provide them with successful experiences at the beginning of the test and help encourage

them to participate in the activity. During administration of the TACL-4, each participant was given periodic breaks as needed. Additionally, one parent of the participant was present during the administration of the TACL-4 to help the individual encourage their child participate. The directive given to participants (e.g., "Show me _____") was changed to "Point to _____" on an as needed basis. This was done in order to make the directions as clear and unambiguous as possible to the participants.

Intervention. Intervention considerations included the selection of vocabulary to use during each session in each condition as well as what materials/activities to use. To ensure that aided language input (ALI) use in each condition was equitable, the following parameters were placed on the principle investigator: (a) During the low intensity condition, ALI was used in roughly 1/3 of opportunities or a maximum number of 90 utterances/pre-stored messages generated by the principle investigator during the 45-minute session and (b) during the high intensity condition, ALI was used in roughly 3/3 of opportunities or a maximum number of 270 utterances/pre-stored messages generated by the principle investigator during the 45-minute session. The interventionist used an electronic pitch counter to ensure that the maximum number of ALI was not exceeded. The electronic pitch counter was a device that allowed the principal investigator to quantify the number of instances where ALI was used by depressing a button to tally. When the max number of ALI was reached in the low-intensity condition, ALI ceased, and the interventionist only provided information to the participants verbally during the remainder of the 45-minute session. If the max number of ALI was reached in the high-intensity condition, the interventionist would have only provided information to the participants verbally during the remainder of the 45-minute session.

The maximum number of ALI use was determined by the principle investigator prior to initiation of this study. This was based upon observation of three different student speech-language pathologists (competent in AAC intervention) who provided therapy in shared reading activities or during play-based activities with clients who use AAC via direct selection. Each clinician was observed for 5 minutes in 1-minute intervals. In each 1-minute interval, the number of sentences spoken to the client was tallied, as were the number of times ALI was utilized. The average number of sentences spoken to a client was nine and the average number of times ALI was used was approximately 6 (6.3). Six instances of ALI per minute was deemed to be "high intensity" (6 instances of ALI x 45 minutes=270 models), four times per minute was deemed "medium intensity" (4 instances of ALI x 45 minutes=180 models), and two times per minute was deemed "low intensity" (2 instances of ALI x 45 minutes=90 models).

Table 11. *Assessment Tools Description*

Assessment Tool	Used for Assessing Level of Communication Complexity for:	Use	Information it Provides
MacArthur-Bates Communicative Development Inventory: Words and Gestures	Pre-intentional through Intentional Symbolic	Pre-intervention	• Receptive/expressive language • speech sound production adaptive and play behaviors • Imitation skills • Vocabulary size
Communication Matrix	Pre-intentional through Intentional Language use (e.g., more sophisticated use of symbols, such as combining symbols)	Pre and post-intervention	• Progress in communication competence (e.g., through the 7 levels) • Communication functions used (e.g., refuse, obtain, socially, sharing information)
Test of Auditory Comprehension of Language -4th Edition	Intentional Symbolic through those using language (e.g., more sophisticated use of symbols, such as combining symbols)	Pre and post-intervention	• Receptive language skills in the areas of vocabulary, morphology, and syntax. • Used Descriptively

Vocabulary. Words selected for instruction were largely comprised of core words. This group of high frequency words allows a wide variety of communication functions to be modeled and may also be used across activities and settings (Snodgrass, Stoner, & Angell, 2013). Additionally, core words needed to be targeted due to the ease of modeling single and multi-symbol utterances at a frequent rate (e.g., once per communication turn in the high-intensity condition). This is because locating fringe vocabulary can be more time consuming, even for individuals who are proficient in using their communication devices. During each session the principal investigator engaged in age appropriate play-based activities while providing aided language input in differing intensities.

Materials/Activities. Materials used during the play-based portion of the study included traditional board games requiring multiple players (i.e., Monkeys Jumping on the Bed) and toys used during play-based activities included an electronic parrot, toy cars and a racetrack, stacking blocks, bubbles, and music. A visual support was provided to each of the participants which served as menu of choices so that participants could choose what they wanted to play with. See Appendix G. This menu was printed on 11" x 17" paper and laminated. This menu was further modified for participant Frank. For Frank, the icons from the original menu were copied and cut so that two options could be presented to him at a time. On each day an intervention session occurred, family members of the participants were asked questions about the status of their family member (e.g., emotional status, relevant information about what happened at home/school). This information was collected, transcribed, and included into the participant's data files to help interpret performance from session to session.

Interaction Procedures. A protocol was used for play-based activities during the first session for the first two participants, Charlie and Frank. During those play-based sessions, the

interventionist utilized a least-to-most prompting hierarchy, beginning with ALI initially using descriptive language/comments, then proceeding to indirect visual cues, direct visual cues, indirect verbal cues, and lastly a non-directive model (e.g., comment related to the activity). When a participant generated a message, the principal investigator responded contingently and recast/expanded as appropriate and provided ALI. See Table 12 for description of the steps in the initial play-based protocol and table 13 for the revised play- based protocol. Following the first session for Charlie and Frank, the use of the initial least-to-most prompting hierarchy was discontinued, and the interventionist utilized a modified version of the least-to-most prompting hierarchy, comprised of aided language input, indirect verbal cues, and non-directive models. The decision to discontinue the use of the initial least-to-most prompting hierarchy was made based on the response of the participants which included pushing the communication device away and other expressions of frustration. Additionally, sequential progress through each step in the least-to-most prompting hierarchy did not allow for the type of flexibility needed by the interventionist to capitalize on natural teaching opportunities. As such, in contrast to the initial procedures, the use of the various types of participant directed speech identified in the revised Play-Based Protocol were not utilized in sequential order but were rather implemented as interactions between the interventionist and participant necessitated their usage. For example, if during play the interventionist used aided language input (e.g., “Our car is fast [FAST]”) and the car proceeded to fall off of the table, the interventionist would not utilize an indirect verbal cue (e.g., “I wonder if you thought that went fast?”) but would instead use that shared moment and additional contextual information provided by the shared moment to model an appropriate word or multi-symbol utterance (e.g., “the car fell *off* the table [OFF]”).

Table 122. *Initial Play-Based Protocol*

	Description
ALI	Interventionist produces verbal speech accompanied by use of the device to match their spoken message (i.e., "The car is red", [presses: CAR]).
Indirect Verbal Cue	Interventionist states verbally some possible messages that the participant may want to communicate (i.e., "I wonder if you think this game is *fun* or *boring*?").
Non Directive Model	Interventionist verbally speaks a message and provides ALI (i.e., "I think the game is *fun*", [Presses: FUN].
Direct Question	Interventionist verbally asks a closed ended question (e.g., "Do you want to play bubbles or cars?)

ALI=Aided Language Input

If the participant generated a message at any stage of the protocol by using their device, sign, or speech, the principle investigator recast and/or expanded on the child's message (using aided language input), then re-started the protocol.

Table 13. *Revised Play-Based Procedure*

	Description
ALI	Interventionist produces verbal speech accompanied by use of the device to match their spoken message (i.e., "The car is red", [presses: CAR]).
Indirect Verbal Cue	Interventionist states verbally some possible messages that the participant may want to communicate (i.e., "I wonder if you think this game is *fun* or *boring*?").
Non Directive Model	Interventionist verbally speaks a message and provides ALI (i.e., "I think the game is *fun*", [Presses: FUN].
Direct Question	Interventionist verbally asks a closed ended question (e.g., "Do you want to play bubbles or cars?)

ALI=Aided Language Input

If the participant generated a message at any stage of the protocol by using their device, sign, or speech, the principle investigator recast and/or expanded on the child's message (using aided language input), then re-started the protocol.

Post-intervention. At the conclusion of the intervention sessions, the TACL-4 and Communication Matrix were re-administered on a separate day to determine if changes occurred in the communication functions utilized by the participants, in the levels of communication as measured by the Communication Matrix, or in receptive morphosyntax as measured by the TACL-4.

To provide families with the information needed to implement the intervention in their homes, post-intervention debriefing and training was available to all interested families. This consisted of explicit description of ALI, review of video from sessions showing how it was used with their family member, discussion of how their family member performed during the course of the study (e.g., review of data). Interested families were offered an opportunity to come back to the clinic with their family member to receive guided practice in using ALI themselves. Two of the three families took advantage of the debriefing and training.

Reliability

Data collection and analyses. Video and audio recording of each session for each participate across all conditions was collected using in room video recorders. For participant Frank, a handheld video camera was also used to capture video when he briefly left the therapy room. These video recordings were reviewed by the primary investigator to determine the number of times the device was activated by the participant and the number of different words/pre-stored messages generated by the participant, the amount of ALI provided by the interventionist, as well as the use of sign language and speech produced by the participants. The number of selections, the number of different words/pre-stored messages, and the number of uses of sign language and/or speech used by each participant were graphed and analyzed via visual inspection, with attention paid to the data's level, trend, variability, immediacy, overlap, magnitude, and consistency (Gast & Ledford, 2018). Data were also analyzed using actual and linearly interpolated values, otherwise known as ALIV, for the purpose of calculating an effect size and a randomization test was utilized to obtain a P-value (Manolov, 2018). The use of ALIV was chosen due to the methodological design of this study, as ALIV is to be used specifically with data obtained from alternating treatments designs and generates the average amount of

distance between data paths from both conditions. Other common effect size measures, such as Tau-U and improvement rate difference, require that a baseline condition is present in order to make a determination of effects and this study did not include a baseline condition, thereby making them inappropriate to utilize.

Data reliability. Transcripts were generated by the principal investigator for each intervention session in both conditions for every participant and codes were applied at the time of transcription using Systematic Analysis of Language Transcripts (SALT) conventions for the number of device activations by the participants, the number of different words used by the participants, and speech/sign generated by the participants. See Appendix H for a sample transcript. Additionally, transcripts were generated by a graduate or undergraduate student in addition to the principle investigator for a minimum of 30% of intervention sessions randomly selected across each participant (Charlie = 6 sessions, Frank = 5 sessions, Dennis = 3 sessions), which were also coded at the time of transcription. Agreement between the transcripts and codes was obtained by dividing the number of agreements by the total number of agreements and disagreements, multiplied by 100 to obtain a percentage. The transcription reliability averaged 91.4% (range = 83.6 – 99.7%). Transcription discrepancies were discussed and corrected. Coding reliability for AAC use averaged 93.2% (range = 85.5 – 99.8), coding reliability for number of different words used averaged 94.1% (range = 87 – 98.3), and coding reliability for communication via AAC/Speech/Sign averaged 88.4% (range = 74.1 – 99.8). All coding discrepancies were discussed and corrected. Coders were blinded to the conditions and the overall purposes of the study. This helped ensure that data reported was objective in nature, as coders were less likely to be influenced by personal bias/expectations, or desire to record/report desirable data to the interventionist (Gast & Ledford, 2018).

Participant directed speech reliability. The transcripts generated for data reliability purposes were also used to quantify the use of the revised play-based protocol. The principal investigator reviewed each transcript using the Participant Directed Speech Coding form and quantified the use of each type of speech directed to the participant by the interventionist for each session. Types of participant directed speech included indirect questions, direct questions, event casting and descriptive language, non-direct language, recast, and general comments/expressions. When the interventionist's utterances were reviewed by the interventionist and secondary coder, the Participant Directed Speech form in Table 14 was used by assigning each utterance with one code by circling an appropriate type of participant directed speech based on the utterance. For example, if the utterance was "We are playing with cars and having fun" the code assigned would be Evt. C to represent that event casting was taking place. See Table 14 for examples. See Tables 15-17 for participant directed speech used with each participant by session number. A secondary coder, a licensed and credentialed speech language pathologist, reviewed 9 transcripts (30% of transcripts for each participant) and applied partner directed speech codes, discrepancies were discussed and corrected. Coding reliability of participant directed speech prior to correction was 95.6%.

Table 14. *Participant Directed Speech Coding Form Example*

Participant Directed Speech Coding Form Example							
Types:	Ind. Q: Indirect Question (e.g., "I wonder if you want to _____")						
	Dir. Q: Direct Question						
	Desc. Lang: Event Casting and General Descriptive Language						
	NDL: Non-Direct Language (e.g., "you could say_____")						
	Recast: Child says "more", clinician says, "you want more"						
	Gen.: General comments/expressions (e.g., "wow", "cool")						
	Other: Any other type of utterance						
Utterance #	Utterance Type (Circle)						
1	Ind. Q	Dir. Q	Desc.	NDL	Recast	Gen.	Other
2	Ind. Q	Dir. Q	Desc.	NDL	Recast	Gen.	Other
3	Ind. Q	Dir. Q	Desc.	NDL	Recast	Gen.	Other
4	Ind. Q	Dir. Q	Desc.	NDL	Recast	Gen.	Other

Table 15. *Participant Directed Speech: Charlie*

Session #	Indirect Question	Direct Question (pretty fun right?)	Non-Direct Language	General Descriptive Language (event casting/ descriptive comments)	Recast/ expand	General Comment/expression
1	4%	8.7%	7.5%	52.9%	13.9%	12.7%
	(7/172)	(15/172)	(13/172)	(91/172)	(24/172)	(22/172)
2	1.4%	12.8%	1.8%	73.6%	3.2%	6.9%
	(4/273)	(35/273)	(5/273)	(201/273)	(9/273)	(19/273)
3	1.6%	10%	1.6%	75%	8%	3.6%
	(4/249)	(25/249)	(4/249)	(187/249)	(20/249)	(9/249)
4	1.3%	1.7%	0%	69.5%	15.5%	11.7%
	(4/289)	(5/289)	(0/289)	(201/289)	(45/289)	(34/289)
5	1.4%	4.5%	0%	78.8%	2.4%	12.6%
	(4/284)	(13/284)	(0/284)	(224/284)	(7/284)	(36/284)
6	3%	3.9%	0%	84.9%	1.8%	6.3%
	(10/332)	(13/332)	(0/332)	(282/332)	(6/332)	(21/332)
7	1.8%	2.4%	0%	83.2%	7.1%	5.2%
	(6/323)	(8/323)	(0/323)	(269/323)	(23/323)	(17/323)
8	1.1%	3.3%	0%	79.1%	1.3%	14.9%
	(5/447)	(15/447)	(0/447)	(354/447)	(6/447)	(67/447)
9	1.5%	4.4%	.6%	83.4%	3.1%	6.6%
	(5/314)	(14/314)	(2/314)	(262/314)	(10/314)	(21/314)
10	.3%	7%	0%	82.3%	2.8%	7.3%
	(1/312)	(22/312)	(0/312)	(257/312)	(9/312)	(23/312)
Average %	1.74%	5.87%	1.15%	76.27%	7.08%	8.78%

Table 16. *Participant Directed Speech: Frank*

Session #	Indirect Question	Direct Question	Non-Direct Language	General Descriptive Language (event casting/ descriptive comments)	Recast/ expand	General Comment/expression
1	10.7% (17/158)	5.6% (9/158)	6.9% (11/158)	51.2% (81/158)	10.7% (17/158)	14.5% (23/158)
2	3.9% (8/204)	6.8% (14/204)	4.9% (10/204)	73% (149/204)	8.3% (17/204)	2.9% (6/204)
3	2.4% (6/249)	10.8% (27/249)	2.8% (7/249)	59.4% (148/249)	7.2% (18/249)	17.2% (43/249)
4	2.7% (8/289)	3.1% (9/289)	1.3% (4/289)	81.6% (236/289)	4.8% (14/289)	6.2% (18/289)
5	4.2% (13/304)	7.8% (24/304)	.9% (3/304)	56.9% (173/304)	14.8% (45/304)	15.1% (46/304)
6	3.2% (9/279)	10% (28/279)	3.2% (9/279)	69.5% (194/279)	5.3% (15/279)	8.6% (24/279)
7	2% (9/431)	5.8% (25/431)	1.8% (8/431)	80.5% (347/431)	4.1% (18/431)	5.5% (24/431)
8	3.2% (11/338)	4.4% (15/338)	3.5% (12/338)	72.7% (246/338)	4.7% (16/338)	11.2% (38/338)
9	1% (4/396)	9.3% (37/396)	1.2% (5/396)	68.1% (270/396)	7.5% (30/396)	12.6% (50/396)
10	2.4% (9/374)	4.5% (17/374)	.2% (1/374)	79.1% (296/374)	6.9% (26/374)	6.6% (25/374)
Average %	3.57	6.81	2.67	69.2	7.43	10.04

Table 17. Participant Directed Speech: Dennis

Session #	Indirect Question	Direct Question	Non-Direct Language	General Descriptive Language (event casting/ descriptive comments)	Recast/ expand	General Comment/expression
1	7.3% (14/190)	4.2% (8/190)	3.1% (6/190)	72.6% (138/190)	11.5% (22/190)	1% (2/190)
2	4.8% (11/229)	7.8% (18/229)	.4% (1/229)	62.8% (144/229)	7.8% (18/229)	16.1% (37/229)
3	2.9% (8/275)	4.3% (12/275)	0% (0/275)	68.7% (189/275)	6.5% (18/275)	17.4% (48/275)
4	3.7% (9/239)	2% (5/239)	3.7% (9/239)	70.2% (168/239)	7.9% (19/239)	12.1% (29/239)
5	.8% (2/242)	3.7% (9/242)	1.6% (4/242)	83.4% (202/242)	4.9% (12/242)	5.3% (13/242)
6	2.2% (8/357)	2.8% (10/357)	3.6% (13/357)	83.4% (298/357)	3% (11/357)	4.7% (17/357)
7	1.7% (7/390)	1.7% (7/390)	.7% (3/390)	89.7% (350/390)	3.5% (14/390)	2.3% (9/390)
8	1.1% (5/444)	2.9% (13/444)	.2% (1/444)	79% (351/444)	2% (9/444)	14.6% (65/444)
9	2.2% (9/406)	4.9% (20/406)	.7% (3/406)	81.2% (330/406)	2.9% (12/406)	7.8% (32/406)
10	2.5% (8/318)	6.6% (21/318)	1.8% (6/318)	74.2% (236/318)	5% (16/318)	9.7% (31/318)
Average %	2.92	4.09	1.58	76.52	5.5	9.1

Social Validity

Prior to the debriefing at the end of the study, families completed an anonymous online survey, administered via Qualtrics, to collect information on their perceptions of the intervention effectiveness. The survey was chosen to be completed anonymously and prior to debriefing at the end of the study for the purpose of avoiding potential influence caused by survey completion with the principal investigator present. See Appendix I for questions from the anonymous survey.

Results

The purpose of this study was to investigate the effects that aided language input intensity may have on the use of AAC, the number of different words/pre-stored messages used by the participants who use AAC, and changes to overall communication of participants. The following three research questions were asked:

1. Does ALI provided at different intensities affect device use?
2. Does ALI provided at different intensities affect the number of different words/pre-stored messages generated by a person who uses AAC?
3. Are there concurrent changes in communication and/or language utilized by participants following intervention?

Following the first session for Charlie and Frank, the use of the initial least-to-most prompting hierarchy was discontinued, and the interventionist utilized a modified version of the least-to-most prompting hierarchy, comprised of aided language input, indirect verbal cues, and non-directive models. The decision to discontinue the use of the initial least-to-most prompting

hierarchy was made based on the response of the participants which included pushing communication device away and other expressions of frustration. Additionally, sequential progress through each step in the least-to-most prompting hierarchy did not allow for the type of flexibility needed by the interventionist to capitalize on natural teaching opportunities. As such, in contrast to the initial procedures, the use of the various types of participant directed speech identified in the revised Play-Based Protocol were not utilized in sequential order but were rather implemented as interactions between the interventionist necessitated their usage. For example, if during play the interventionist used aided language input (e.g., "Our car is fast [FAST]") and the car proceeded to fall off of the table, the interventionist would not utilize an indirect verbal cue (e.g., "I wonder if you thought that went fast?") but would instead use that shared moment and additional contextual information provided by the shared moment to model an appropriate word or multi-symbol utterance (e.g., "the car fell *off* the table [OFF]").

For each of the three participants, the maximum number in the high-intensity condition was not reached. The average amount of aided language input within the high-intensity condition for Charlie was 243.4 (range = 206-260), the average amount of aided language input within the high-intensity condition for Frank was 179 (range = 111-208), and the average amount of aided language input within the high-intensity condition for Dennis was 198.6 (range = 178 – 218).

Aim 1: Participant Use of AAC

Aided language input provided at different intensities did not affect AAC device use.

Descriptive data Charlie. Charlie's use of AAC in the lower intensity condition exceeded his amount of AAC use in the high intensity condition in both the average, 24 in the

low intensity condition versus 14 in the high-intensity condition, as well as in the median amount of AAC use, 20 in the low intensity condition versus 12 in the high-intensity condition. See Table 18. The average difference between the low-intensity and high-intensity conditions for Charlie was 10 device uses.

Descriptive data Frank. Frank's use of AAC in the lower intensity condition exceeded his amount of AAC use in the high intensity condition in both the average, 18.6 in the low intensity condition versus 15.6 in the high-intensity condition, as well as in the median amount of AAC use, 15 in the low intensity condition versus 13 in the high-intensity condition. See Table 18. The average difference between the low-intensity and high-intensity conditions for Frank was 3 device uses.

Descriptive data Dennis. Dennis's use of AAC in the lower intensity condition was less than his amount of AAC use in the high intensity condition in the average, .2 in the low intensity condition versus 1.2 in the high-intensity condition. The median use of AAC in both conditions was 0. See Table 18. The average difference between the low-intensity and high-intensity conditions for Dennis was -1 device uses.

Table 18. *Descriptive Data on the Amount of AAC Use*

Aim 1 Data Summary						
	Charlie		Frank		Dennis	
	Low Intensity	High Intensity	Low Intensity	High Intensity	Low Intensity	High Intensity
Mean	24.4	14.8	18.6	15.6	.2	1.2
Median	20	12	15	13	0	0
SD	16.27	7.15	7.49	7.84	.4	2.41
Minimum	6	8	11	9	0	0
Maximum	48	28	29	30	1	6
Mean Difference: A-B	10		3		-1	
Nonoverlap of all pairs	.62		.6		.48	
Low Intensity Trend	Negative monotonic trend: 40% decrease		Positive monotonic trend: 20% increase		Negative monotonic trend: 40% decrease	
High Intensity Trend	Absence of monotonic trend		Negative monotonic trend: 10% decrease		Negative monotonic trend: 40% decrease	

Visual analysis Charlie. The amount of variability in the data series for participant Charlie was largest for the low intensity condition and less so in the high intensity condition. See Figure 1. In both conditions, a decrease in the dependent variable (AAC device use) was observed, although in the high intensity condition the decreasing trend was at a lower rate. The order of sessions for Charlie were as follows: A, B, B, A, B, A, A.

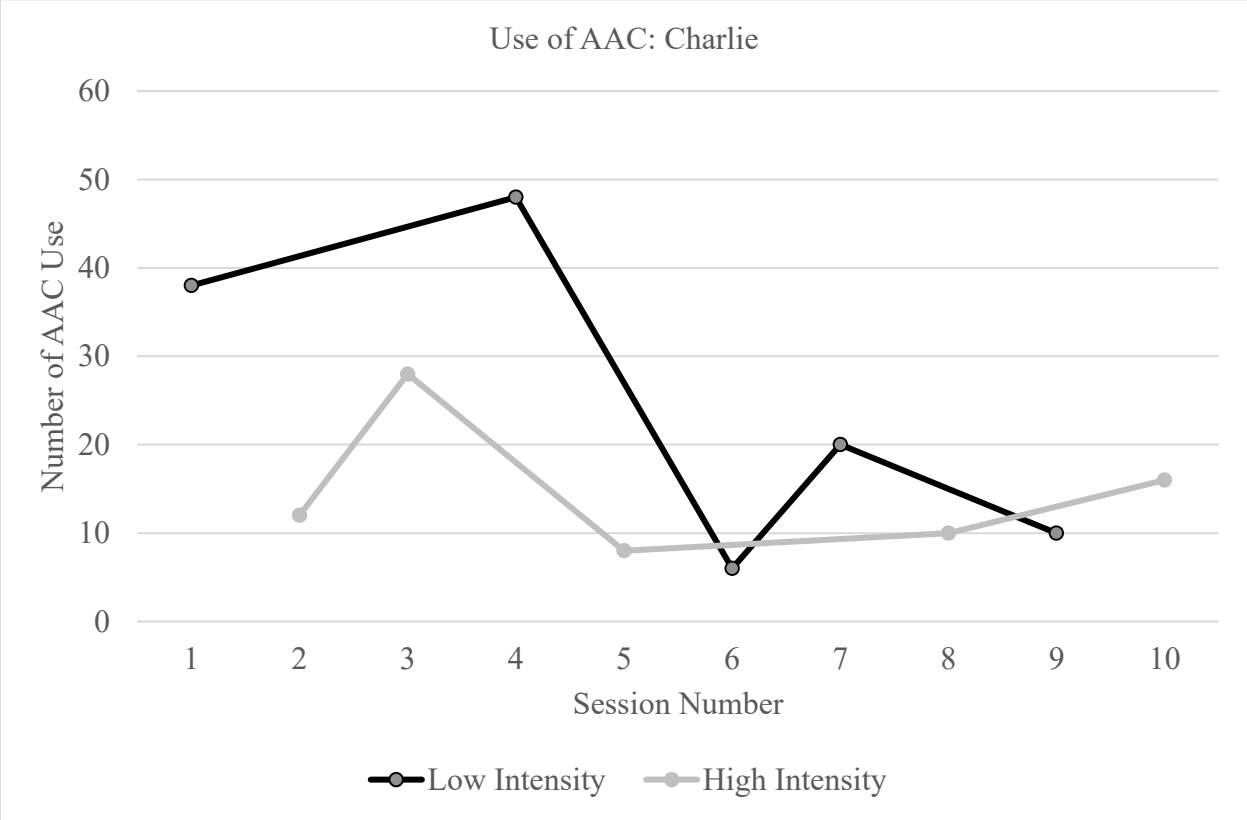

Figure 1. *Amount of AAC use: Charlie.*

Visual analysis Frank. The level, or amount of variability in the data series, was also relatively high for Frank in both conditions. Frank's data specific to the use of his AAC device showed a positive trend for both conditions, although lower intensity condition showed a slightly steeper trend line. See Figure 2. The order of sessions for Frank were as follows: B, A, A, B, A, B, A, B, A, B.

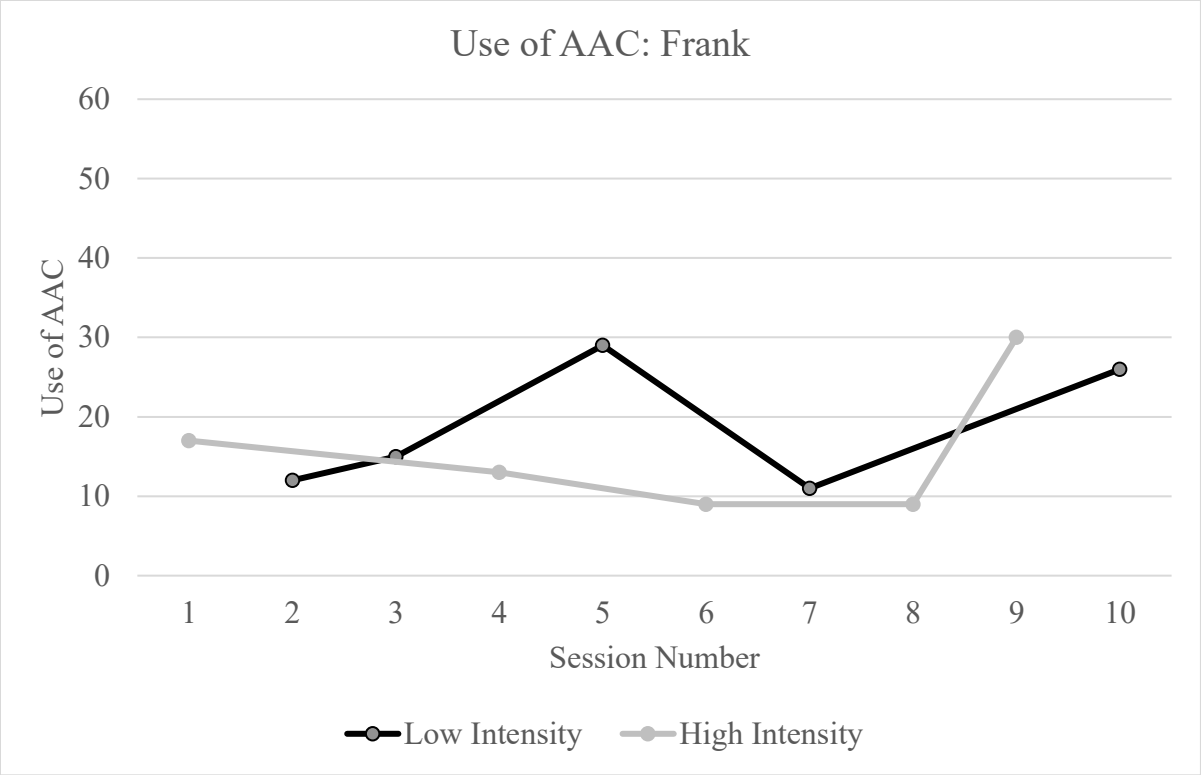

Figure 2. *Amount of AAC Use: Frank.*

Visual analysis Dennis. Following the first two sessions, Dennis's use of his device went from a maximum of six uses in a session and decreased to zero uses per session, regardless of the condition, which also created a high amount of overlap between the data from aim one. See Figure 3. The order of sessions for Dennis were as follows: B, A, B, A, A, B, A, B, A, B.

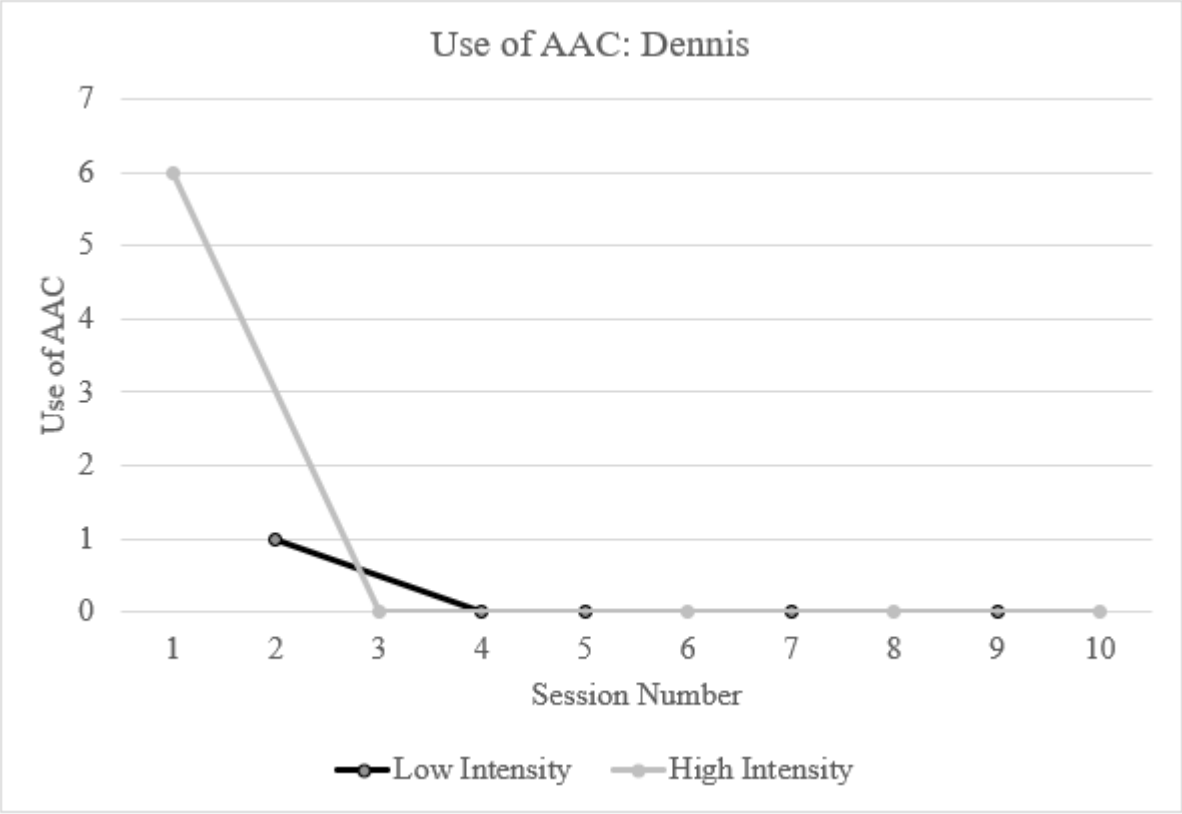

Figure 3. *Amount of AAC use: Dennis.*

Effect size Charlie. The actual and linearly interpolated value (ALIV) for Charlie's aim 1 data was 13.12, meaning that the average difference between data paths in both conditions had an average difference of 13.12. A p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value for ALIV for Aim 1 was .15, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Effect size Frank. The actual and linearly interpolated value (ALIV) for Frank's aim 1 data was 4.38, meaning that the average difference between data paths in both conditions had an average difference of 4.38. A p value was estimated via a Monte Carlo random selection of all

possible randomizations. The p value for ALIV for Aim 1 was .22, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Effect size Dennis. The actual and linearly interpolated value (ALIV) for Dennis's aim 1 data was -.19, meaning that the average difference between data paths in both conditions had an average difference of -.19. A p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value for ALIV for Aim 1 was .82, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Aim 2: Number of Different Words Used by Participants

Aided language input provided at different intensities did not affect the number of different words used by participants.

Descriptive data Charlie. The average number of different words used by Charlie in the high intensity condition was slightly higher than in the low intensity condition, 10.2 in the high-intensity condition versus 9 in the low intensity-condition. The mean difference between the low-intensity and high-intensity conditions was -1. See Table 19.

Descriptive data Frank. The average number of different words used by Frank in the high intensity condition was slightly higher than in the low intensity condition, 7.6 in the high-intensity condition versus 6.83 in the low intensity-condition. The mean difference between the low-intensity and high-intensity conditions was 1. See Table 19.

Descriptive data Dennis. The average number of different words used by Dennis in the high intensity condition was slightly higher than in the higher intensity condition, .4 in the high-intensity condition versus .2 in the low intensity-condition. The median number of different

words used by Dennis was the same, 0, across both conditions. The mean difference between the low-intensity and high-intensity conditions was 0. See Table 19.

Table 19. *Descriptive Data on the Number of Different Words Used*

Aim 2 Data Summary						
	Charlie		Frank		Dennis	
	Low Intensity	High Intensity	Low Intensity	High Intensity	Low Intensity	High Intensity
Mean	9	10.2	7.6	6.83	.2	.4
Median	9	9	8	7.5	0	0
SD	3.71	3.51	2.28	2.47	.4	.8
Minimum	4	6	4	2	0	0
Maximum	14	16	11	10	1	2
Mean Difference: A-B	-1		1		0	
Nonoverlap of all pairs	.42		.58		.48	
Low Intensity Trend	Absence of monotonic trend		Positive monotonic trend: 10% increase		Negative monotonic trend: 40% decrease	
High Intensity Trend	Absence of monotonic trend		Negative monotonic trend: 66.67% decrease		Negative monotonic trend: 40% decrease	

Visual analysis Charlie. Charlie's use of different words varied much across both conditions and from session to session. See Figure 4. However, in the low intensity condition there was a slight negative trend and a stable trend in the high-intensity condition. Similar to his data in the first aim, Charlie's data was variable. It was not uncommon for Charlie's use of different words to increase by two times the amount in a particular session or decrease by two times (or greater). The order of sessions for Charlie were as follows: A, B, B, A, B, A, A, B, A, B.

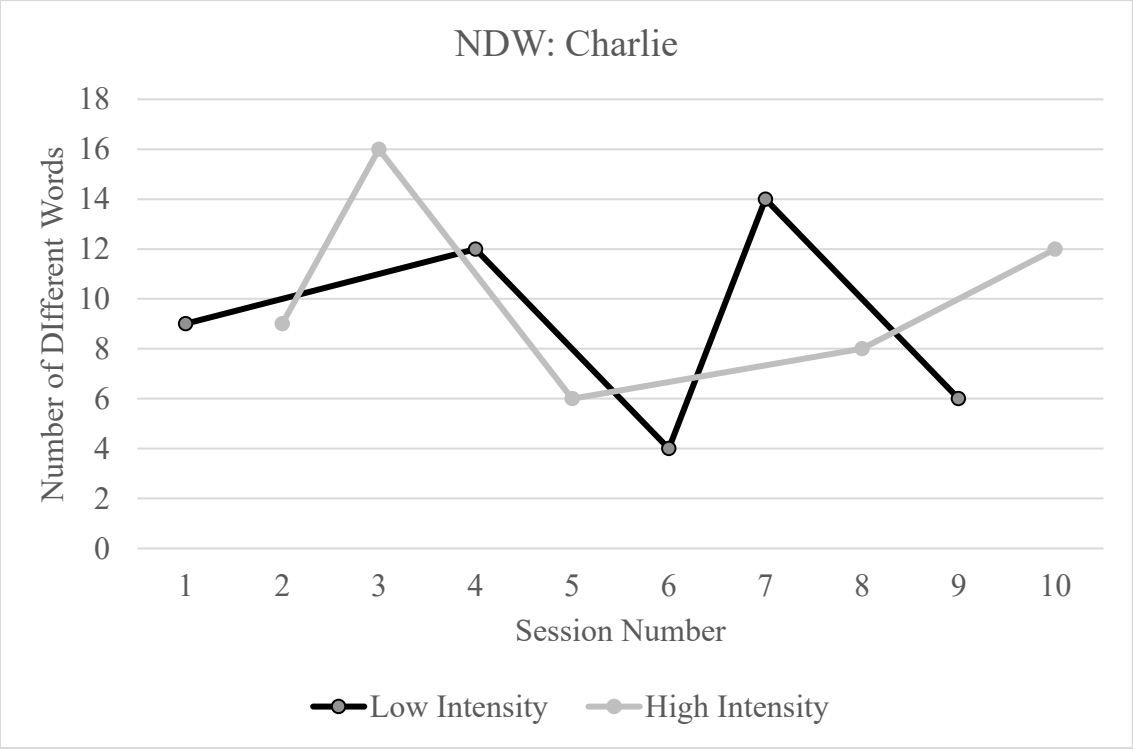

Figure 4. *Number of Different Words Used: Charlie.*

Visual analysis Frank. Frank's use of different words showed variability, with the level of variability being the highest in the low intensity condition. See Figure 5. However, there was a

positive trend noted in the low intensity condition in comparison to the high intensity condition. Identical to Frank's data for aim one, there was a high amount of overlap, with only one nonoverlapping data point. Unlike his data from aim one, the magnitude of change was less from the beginning to end of the study, regardless of the condition. The order of sessions for Frank were as follows: B, A, A, B, A, B, A, B, B, A.

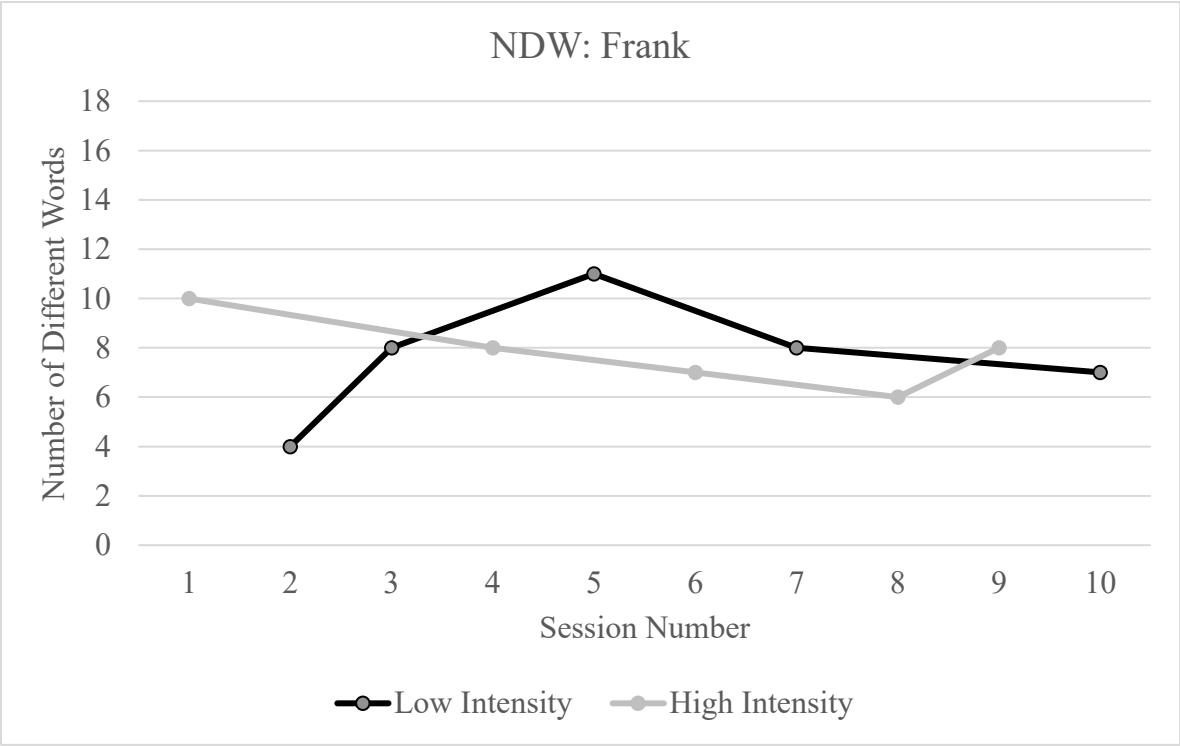

Figure 5. *Number of Different Words Used: Frank.*

Visual analysis Dennis. Dennis's performance related to the use of different words on his device is similar to his performance on the overall use of his device. That is, he did not use his device in the majority of his sessions and therefore the number of different words he used is low. See Figure 6. Additionally, Dennis's data shows a decreasing trend in both conditions with a high degree of overlap between data points from both conditions. The order of sessions for Dennis were as follows: B, A, B, A, A, B, A, B, A, B.

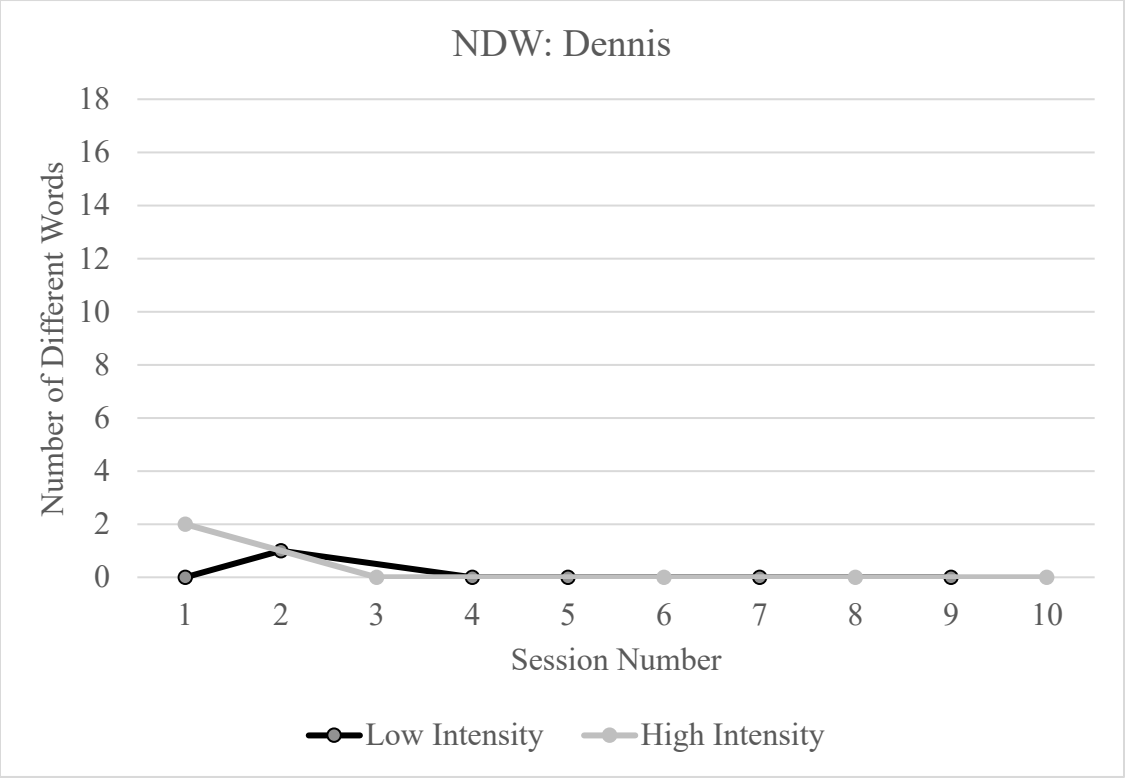

Figure 6. *Number of Different Words Used: Dennis.*

Effect size Charlie. The actual and linearly interpolated value for Charlie's Aim 2 was .12, meaning that the average difference between data paths in both conditions had an average difference of .12. For Aim 2, a p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value of ALIV for Aim 2 was .5, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Effect size Frank. The actual and linearly interpolated value for Frank's Aim 2 data was .67, meaning that the average difference between data paths in both conditions had an average difference of .67. For Aim 2, a p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value of ALIV for Aim 2 was .24, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Effect size Dennis. The actual and linearly interpolated value for Dennis's Aim 2 data was .06, meaning that the average difference between data paths in both conditions had an average difference of .06. For Aim 2, a p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value of ALIV for Aim 2 was .5, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Aim 3: Changes in Overall Communication and/or Language

Changes in communication and/or language (e.g., use of sign, speech, and AAC) were noted for each of the three participants in the study. However, the changes in overall communication and/or language were observed to have occurred differently in each participant and may not be attributed solely to one condition.

Descriptive data Charlie. Charlie's communication through various modalities, such as AAC/sign/speech, was higher in the low intensity condition than in the high intensity condition, with an average of 28.2 communication acts in the low intensity condition and 18.2 communication acts in the high-intensity condition. The mean difference between the low-intensity and high-intensity conditions for Charlie was 10. In the high intensity condition there was an absence of a monotonic trend, whereas in the low intensity condition a 40% negative trend was observed. See Table 20.

Descriptive data Frank. Frank's communication through various modalities, such as AAC/sign, was slightly higher in the low intensity condition than in the high intensity condition, with an average of 26.4 communication acts in the low intensity condition and 20.2 communication acts in the high-intensity condition. The mean difference between the low-

intensity and high-intensity conditions was 6. In the high intensity condition, a 10% negative decrease was noted whereas in the low intensity condition a 60% positive increase was observed. See Table 20.

Descriptive data Dennis. Dennis's communication through various modalities, such as AAC/speech, was slightly higher in the high intensity condition than in the low intensity condition, with an average of 28.8 communication acts in the high intensity condition and 23.2 communication acts in the low-intensity condition. The mean difference between the low-intensity and high-intensity conditions was 6. In the high intensity condition, a 20% positive increase was noted whereas in the low intensity condition a 40% decrease was observed. See Table 20.

Table 20. *Descriptive Data on AAC/Speech/Sign Use*

Aim 3 Data Summary						
	Charlie		Frank		Dennis	
	Low Intensity	High Intensity	Low Intensity	High Intensity	Low Intensity	High Intensity
Mean	28.2	18.2	26.4	20.2	23.2	28.8
Median	24	17	22	17	22	28
SD	17.9	6.66	11.34	9.34	2.94	3.39
Minimum	7	10	15	13	20	25
Maximum	54	30	47	38	28	35
Mean Difference: A-B	10		6		-6	
Nonoverlap of all pairs	.6		.72		.12	
Low Intensity Trend	Negative monotonic trend: 40% decrease		Positive monotonic trend: 60% increase		Negative monotonic trend: 40% decrease	
High Intensity Trend	Absence of monotonic trend		Negative monotonic trend: 10% decrease		Positive monotonic trend: 20% increase	

Visual analysis Charlie. The amount of variability in the data series for participant Charlie in Aim 3 was nearly identical visually as his performance was on Aim 1. That is to say that greater variability in data was noted in the low intensity condition and less variability was noted in his performance within the high intensity condition. See Figure 7. In both conditions, a decrease in the dependent variable, communication through various modalities was observed, although in the high intensity condition the decreasing trend was at a lower rate. Charlie's performance fluctuated in each condition, but to the greatest degree in the low intensity condition, where his highest (48) and lowest (6) uses of AAC were noted. Apart from the first two sessions of the low intensity condition, the remainder of the sessions had a high amount of overlap. What differentiated the two conditions the most, was the magnitude of change. The order of Charlie's sessions were as follows: A, B, B, A, B, A, A, B, A, B.

Visual analysis Frank. Frank's performance on Aim 3, or use of various modalities to communicate, was also visually similar to his data relative to Aim 1. That is to say, that the amount of variability in the data series was also relatively high for Frank in the high intensity and low intensity conditions. Just as his data from Aim 1 showed, Frank's data specific to the use of various communication modalities showed a positive trend for both conditions, although the lower intensity condition showed a slightly steeper trend line. See Figure 8. Along with the high variability in the amount that Frank used his AAC device, the magnitude of change based on these 10 sessions is difficult to interpret as he had such wide fluctuations in how much he communicated through various modalities from session to session and in either condition. The order of Frank's sessions were as follows: B, A, A, B, A, B, A, B, B, A.

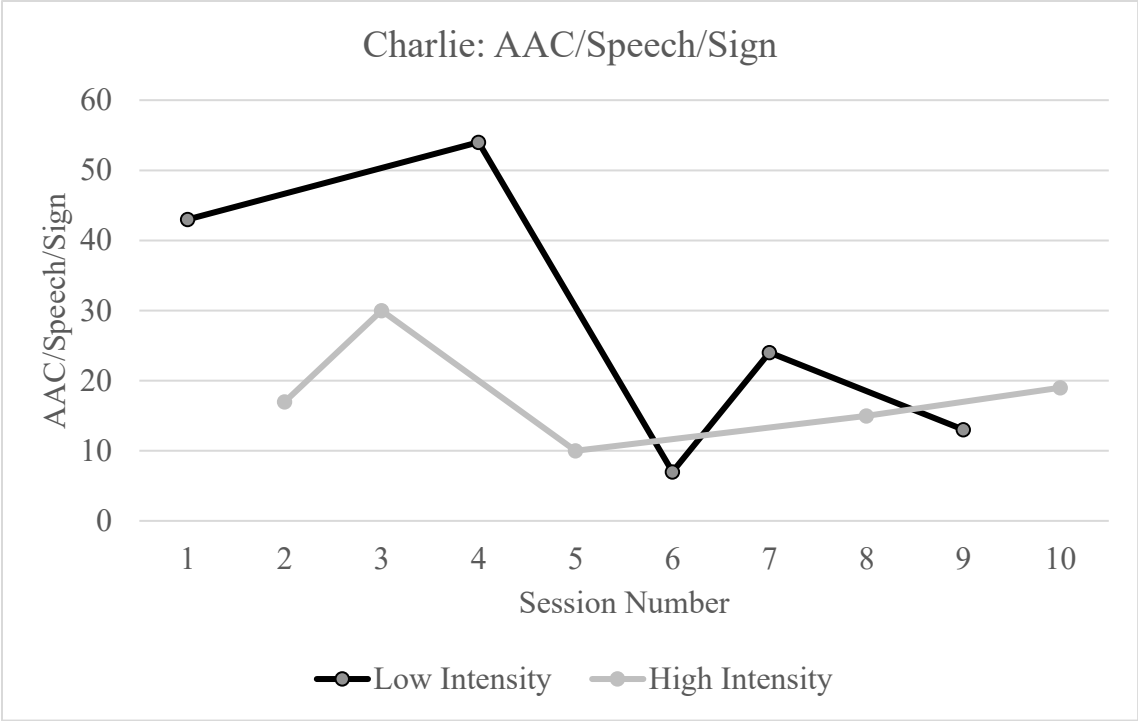

Figure 7. *Amount of AAC/Sign/Speech Use: Charlie.*

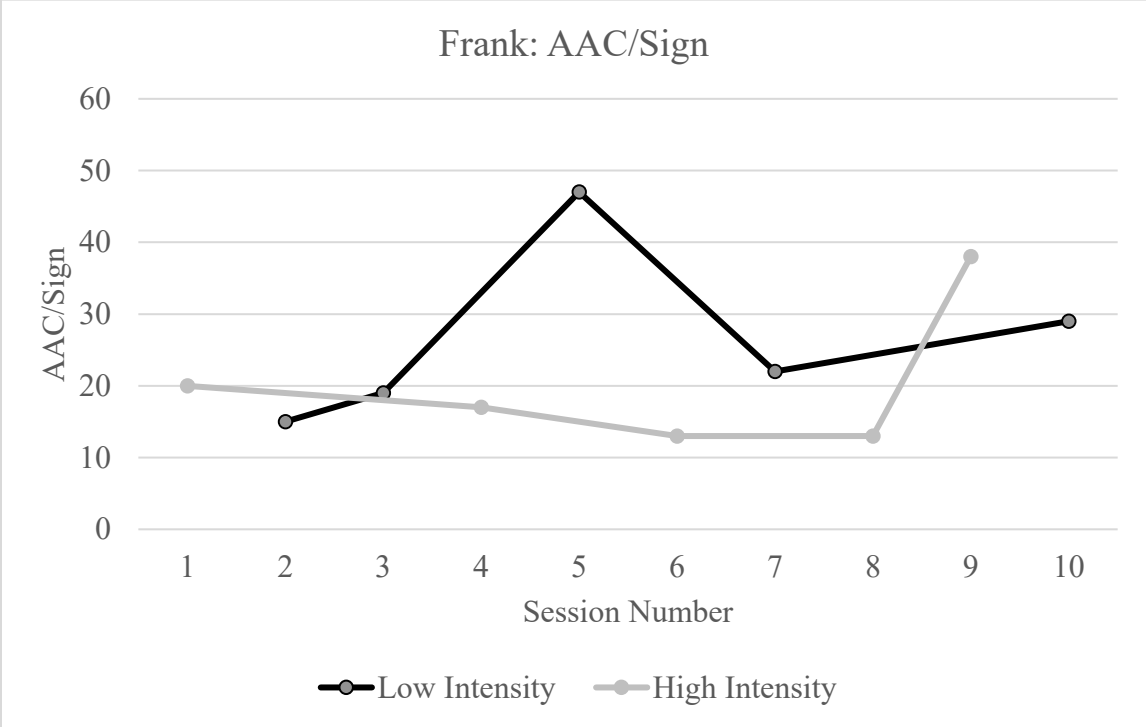

Figure 8. *Amount of AAC/Sign use: Frank.*

Visual analysis Dennis. A positive trend was observed for participant Dennis in his use of various modalities to communicate, with the overwhelming majority of his communication being through the speech modality. See Figure 9. Dennis had slightly decreasing trends in the use of speech within the low intensity condition and a clear positive trend in the high intensity condition. However, the magnitude of change in communication in the high intensity condition was modest. His mean length of utterance (MLU) in words was also calculated for each session in both conditions. See Figure 10. In comparison to his data displayed in Figure 3, positive trends in MLU were noted in both conditions. The order of Dennis's sessions were as follows: B, A, B, A, A, B, A, B, A, B.

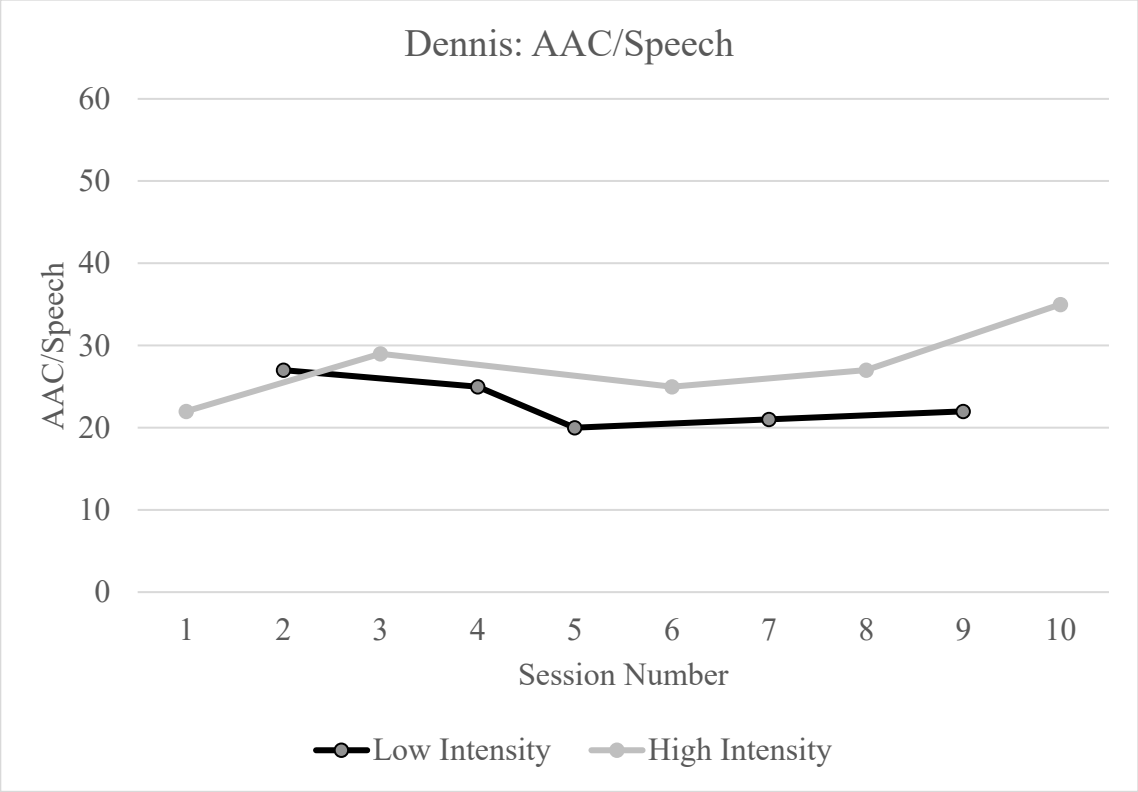

Figure 9. *Amount of AAC/Speech Use: Dennis.*

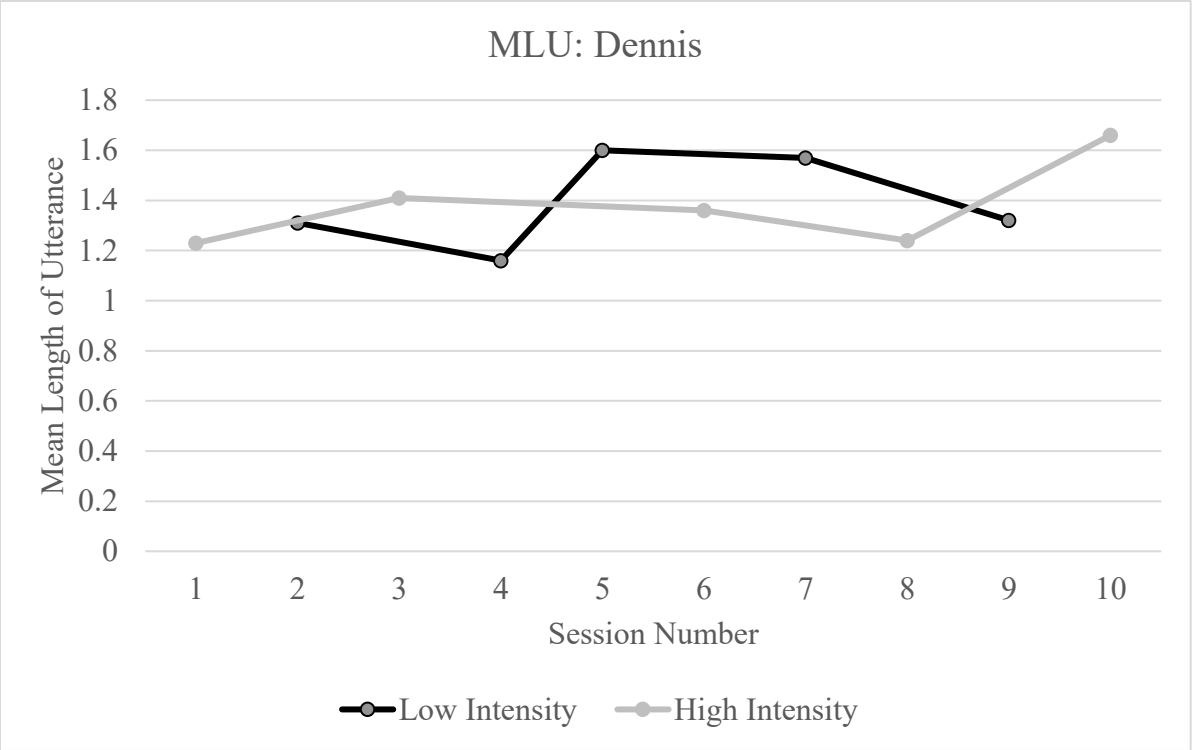

Figure 10. *Mean Length of Utterance: Dennis.*

Effect size Charlie. For Aim 3, the actual and linearly interpolated value was 13.75, meaning that the average difference between data paths in both conditions for Charlie was 13.75. A p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value for the ALIV in Aim 3 was .19, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Effect size Frank. For Aim 3, the actual and linearly interpolated value was 9.44, meaning that the average difference between data paths in both conditions was 9.44. A p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value for the ALIV in Aim 3 was .17, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Effect size Dennis. For Aim 3, the actual and linearly interpolated value was -4.5, meaning that the average difference between data paths in both conditions was -4.5. A p value was estimated via a Monte Carlo random selection of all possible randomizations. The p value for the ALIV in Aim 3 was .97, meaning that the difference between the low intensity and high intensity conditions was not statistically significant.

Communication Matrix pre-intervention and post-intervention. All three participants had improved scores on the Communication Matrix at the conclusion of the study, with Dennis showing the greatest degree of change, moving from a primary level of 3 to primary level 4, and Charlie showing the least change. See Table 21 for the total pre and post-intervention Communication Matrix scores and Tables 22-24 for the percentage of mastery for each communication level. See Appendices J-O for each participants' pre and post Communication Matrix, and Appendix P for more thorough descriptions of each of the levels.

Table 21. *Communication Matrix Pre-Intervention and Post-Intervention Total Scores*

Communication Matrix Results: Pre-Intervention and Post-Intervention for All Participants				
	Pre-Intervention Total Score (Max = 160)	Percentage	Post-Intervention Total Score (Max = 160)	Percentage
Charlie	110	69%	111	69%
Frank	73	46%	76	47%
Dennis	97	61%	124	78%

Table 22. *Communication Matrix Pre-intervention and Post-intervention Communication Matrix: Charlie*

Pre and Post-Intervention Communication Matrix Results: Charlie		
Communication Level	% Mastered or Surpassed (Pre-Intervention)	% Mastered or Surpassed (Post-Intervention)
1 Pre-Intentional	100	100
2 Intentional	100	100
3 Unconventional	100	100
4 Conventional	100	100
5 Concrete	47	47
6 Abstract	88	94
7 Language	0	0

Table 23. *Communication Matrix Pre-intervention and Post-intervention Communication Matrix: Frank*

Pre and Post-Intervention Communication Matrix Results: Frank		
Communication Level	% Mastered or Surpassed (Pre-Intervention)	% Mastered or Surpassed (Post-Intervention)
1 Pre-Intentional	100	100
2 Intentional	100	100
3 Unconventional	100	100
4 Conventional	33	53
5 Concrete Symbols	6	0
6 Abstract Symbols	35	24
7 Language	0	0

Table 24. *Communication Matrix Pre-intervention and Post-intervention Communication Matrix: Dennis*

Pre and Post-Intervention Communication Matrix Results: Dennis		
Communication Level	% Mastered or Surpassed (Pre-Intervention)	% Mastered or Surpassed (Post-Intervention)
1 Pre-Intentional	100	100
2 Intentional	100	100
3 Unconventional	100	100
4 Conventional	73	100
5 Concrete Symbols	18	47
6 Abstract Symbols	12	76
7 Language	18	65

TACL-4 pre-intervention and post-intervention. Two out of the three participants, Charlie and Dennis, improved or maintained their scores on the TACL-4. The third participant, Frank, scored lower on each subtest of the TACL-4 at the conclusion of the study. See Table 25 for additional information on their performance on each subtest.

Table 25. *TACL-4 (Pre-Intervention and Post-Intervention)*

Participant	Sub-test	Pre-Intervention	Post-Intervention
Frank	Vocabulary	6	0
	Morphemes	3	0
	Syntax	6	0
Charlie	Vocabulary	12	21
	Morphemes	2	4
	Syntax	8	7
Dennis	Vocabulary	19	19
	Morphemes	11	11
	Syntax	11	10

Parent Survey

Parents of the participants reported that they noticed changes in the communication skills of their children following conclusion of the study and that their child was using a greater variety of words on their communication device, via sign, or producing a greater variety of words verbally. See Table 26 for data from the survey. Only one parent indicated on the survey that their child was not using their device more at home or in the community. However, all parents reported that they were pleased with the outcomes of the study and that they felt more knowledgeable about utilizing aided language input at home with their child.

Table 26. *Parent Survey Results*

Parent Survey Results					
Question #	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
1				2	1
2				1	2
3		1		1	1
4				1	2
5					3

Discussion

Considering the facilitative effect that language input is known to have on the communication and language development, it was anticipated that the high intensity condition would yield increased use of AAC as well as show that participants would use a greater number of different words in the high-intensity condition. Data from the study show that the opposite was generally true for these participants, with the use of AAC and number of different words used during a session being greater in the low intensity condition. This may be due to the following factors: quality versus quantity of aided language input, influence of diagnosis, and the impact of participant directed speech.

Additional information was provided by the post-intervention testing and parent report measures, with improvement observed for some of the participants and slight decreases for

others. It is important to note that the post-testing measures in this alternating treatments design can only be interpreted as an additional source of information, as no causative conclusions can be drawn regarding the changes from pre to post based on the methodological design of this study.

The fact that changes in use of AAC and in the number of different words were not commensurate with the amount of input may be due to the quality versus quantity of aided language input, the influence of diagnosis, the impact of participant directed speech, as well as the design and length of the intervention. Ideally, each instance of ALI provided by the interventionist would be visually attended to by each participant. However, it was not uncommon for participants to periodically look in various directions when ALI was occurring. This means that while they were provided with the verbal message and synthetic voice output of the communication device, they were not able to see the interventionist navigate the path to select what was communicated on this device. By not seeing the path to access the symbol, participants may not have known how to locate those words/messages, especially if they are novel.

Intrinsic characteristics as well as each child's diagnoses may have influenced their responsivity to the treatment. For example, participant Frank had diagnoses of Down syndrome, autism spectrum disorder, and intellectual disability. During some sessions, Frank selected words that were not readily interpreted based on the context of the activity. While Frank was expanding his expressive language skills by selecting new words, it appeared as though he did not remember the correct path to locate a certain item. These selections could have inflated his number of different words generated as reported in Aim 2. Another intrinsic factor contributing to Frank's performance were his play skills. In each session, it was necessary for the interventionist to lead the activity. While in some cases this might have motivated Frank to

engage in the activity, the fact that he did not share an equal role in contributing to the play/activity may have decreased his motivation to communicate in the activity. His generally increased device use and number of different words used in the low intensity condition may indicate that ALI may be best applied when the participant has a sufficient amount of processing time. For example, ALI provided in a manner that lengthens the amount of the communication exchange, such as when ALI is provided asynchronously (e.g., "The car is red [CAR+RED]"), rather than synchronously where both verbal and visual information are provided simultaneously (e.g., "The car [CAR] is red [RED]).

Likewise, for participant Charlie who had a diagnosis of Down syndrome and a preference for independent play, the environmental configuration may need to have been altered to increase natural opportunities to communicate. For example, he consistently used the visual support Play Menu to request different toys/games. It is possible that by eliminating the Play Menu he may have utilized his device more. While Charlie enjoyed a variety of activities during his sessions, he demonstrated good attention skills, evidenced by engaging in play within the same activity for generally long periods of time. When Charlie was motivated to communicate to the interventionist, he attended to his device and took his time to locate the relevant word that he was looking for. Another intrinsic factor of Charlie's that was observed over the course of the study were his memory skills. It was evident that he remembered the choices available, but also how to set up activities and begin play (e.g., setting up the racetrack).

Lastly, participant Dennis, who had a diagnosis of autism spectrum disorder, may have responded differently to the intervention if it was clearly communicated to him that he was expected to use his device, rather than have this implied. The interventionist did not want to provide that type of instruction or directives to the participants, but rather allowed them to

communicate through whatever modalities they so choose. The first intrinsic factor observed to influence Dennis's response to the intervention was his speech production abilities. Given the general ease that he had in communicating verbally, it was not surprising that he had a preference for using his speech rather than navigate on the communication device, despite remembering where certain vocabulary items were located that required navigation across multiple pages (e.g., "bubbles"). In addition to the potential influences of how expectations were communicated and speech production capabilities of the participants, it is possible that the outcomes of the intervention was influenced by parent related factors. More specifically, Dennis's mother reported that she was unfamiliar with operational aspects of the device, which may have been a barrier to use of the device at home. Another parent related factor which may have had an influence on the outcomes of the study was the fact that Dennis's mother observed each session. This may have increased her awareness of overt and subtle methods of communication used by her son as the interventionist interacted with him. By observing each session and completing the Communication Matrix prior to the initiation of intervention, it is possible that Dennis's mother was simply more cognizant of her son's communication methods, communication functions, and communication complexity.

The fact that two of the three participants had a diagnosis of autism also plays into the effects that the participant directed speech may have had. It was not uncommon for the interventionist to use indirect questions and non-direct language, which are generally less readily interpreted by individuals with autism as opposed to direct questions and direct language. Taken together, the intrinsic variables described earlier in this section may partially explain the variability in performance for each participant, as intrinsic variables are known to be a contributor to expressive language outcomes in individuals who use AAC (Smith, 2015).

Lastly, it is worthwhile to note the characteristics of the study which likely influenced the outcomes. More specifically, the length of the intervention was relatively short, spanning only 5 weeks. It is known that individuals who require AAC may best show progress over time and most often, it is more common to see progress when data is taken over the course of at least a few months. In addition to the length of the intervention, it is necessary to reiterate that the intervention provided constituted a very small amount of time that was devoted to providing aided language input. As such, while "high" and "low" aided language input dosages were provided throughout the course of the study, the intervention could overall be considered low intensity.

Aim 1. Use of AAC device

Over the course of the study Charlie's use of his communication device decreased in both conditions. See Figure 1. Charlie's performance fluctuated in each condition, but to the greatest degree in the low intensity condition, where his highest (48) and lowest (6) uses of AAC were noted. Apart from the first two sessions of the low intensity condition, the remainder of the sessions had a high amount of overlap. What differentiated the two conditions the most was the magnitude of change. Charlie's use of AAC reduced by ¼ from the start to the end of the study in the low intensity condition, whereas in the high intensity condition it decreased, but to a much lesser degree. When using his communication device, Charlie typically used it for the purpose of requesting more of an item or the recurrence of an action by the interventionist (e.g., making the toy cars go around the loop). It is possible that the provision of a general visual support menu of choices influenced his preference of using his device as it was more efficient for him to simply point to the toy or item that he wanted to play with. To use his device for the same purpose, Charlie would need to navigate across multiple pages, not only taking more time but more effort

in visually scanning the picture symbols as opposed to looking at the photographs of the actual toys being used in the play-based activities. Additionally, after a few sessions with the toys and games available, Charlie began to become more independent in his play, thereby having a decreased need to request the interventionist to assist him during play, with his device or through the use of sign.

In comparison to Charlie, Frank's data showed a small increasing trend in the use of his device, with the trend increasing to a greater degree in the low intensity condition. See Figure 2. In Frank's sessions, there was a high amount of variability in both conditions, although there was perhaps the most variability in the low intensity condition, where Frank's use of AAC doubles from session two to session three, which then decreased by 1/3 from session three to session 4, only to increase by roughly the same amount in the last session of that condition. This is in comparison to the variability seen in the high intensity condition where there was a gradual decrease in the use of AAC in the first three sessions, followed by one session of the same amount of AAC use and finally another large increase in the use of AAC. The amount of overlap of the sessions was very high (90%), with only one data point exceeding the amount from any other condition. Along with the high variability in the amount that Frank used his AAC device, the magnitude of change based on these 10 sessions is difficult to interpret as he had such wide fluctuations in how much he used his device from session to session and in either condition. It is possible that the lower-intensity condition made the use of his device more appealing as he had more conversational space in which he could occupy or contribute to than in the high intensity condition. In comparison to Charlie, Frank continued to require the interventionists assistance in using the toys, playing the games, and accessing the materials and used his device as well as sign with a generally increasing trend. Frank seldom used the visual support menu and often the

interventionist provided Frank with choices of an activity by holding up two different toys or games and using Frank's eye-gaze as a means to determine what he wanted to do next. It is possible that during sessions where he did not use his device much, such as sessions two, three, and four of the high intensity condition, that some of the opportunities to use his device were pre-empted by the interventionist. In these types of sessions where he was more passive in communicating, it was necessary for the interventionist to continue in an activity or in play so that language could be modeled a sufficient number of times on the device for that session as well as to keep the session progressing to be fun and/or engaging for Frank.

In comparison to Charlie, Dennis preferred to communicate through verbal speech. Dennis's use of his device, or lack thereof, is reflected in the data by large standard deviations for both conditions for Aim 1. Out of the three participants, Participant Dennis had the least amount of variability, although this was due to his lack of using his AAC device for the overwhelming majority of the sessions It is believed this preference to use his speech is due to the efficiency of his communication. In order for Dennis to use the same vocabulary present on the device that he was producing verbally (e.g., bubbles), it would require that he navigate across multiple pages, making speech the most efficient method of communication for him. His performance from the first two intervention sessions, one in the low intensity condition and one in the high intensity condition, showed that he knew where relevant vocabulary was to fulfill his most frequently occurring communication needs during the session, requesting bubbles or music. Likewise, he expressed his feelings about the activities via facial expression and/or other non-verbal means, such as clapping his hands. That said, his communication did evolve over the course of the study and in later sessions Dennis began to use speech to comment on what he did (e.g., "take three bite"). Out of the three participants, it was more challenging to provide Dennis

with aided language input that one might consider high in quality in addition to being high in quantity. For example, the presence of a mirror in the intervention room frequently gained his attention which influenced how much he visually attended to the device, even when it was placed into his visual field. Therefore, the modeling of some words by the interventionist may not have been as helpful in this circumstance, as Dennis needed to watch the motor movements necessary to select individual words on the dynamic display device. In other words, the interventionist could model a specific word in every instance of aided language input, but Dennis would not know how to locate the word unless he visually attended to the device models. It is also important to consider the amount of device use and support Dennis had in his other communication environments. His parent reported that his school team provided Dennis with access to the device but did not utilize it in the same manner that it was during the play-based sessions in this study or support the use of it in the form of training communication partners, teachers, and paraprofessionals. Additionally, Dennis's parent indicated that he continued to rely on speech at home. When he did use his iPad to communicate at home, he preferred to exit the communication software, navigate to the picture taking application on the device, and take photos of desired items/activities that he would then show to a communication partner. Lastly, Dennis's use of his device, or lack thereof, may be a function of the device itself. His most recent AAC evaluation, which occurred two years prior to the start of this study, ended with the recommendation for an AAC device with a very different type of language organizational scheme than what he used during the study. Dennis's AAC device used during the study is organized in an associative fashion in comparison to the device that was recommended based on feature matching principles and device trials which was a device with software that has language represented in a categorical fashion. It may be the case that this difference in organizational

scheme created a barrier to his uptake of the device and use of it in various communication environments.

Aim 2. Use of different words

Results related to the use of different words were mixed, with negative or stable trends noted for two of the three participants for the majority of sessions. It should be noted that standard deviations for both conditions were once again rather large, which was a reflection of the performance of participant Dennis who did not utilize his AAC device, and in turn did not use different words on his device for the overwhelming majority of sessions regardless of the condition.

Data relative to Charlie's use of different words is somewhat promising, as it may indicate that although Charlie tended to use his device less over the course of the study, his selections were generally diverse lexically. Additionally, he maintained this use of varied words in one of the two conditions, as evidenced by the trend of the data in the high intensity condition. As a function of needing to provide a high amount of aided language input, it is possible that the frequent and repeated exposure to a variety of words provided Charlie with the chance to observe the use of these words in a meaningful context as well as the opportunity to use them in a meaningful context. The stability of the trendline of number of different words used by Charlie in the high intensity condition should be interpreted with caution, however, as the trendline is influenced by the largest numerical data point, which was session two from the high intensity condition. Given that the date of this intervention session was at the beginning of treatment, it is possible that the novelty of the intervention session and toys utilized during the session increased his motivation to engage in play and communicate through the use of his device. Additionally,

since the toys/games were still relatively new to him, he was less able to use the toys independently, creating a genuine need for him to request help from the interventionist.

Frank's use of different words was visually similar to his device use. In other words, the more that Frank used his device in a session, the greater number of different words he utilized within that session. Although Frank has had his communication device for the longest amount of time out of all the three participants, it was reported that he typically used a relatively small repertoire of words, such as “juice”, “go”, and “tv.” The fact that Frank used a wider variety of words during his sessions, with 50% of the sessions showing he used 8 different words or more, provided evidence of growth using his device. Additionally, Frank used certain core words on his device to fulfill different purposes. For example, previously Frank used the word “go” to indicate that he wanted to have a break by going on a walk. During many of the sessions in both conditions, Frank used “go” to direct the interventionist to “go” and continue the activity.

Dennis did not use many different words on his device in either condition. During one session he used 2 different words and in the other session he generated one message using his device. This may be due in part to his preference for more rapid communication through the use of speech. When Dennis selected “bubbles” on his device to request more bubbles, he did so independently, efficiently, and without any prior modeling of the word by the interventionist to find that word. This suggests that Dennis was at least somewhat familiar with the language on his device. Again, it is worth noting that in order to find that word within the specific software that Dennis uses, it takes navigation across multiple pages and 3 symbol selections. Dennis’s use of the number of different words is likely to be lower because the use of his speech was a more efficient method of communication for him within the context of this study. Additionally, his mother reported that his school did not implement systematic communication partner training

related to his device and generally did not support the use of his device beyond the provision of the technology itself.

Aim 3. Communication and Language

For all three participants, positive gains were observed in either (a) communication skills, such as communicating in a variety of modalities, (b) receptive language measures, and/or (c) positive parental perceptions.

Charlie's use of AAC/sign/speech closely approximated his overall device use over the course of the study as he generally communicated using those modalities less over time. As noted previously, Charlie was often independent in his play. As sessions progressed, Charlie was able to utilize the toys without the need to request help or request the recurrence of an action as he was already engaged in the play himself.

Similar to Charlie, Frank's use of various communication modalities also approximated his performance observed in Aim 1, with a slight increasing trend in his communication through various modalities. This may be a function of familiarity with the tasks/activities as well as with the interventionist. As noted previously, Frank's decrease in scores on the post-intervention TACL-4 are not believed to be accurate representations of his receptive language skills. On the day of testing he was observed to be participating in answering the questions rapidly and without the type of visual attention to the stimuli as was observed in his first completion of the TACL-4.

While Dennis did not use his device much throughout the course of the study and in turn, did not use many different words on his device in either condition, visual inspection of data on Aim 3 suggests positive changes in language and communication occurred. In the low intensity condition, Dennis's overall use of speech showed a positive trend (See Figure 9) and his mean

length of utterance showed modest improvement over the 5 weeks of the intervention in both conditions (see Figure 10). The other sources of information collected also provided information that suggests his communication skills improved. For example, his primary communication level and higher communication level improved on the post-intervention Communication Matrix, with his primary level moving from 3 to 4, and his higher communication level moving from 4 to 6.

TACL-4 performance. Charlie's post-intervention performance on the TACL-4 showed improved scores, especially on the vocabulary subtest. It is possible that this was due in part to him being more familiar with the picture stimuli and the interventionist, thereby making it less challenging to locate the most important aspect of each picture which he then used to select the correct response between the similar stimuli cards. Generally speaking, the syntax subtest of the TACL-4 is the most challenging as it places burdens on short term memory. It is also worthwhile to note that it comes at the end of the test, meaning that it is possible that Charlie's performance was impacted by fatigue.

Frank's post-intervention TACL-4 scores showed a decrease in each subtest of the TACL-4. However, his performance was not believed to be an accurate representation of his receptive language skills in the areas of vocabulary, morphology, and syntax as during testing he pointed to the stimulus item in the bottom right-hand corner of the card rapidly without taking the same amount of time to visually scan the cards to locate the picture corresponding to the word or sentence provided verbally by the interventionist.

Dennis's post-intervention TACL-4 scores remained generally stable, with the exception being one-point lower on the syntax subtest. On the day of testing, it was evident that Dennis expected to play. Even with frequent play breaks incorporated into the administration of the test, it was evident that he wished to leave. For example, at the conclusion of the test, he took his

mother's hand and placed it with the palm facing the interventionist and moved her hand back and forth to indicate "bye".

Communication Matrix performance. Participant Charlie and participant Frank's families overall did not report much difference from the beginning of the study to the end of the study on the Communication Matrix. This is not surprising as the length of the intervention was only 5 weeks. It is not uncommon for speech and language therapy to require a longer amount of time in order to document significant changes in communication and language skills for children who use AAC. In comparison to Charlie and Frank, Dennis had the most change observed on his Communication Matrix levels with an increase in the primary communication level as well as the higher communication level. Unlike Charlie and Frank, Dennis had not received any private speech and language therapy which might explain the increase on the parent report measure. It is also possible that the increase on his post-intervention Communication Matrix was a result of his mother's familiarity with the items on the communication matrix. After becoming aware of all the different ways that individuals might communicate when completing the Communication Matrix the first time, his mother may have simply been more aware of how her son was communicating over the 5 weeks. It is positive to note that each participant's family had positive perceptions of the intervention overall.

To extend the benefits of clinical intervention, it is important that the intervention utilized is perceived positively by the relevant stakeholders. Social validity has previously been described as being composed of three elements: (a) goals, (b) procedures, and (c) outcomes (Snodgrass, Chung, Meadan, & Halle, 2018). This study had high social validity due to the goals, procedures, and outcomes selected. The overarching goals of AAC intervention are concerned with improving the efficiency and effectiveness of communication for the person who

uses AAC as well as improving their expressive/receptive language skills. More frequent device use may be considered a proximal measure of effective AAC use, the number of different words/phrases selected in meaningful contexts considered a proximal (and objective) measure of expressive language skills, and overall communication and receptive language skills considered outcomes known to be considered socially important. In addition to the goals selected, the intervention procedures are also believed to possess social value, as the use of ALI is cost effective, only requiring a communication partner to implement. Parent report from the survey completed at the conclusion of the study showed that overall the parents agreed that noticeable changes in the communication skills of their child occurred as well as noticeable changes in the words/phrases/signs their child uses. The majority of parents (66%) reported their child was using their device more frequently at home and/or in the community. Lastly, all parents were pleased with the outcomes of this study and felt that they could implement ALI with their child, indicating that the intervention was perceived positively by parents.

Clinical Implications

It is recommended that clinicians are mindful of factors contributing to communication and language learning outcomes and make an effort to (a) increase the salience of aided language input in meaningful activities, (b) be mindful of the type of speech that is directed to individuals who use AAC, (c) take data on the amount of ALI that is being provided to each person who uses AAC, (d) support language input in different contexts by making communication partner training a priority in service delivery, (e) utilize a combination of general language stimulation as well as focused instruction.

In order to have aided language input that is high in quality, it is necessary that the interventionist not only select words that may be utilized frequently in meaningful interactions and contexts, but also make some effort in explicitly identifying what words are being modeled. For example, in language therapy for children who are verbal communicators, it is common practice for speech-language pathologists to identify what language feature or words are being addressed in the session, often through direct instruction as well as altering the intonation patterns of their speech. For children learning to use AAC, the process of providing direct instruction should be similar those procedures, containing the same elements of explicit instruction paired with the picture symbols. It is possible that higher-intensity aided language input may have different effects when utilized with different types of clients (e.g., Frank's performance in the lower-intensity condition). Children who require a communication device but have otherwise intact cognition and language skills may be the individuals who perform best in the higher intensity condition (e.g., childhood apraxia of speech, cerebral palsy, etc.), although more research is needed to confirm this. For individuals who use AAC, specifically young children and those that are beginning to learn to use their device, it is important that practitioners utilize high interest and motivating activities that will sustain the individual's attention. This allows the interventionist to utilize natural teaching moments and map the language on a communication device to the nonverbal communication acts of the individual, potentially serving as a bridge between their current communication methods with those that they may utilize with unfamiliar communication partners in the future.

It is important that practitioners are aware of the type of speech that they are directing towards their clients who use AAC, as the type of speech that is directed to a client influences their role within a communication interaction. For example, when clients who use AAC are

frequently in communicative interactions that are largely interrogative in nature, they are by default put into a passive role as a communicator. By using a least to most prompting hierarchy as a guide, practitioners may be able to provide the conversational space and opportunity for individuals who use AAC to assume a more active role as a communicator rather than be the recipient of closed ended questions. It is also important to note that a least to most prompting hierarchy will likely need to be modified based on client needs on a session to session basis or perhaps even within the same session.

Speech language pathologists often collect various types of client data in order to report progress for the client. In addition to collecting data on client performance, it is recommended that speech language pathologists and pre-service speech language pathologists track how many times in a session or in a predetermined amount of time that they are utilizing aided language input. For pre-service speech language pathologists, using aided language input may be unnatural and by tracking how much they're using it may help them utilize aided language input at higher intensities until the behavior of device modeling becomes habitualized. Speech language pathologists and pre-service speech language pathologists should also be aware that their goal amount of aided language input to use during each session should be individualized to the client, based upon what amount is feasible for each individual and what amount would allow the speech language pathologist to provide the highest amount of aided language input that is also high in quality.

The setting and context for the activities within this study show the effects of what can happen when aided language input is used at different intensities in a clinical setting. Similar to what is known about typical language development, distributed language input is likely to be superior to massed language input (Childers & Tomasello, 2002). As such, it is essential that

practitioners place a high emphasis on communication partner training in order to achieve the distributed language input necessary for individuals who require AAC to learn their communication systems to the best of their abilities. To accomplish this, it is important that practitioners not only understand the importance of communication partner training but make sure that it is documented within relevant documents such as Individual Education Programs as well as provide the training in a systematic fashion with ongoing monitoring as needed to ensure maintenance (Kent-Walsh & McNaughton, 2005).

This study consisted predominately of general language stimulation, where each participant was provided with language input in a variety of modalities within meaningful and motivating activities without explicit instruction on specific symbols to use. It is important that practitioners plan for both types of instruction to occur, so that new vocabulary is clearly identified to the individual who uses AAC with opportunities to use that novel vocabulary in other meaningful activities in a variety of contexts.

Limitations

The present study utilized an alternating treatments design to investigate the effects of aided language input provided at different intensity levels. Limitations of the study include the lack of a baseline condition, the number and types of individuals participating in the study, the context in which the study was conducted, the lack of systematic manipulation of when aided language input was used in conjunction with language provided verbally, the number of intervention sessions, and how much is known about the amount of aided language input provided to each participant in the other contexts in which they interact.

The inclusion of a baseline condition in this study would be beneficial in order to compare each participants' performance during the intervention conditions to what their performance when the intervention procedures are not utilized. The baseline condition would have provided a control condition.

Another limitation of the study is the limited number of individuals participating in the study and the type of participants. While single case research is designed specifically for small sample sizes, the incorporation of additional participants would allow additional examination of the effects of the intervention to be observed in different individuals. Additionally, the individuals who participated in this study were quite different from one another in terms of diagnosis/diagnoses as well as in general language and communication skills. While this diversity does exist in the population of individuals who use AAC, it would have been beneficial to have more specific inclusionary criteria in order to recruit individuals who are similar on many measures. This would allow for the effects of the intervention to be observed in a very specific group of individuals (e.g., children with autism who are at primary communication level 3 as measured by the Communication Matrix).

The context in which the study occurred may also be considered a limitation. More specifically, it was in a play-based format within a clinical environment rather than the place in which each participant typically interacts. This may have impacted skill acquisition and generalizability inadvertently.

An additional limitation of the study is the fact that aided language input was provided without systematically manipulating the point in time in which it was provided. In other words, the interventionist provided aided language input asynchronously at times and synchronously in other instances, based on what the situation necessitated. It is possible that aided language input

dispensed consistently in either configuration, asynchronously or synchronously, may have impacted the efficacy of the intervention.

It is believed that the number of the intervention sessions was a limitation. To utilize an alternating treatments design, it is necessary to have a minimum of 5 data points per condition (Gast & Ledford, 2018). However, many children who use AAC take longer to respond to treatment and their performance from day to day can fluctuate to a large degree.

Lastly, within the current study no mechanisms were put into place to track how much ALI was being provided to the participants in the other settings in which they interact. Furthermore, it is not known if or how much their devices are consistently present in those other settings that they typically spend their time in.

Future Directions

In the current study two intensity levels of aided language input were compared in a controlled clinical setting. It is recommended that the intensity of aided language input continue to be studied. Future inquiry into aided language input intensity would benefit from alterations to the methods utilized in this study. These recommended changes include the addition of a baseline condition and the selection of pre/post measures. Moreover, further manipulation of how aided language input is disbursed in clinical and real-world settings is recommended.

As mentioned previously, the inclusion of a baseline condition is helpful for researchers to see the effects of the intervention with comparison to a no intervention condition. Additionally, including a baseline condition would allow for more commonly known effect size

measures to be used, which may allow the results to be readily compared to results from other intervention studies.

Use of pre/post testing measures that are more robust to the variability in performance seen on testing related measures may be useful in future research related to ALI. Often, standardized testing instruments do not possess any real meaning to the individuals completing the test, which in turn can decrease participants' motivation to attend to the stimulus items within a test as well as complete it to the best of their ability. One option other than standardized testing instruments is the use of language activity monitoring, as it can provide valuable information on the performance of an individual who uses AAC in a manner that is non-intrusive. With some of the limitations of standardized testing instruments acknowledged, it is worth mentioning that the use of testing related measures is not without benefits, as other researchers may use the same instrument on various individuals. If future research efforts include measures that use more formal types of testing, it is recommended that an effort is made to clearly review what will occur in each session to each participant in advance and in addition to oral assents. This may be best addressed through the incorporation of some form of preparation for the participants, such as using social stories which will clearly articulate what will happen in the next each session to the participants. Oral assents were used with each client on the day of the session, but pre-viewing what is going to occur by sending home social stories for the participants to review with their family are believed to improve the quality of the performance of each participant. For example, without clearly explaining what is going to happen during each session, the performance of the participants on the test measures may be lower at the conclusion of the intervention sessions due to the participants' expectation that they were going to engage in play, rather than point to pictures.

Systematic examination of aided language input intensity may be accomplished in different ways, including in clinical settings as well as in real world environments. As mentioned previously, investigation of ALI intensity would benefit from extending the intervention, regardless of context and setting (e.g., clinical vs. real-world). For reduplication of this intervention conducted in a clinical setting, it is advisable to extend the amount of sessions beyond five sessions per condition to span a minimum of three to four months, roughly 24-32 intervention sessions, unless a longer intervention schedule is feasible. These additional sessions can provide a more accurate picture of participant responsivity to the treatment. Furthermore, the additional amount of data points provided by a higher number of intervention sessions would help identify trendlines that are more robust to extremely high and/or low data points.

Given the results of this study, future research conducted in clinical environments and/or in relatively short sessions (e.g., 30-45 minutes) should consider further manipulation of the amount of aided language input used in the various conditions. It is likely that the optimal amount of ALI is likely to vary based on the individuals who are participating, the goal(s) of the study, as well as the context and dose form where the intervention is occurring. For example, if investigating the effects of ALI on answering curricular related comprehension questions within a brief intervention session, the description of what constituted low intensity of ALI in this study would not likely work, as shared reading activities do not frequently occur in 45-minute periods. As such, it may be beneficial to create a different "low intensity" for comparison to a higher intensity condition which more accurately reflects the intended meaning of the initial name of the low intensity condition. Such a condition may involve 1 model per minute or less in order to reflect what may actually constitute low intensity of aided language input in real world environments as well as account for the language processing demands involved with frequent

verbal and visual input. For studies utilizing play-based interventions, it is recommended to alter the amount of aided language input by decreasing the maximum amount for the low intensity condition as well as the decreasing the maximum amount for the high intensity condition. For example, this might involve a lower-intensity condition of 1 model per minute and a higher-intensity condition of 3 models per minute.

Future research efforts documenting the percentage that aided language input is provided throughout the day in real-world environments may allow for more specific intervention intensity information (i.e., cumulative intervention intensity) to be calculated. This is opposed to reporting how intensely aided language input is being utilized within short intervention sessions. It may be the case that comparison of low cumulative intensity interventions with and high cumulative interventions intensities provide evidence contrary the results of this study, with the highest cumulative intervention intensity showing the most use of AAC. However, more research is needed and a methodological design other than alternating treatments may be necessary for that type of inquiry which would be determined by the specific aim(s) of that study. For potential research projects conducted in real world environments, it is recommended that a sufficient amount of difference exists between the two intensities that is also feasible. For example, a difference may involve aided language input provided throughout 25% of the school day in comparison to a higher amount of aided language input, constituting 75% of the school day. In regard to feasibility, the current educational programming and supports in place for participants will need to be taken into consideration prior to initiation of the intervention procedures, as it is likely that para professional support will need to be utilized in order to provide distributed aided language input throughout the day. With information known about specific educational programming and supports for each participant, it may be necessary to modify the percentage of

the school day where aided language input is provided in the both conditions based upon what is possible.

It is possible that some individuals may respond best to aided language input that is provided at high intensity levels. Such individuals may include those with good receptive language, memory skills, and play skills that are exposed to language rich environments. This may include children with Childhood Apraxia of Speech or Cerebral Palsy. It is recommended that future research efforts seek to complete case studies of individuals who meet the aforementioned criteria with attention paid to extending the length of the intervention over multiple months.

Conclusions

There were no large differences in device use and the number of different words produced during low and high intensity the two conditions. There were some changes observed by parents and generally positive changes occurred on receptive language measures. There were mixed results from the Communication Matrix scores. In other words, benefits to each of the three participants were manifested differently.

Investigation of communication and language intervention efficacy and effectiveness for individuals with complex communication needs remains an area of scientific inquiry that requires additional exploration in order to fully understand the impact the interventions using ALI may have as well as elucidate the mechanisms for language learning in different profiles of language learners. Researchers may best address the need for additional information in obtaining data which may be compared to a baseline condition and over time, with intervention sessions increased as much is feasible for participating families. Additionally, using a combination of

general language stimulation and focused language stimulation is recommended as well as selecting pre/post measures that are descriptive and sensitive to changes in the communication and language skills of individuals who use AAC. By continuing to refine language interventions and understand the factors which influence the efficacy of ALI, practitioners may fully maximize language learning development in this population and provide them with the tools to interact with the people in their lives possible.

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Appendix A

Order of Sessions by Participant

Participant A

Session #	Condition
1	A
2	B
3	B
4	A
5	B
6	A
7	A
8	B
9	A
10	B

Participant B

Session #	Condition
1	B
2	A
3	A
4	B
5	A
6	B
7	A
8	B
9	B
10	A

Participant C

Session #	Condition
1	B
2	A
3	B
4	A
5	A
6	B
7	A
8	B
9	A
10	B

Appendix B

Email to Recruit Participants

Greetings _____,

I am a speech-language pathologist within the Department of Speech-Language-Hearing at the University of Kansas. I am conducting a research study that is related to language input for people who use speech-generating communication devices. I am looking for people who use speech-generating augmentative and alternative communication (AAC) devices between the ages of 3-50.

During each session, I will teach people to communicate with their AAC device during shared reading and gameplay. It is expected that the study will occur during 12 sessions during the months of February-April, with each individual session lasting roughly 45 minutes. Each of the sessions will take place at the Schiefelbusch Speech-Language Hearing Clinic located on the University of Kansas Campus.

Benefits for your family member may include increased competence using and navigating their device to communicate. At conclusion of the study participants will receive $100 dollars and a $25 gift card for a local gas station.

People choosing to participate may withdraw at any time. If you do withdraw from this study, not participate in this study, or participate in this study, it will not affect your relationship with the Schiefelbusch Clinic, the services it may provide to you, or the University of Kansas.

If you are interested, please contact Russell Johnston at rjohnston@ku.edu or Dr. Jane Wegner at jwegner@ku.edu for additional information

Appendix C

Letter to Recruit Participants

Dear (Insert name),

My name is Russell Johnston and I am a Speech-Language Pathologist at the Schiefelbusch Speech-Language-Hearing Clinic and doctoral candidate in the Department of Speech-Language-Hearing at the University of Kansas-Lawrence campus. I am currently conducting a research study related to Augmentative and Alternative Communication (AAC) devices. My goal is to recruit participants for this study between the ages of 3 and 50 years of age. This study will occur over approximately 12 sessions, with each session lasting 45 minutes in length. These sessions will take within the Schiefelbusch Speech-Language-Hearing clinic located on the University of Kansas-Lawrence campus.

The purpose of my study is to investigate the effect that language modeling may have on the amount that a person who uses AAC utilizes their device. Additionally, this study will investigate the effect that language modeling may have on the number of words/phrases generated by a person who uses AAC.

People choosing to participate in this study may withdraw at any time. If you decide it is necessary to withdraw from this study, choose not to participate in this study, or choose to participate in the study, it will not affect your relationship with the Schiefelbusch Clinic, the services it may provide to you, or the University of Kansas.

Attached to this letter is the flyer with additional information specific to the study.

Benefits for your family member may include increased competence using and navigating their device to communicate. At conclusion of the study participants will receive $100 dollars and a $25 gift card for a local gas station.

If you have any questions, feel free to contact me at rjohnston@ku.edu. Additionally, you can contact my research advisor, Dr. Jane Wegner, at jwegner@ku.edu.

Thank you for your time,

Russell Johnston, M.A., CCC-SLP
Speech-Language Pathologist
Doctoral Candidate
Schiefelbusch Speech-Language-Hearing Clinic

Appendix D

Recruitment Flyer

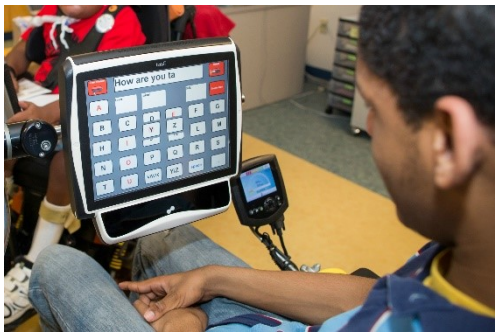
Improving Communication and Language for People Who Use AAC

Who is needed: People who use speech-generating augmentative and alternative communication (AAC) devices between the ages of 3-50.

What: A research study focused on teaching people to communicate with their AAC device during shared reading and gameplay.

When: The study is estimated to occur over 12 sessions during the months of February-April, with each individual session lasting roughly 45 minutes.

Where: The study will take place at the Schiefelbusch Speech-Language Hearing Clinic located on the University of Kansas Campus.



Why: Benefits for your family member may include increased competence using and navigating their device to communicate. Additionally, participants will receive $100 dollars and a $25 gift card for a local gas station for attending all 12 sessions.

People choosing to participate may withdraw at any time. If you do withdraw from this study, not participate in this study, or participate in this study, it will not affect your relationship with the Schiefelbusch Clinic, the services it may provide to you, or the University of Kansas.

If you are interested, please contact Russell Johnston at ***rjohnston@ku.edu*** *or Dr. Jane Wegner at* ***jwegner@ku.edu*** *for additional information*

This study is affiliated with the University of Kansas Department of Speech-Language and Hearing

Appendix E

Consent Form

Aided Language Input, Intensity, and Speech Generating Device Use

KEY INFORMATION

- This project is studying the effect that frequent language input may have on the use of speech generating devices.
- Your participation in this research project is completely voluntary.
- Your participation will take 9.5 hours across 12 days.
- You will be asked to do the following procedures:
    - Pre-intervention: Interview and completion of two questionnaires. This will take roughly 30 minutes to 1 hour.
    - Post-intervention: re-completion of one questionnaire that was given previously and completion of one anonymous survey. This is also estimated to take 30 minutes to 1 hour.
    - More detailed information on the procedures can be found below.
- There are no known risks or discomforts associated with this study.
- Benefits for your family member may include increased competence using and navigating their device to communicate. Additional benefits may include increased expressive language (i.e., larger vocabulary).
- Your alternative to participating in this research study is not to participate.

The Department of Speech Language and Hearing at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish your family member to participate in the present study. You may refuse to sign this form and not allow your family member to participate in this study. You should be aware that even if you agree to allow your family member to participate, you are free to withdraw at any time. If you do withdraw your family member from this study, it will not affect your relationship with the Schiefelbusch Speech-Language-Hearing Clinic, the services it may provide to you, or the University of Kansas.

PURPOSE OF THE STUDY

The purpose of the study is to investigate what amount of language modeling is the most effective to teach your family how to use their augmentative and alternative communication (AAC) device to communicate and build their language skills. When language modeling is used, the interventionist will supplement their spoken language with modeling of how to use the AAC

device to construct a message containing the important content words. For example, if the interventionist says, "The car is red", they may select the symbols CAR and RED on the device. This modeling can be incorporated into any activity and can target any function of communication, such as commenting on activities/events, describing what is happening, and/or labeling items in the environment.

PROCEDURES

Prior to the beginning the study, you will be interviewed about how your family member who uses a speech generating communication device currently communicates, the purposes they use communication for, and what their interests are. This will help collect information related to receptive/expressive language, speech sound production, adaptive and play behaviors, imitation skills, and vocabulary size. Additionally, you will complete the Communication Matrix in paper form with the primary interventionist present to answer any questions that may arise. Following the 10th intervention session, the Communication Matrix will be completed again in paper form with the interventionist present to answer any questions.

Lastly, the Test of Auditory Comprehension of Language fourth edition (TACL-4) will be administered prior to the initiation of the intervention and after completion of the 10 intervention sessions. The TACL-4 is a norm referenced test for children aged 3;0-12;11 that collects information on receptive language skills in the areas of vocabulary, morphology, and syntax. To participate in the completion of the TACL-4, the interventionist provides the person who uses AAC with a spoken sentence and the person who uses AAC chooses which picture matches the sentence provided by the interventionist. Administration time for the TACL-4 is 20-30 minutes.

This study consists 2 conditions: a low intensity condition and a high intensity condition. All sessions will be 45 minutes in length and will occur twice per week at a mutually agreeable time. Your family member will participate in both conditions. During a low intensity condition, I will provide your family member with device modeling in 33% of opportunities and in the high intensity condition I will provide your family member with device modeling in 99% of opportunities.

Low Intensity Condition

During the low intensity condition your family member and I will engage in a shared reading activity and play an age appropriate board and/or card game. During the shared reading and game play, I will model the use of the device in 33% of opportunities. This condition will take place randomly across all sessions and will constitute 1/3 of the sessions (5 sessions total). Sessions will take place in the Schiefelbusch Clinic at the KU campus at a time that is convenient to your family. While your family member and I are reading and playing the game(s) I will videotape the sessions and later analyze it for AAC use, such as number of times your family member uses their device and the number of different words or phrases they use.

High Intensity Condition

During this condition your family member and I will continue to engage in a shared reading activity and play an age appropriate board and/or card game. During the shared reading and game play, I will model the use of the device in 99% of opportunities. This condition will take place randomly across all sessions and will constitute 1/3 of the sessions (5 sessions). Sessions will take place in the Schiefelbusch Clinic at the KU campus at a time that is convenient to your family. While your family member and I are reading and playing the game(s) I will continue to videotape the sessions and later analyze it for AAC use, such as number of times your family member uses their device and the number of different words or phrases they use.

In total, the study is estimated to take approximately 9.5 hours across a period of 12 sessions. This includes 10 intervention sessions lasting 45 minutes (7.5 hours) and one pre-intervention session and one post-intervention session lasting roughly one hour in duration each, totaling 9.5 hours. The total time and number of sessions may change depending on unforeseen circumstances such as illnesses of the participants or severe weather. In the event your family member is unable to attend a session, an opportunity to reschedule will be available.

Video recordings will be taken during all sessions in each phase of the study. Your family member will be told before each session begins that to participate in the study it is 1) required that each session be video recorded, 2) that they will be video recorded during that session, and 3) that they have the option of stopping the recording at any time throughout the study. If they choose not to be video recorded they will not participate in the study.

During the study the video will only be used by the primary researcher and his faculty supervisor. The videos will be stored in a locked cabinet in the Schiefelbusch Speech-Language-Hearing Clinic when not in use. After the study is completed, the video will be stored in a de-identified manner for a period of 5-years for future data analysis. After 5 years have elapsed, the video will be destroyed in a manner consistent with University policy

RISKS

Minimal to no risks are anticipated.

BENEFITS

Benefits for your family member may include increased competence using and navigating their device to communicate. Additional benefits may include increased expressive language (i.e., larger vocabulary).

PAYMENT TO PARTICIPANTS

At the conclusion of this study, compensation is available to participants who attend 12 sessions. All 12 sessions have to be attended to receive compensation. Participants will receive $100 dollars. Additionally, a $25 gift card for a local gas station will be provided at conclusion of the study.

PARTICIPANT CONFIDENTIALITY

Your family member's name will not be associated in any publication or presentation with the information collected about your family member or with the research findings from this study. Instead, the researcher will use a pseudonym rather than your family member's name. Your family member's identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission.

Prior to initiation of the study, you will be asked to provide basic information about your family member in questionnaire form. Information to be collected includes your family member's age, grade, type of device, and the length of time they have had their device. Additionally, you will be interviewed about how the person who uses speech generating communication devices currently communicates, the purposes they use communication for, and what the person's interests are. Lastly, the Test of Auditory Comprehension of Language fourth edition (TACL-4) will be administered to your family member prior to the initiation of the intervention and after completion of the 10 intervention sessions. The TACL-4 is a test that provides information on receptive language skills in the areas of vocabulary, morphology, and syntax. To participate in the completion of the TACL-4, the interventionist provides your family member who uses AAC with a spoken sentence and the person who uses AAC chooses which picture matches the sentence provided by the interventionist by pointing to a picture or using eye gaze. Administration time for the TACL-4 is 20-30 minutes. Additionally, after completion of the 10 intervention sessions, you will be interviewed again about your family member's communication and language skills.

Permission granted on this date to use and disclose your information remains in effect indefinitely. By signing this form you give permission for the use and disclosure of your family member's information, excluding your family member's name, for purposes of this study at any time in the future.

PRIVATE INFORMATION (DATA)

Your identifiable information may be removed from the data collected during this project, and the de-identified data will be used for future research without additional consent from you.

REFUSAL TO SIGN CONSENT AND AUTHORIZATION

You are not required to sign this Consent and Authorization form and you may refuse to do so without affecting your right to any services you are receiving or may receive from the University of Kansas or to participate in any programs or events of the University of Kansas. However, if you refuse to sign, your family member cannot participate in this study.

CANCELLING THIS CONSENT AND AUTHORIZATION

You may withdraw your consent to allow participation of your family member in this study at any time. You also have the right to cancel your permission to use and disclose further information collected about your family member, in writing, at any time, by sending your written request to:

Russell Johnston
Dept. of Speech-Language-Hearing
2101 Haworth Hall
University of Kansas, Lawrence, KS 66045

If you cancel permission to use your family member's information, the researchers will stop collecting information about your family member and destroy data collected.

QUESTIONS ABOUT PARTICIPATION

Questions about procedures should be directed to the researcher(s) listed at the end of this consent form.

PARTICIPANT CERTIFICATION:

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study. I understand that if I have any additional questions about my family member's rights as a research participant, I may call (785) 864-7429, write to the Human Research Protection Program Lawrence Campus (HRPP), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7568, or email irb@ku.edu.

I agree to allow my family member to take part in this study as a research participant. By my signature I affirm that I am at least 18 years old and that I have received a copy of this Consent and Authorization form.

_____ _____

Type/Print Participant's Name Date

_____

Parent/Guardian Signature

[If signed by a personal representative, a description of such representative's authority to act for the individual must also be provided, e.g. parent/guardian.]

Researcher Contact Information

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Principal Investigator
Dept. of Speech-Language-Hearing
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University of Kansas
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Jane Wegner, Ph.D., CCC-SLP
Faculty Supervisor
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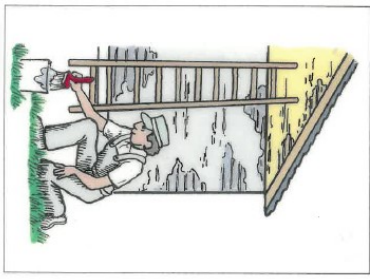
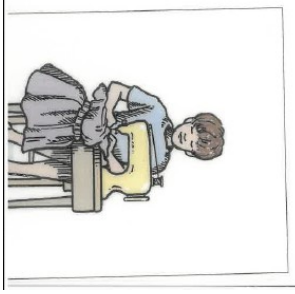
2101 Haworth Hall
University of Kansas
Lawrence, KS 66045
(785) 864-4690
jwegner@ku.edu

Appendix F

Modified TACL-4 Example





Appendix G

Play Menu

Appendix H

Sample Transcript

$ Child, Examiner Parent
+ Language: English
+ ParticipantId: Alpha
+ Name: Charlie
+ Gender: M
+ Context: play
+ Session 2
- 0:00
E It's nice to see you, cause I like to see you.
E There are different things to play with if you want to play [ALI_youwant].
C [DA_putting].
E Putting?
E Maybe, something that you want to do.
E Oh.
E you want to play with some more monkeys [ALI_youwantmore].
E I'm going to put that right there [ALI_putting].
E And you can have one of these of these [ALI_youcanhave].
E Sound OK to you [ALI_OK]?
E Alright I get to go [ALI_mego].
E Let's Put that right on there [ALI_that].
E Now you can go [ALI_yougo].
E You're helping me [ALI_help].
E Do you want some more help [ALI_youwant].
E Oh more help [ALI_morehelping].
E I could help you [ALI_help].
E Do this activity with you [ALI_do].
E Russell put one monkey on the bed.
E One fell off and bumped his head[ALI_put].
E Can you help me knock him off [ALI_help]?
E YES.
E Took him to the doctor and the doctor said, that you should not put monkeys and let them jump on the bed [ALI_put].
E You want what [ALI_youwantwhat]?
E More help [ALI_morehelping]?

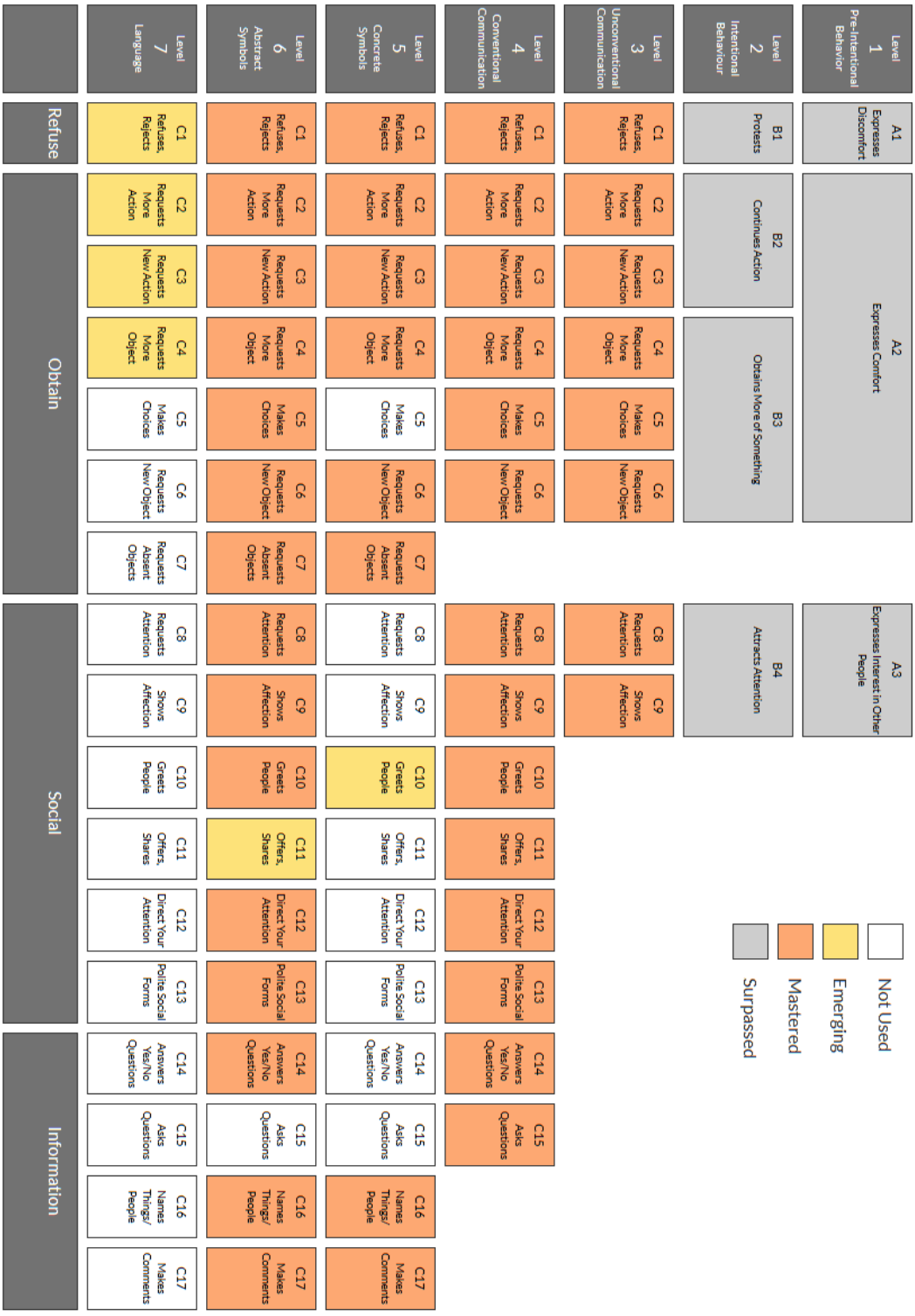
Appendix I

Sample Questions from Survey

#	Question	Question type
1	I have noticed a change in how my family member tells me what they want, what they are thinking, or how they feel since the study began.	1 – Strongly disagree 2 – Disagree 3 – Neither agree or disagree 4 – Agree 5 – Strongly agree
2	I have noticed a change in the words and phrases my family member uses since the beginning of the study.	1 – Strongly disagree 2 – Disagree 3 – Neither agree or disagree 4 – Agree 5 – Strongly agree
3	My family member uses their AAC device more frequently at home/in the community.	1 – Strongly disagree 2 – Disagree 3 – Neither agree or disagree 4 – Agree 5 – Strongly agree
4	I feel confident that I can provide aided language input to my family member.	1 – Strongly disagree 2 – Disagree 3 – Neither agree or disagree 4 – Agree 5 – Strongly agree
5	I am pleased with the outcomes of the study.	1 – Strongly disagree 2 – Disagree 3 – Neither agree or disagree 4 – Agree 5 – Strongly agree

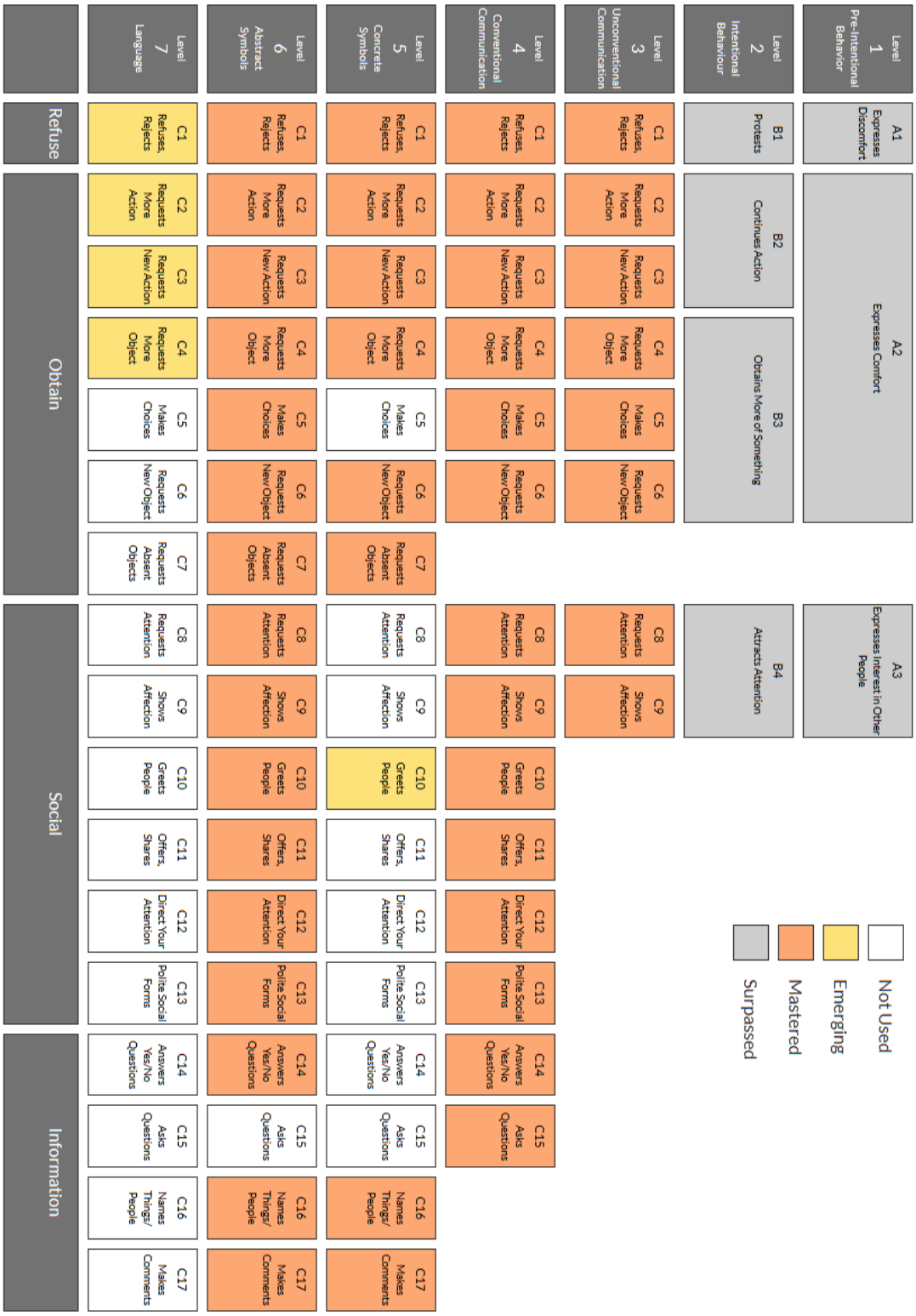
Appendix J

Pre-Intervention Communication Matrix Results: Charlie



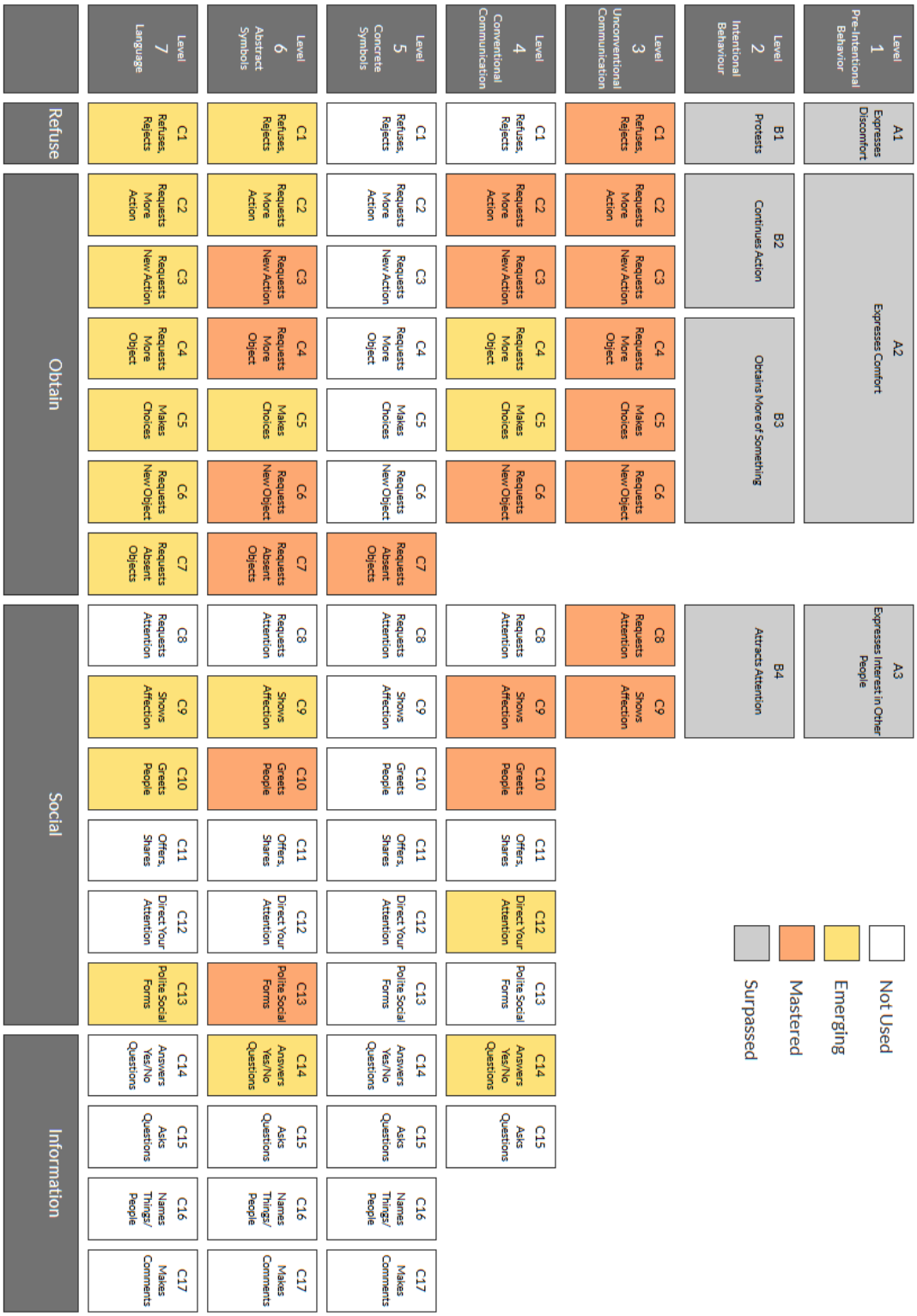
Appendix K

Post Intervention Communication Matrix Results: Charlie



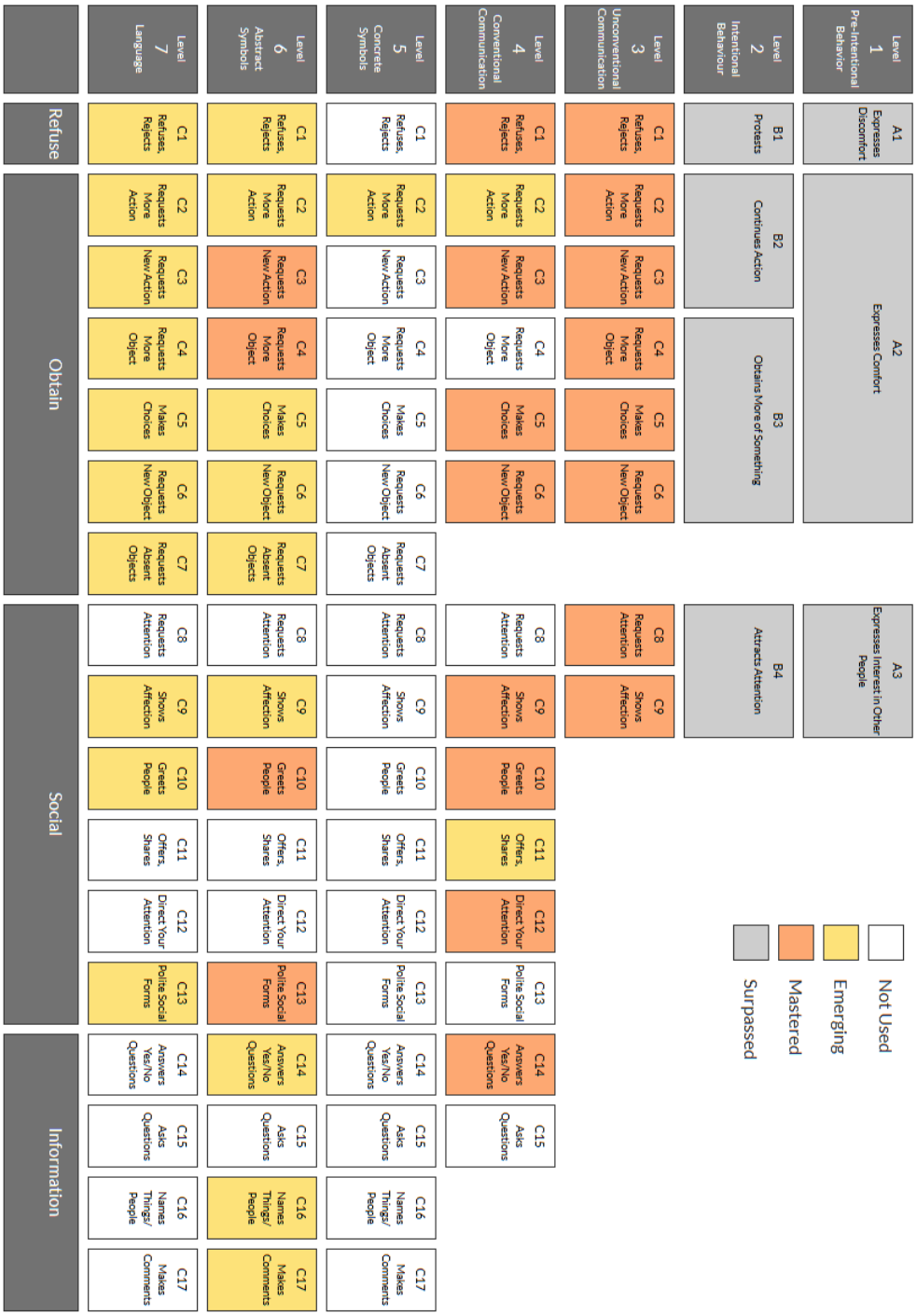
Appendix L

Pre-Intervention Communication Matrix Results: Frank



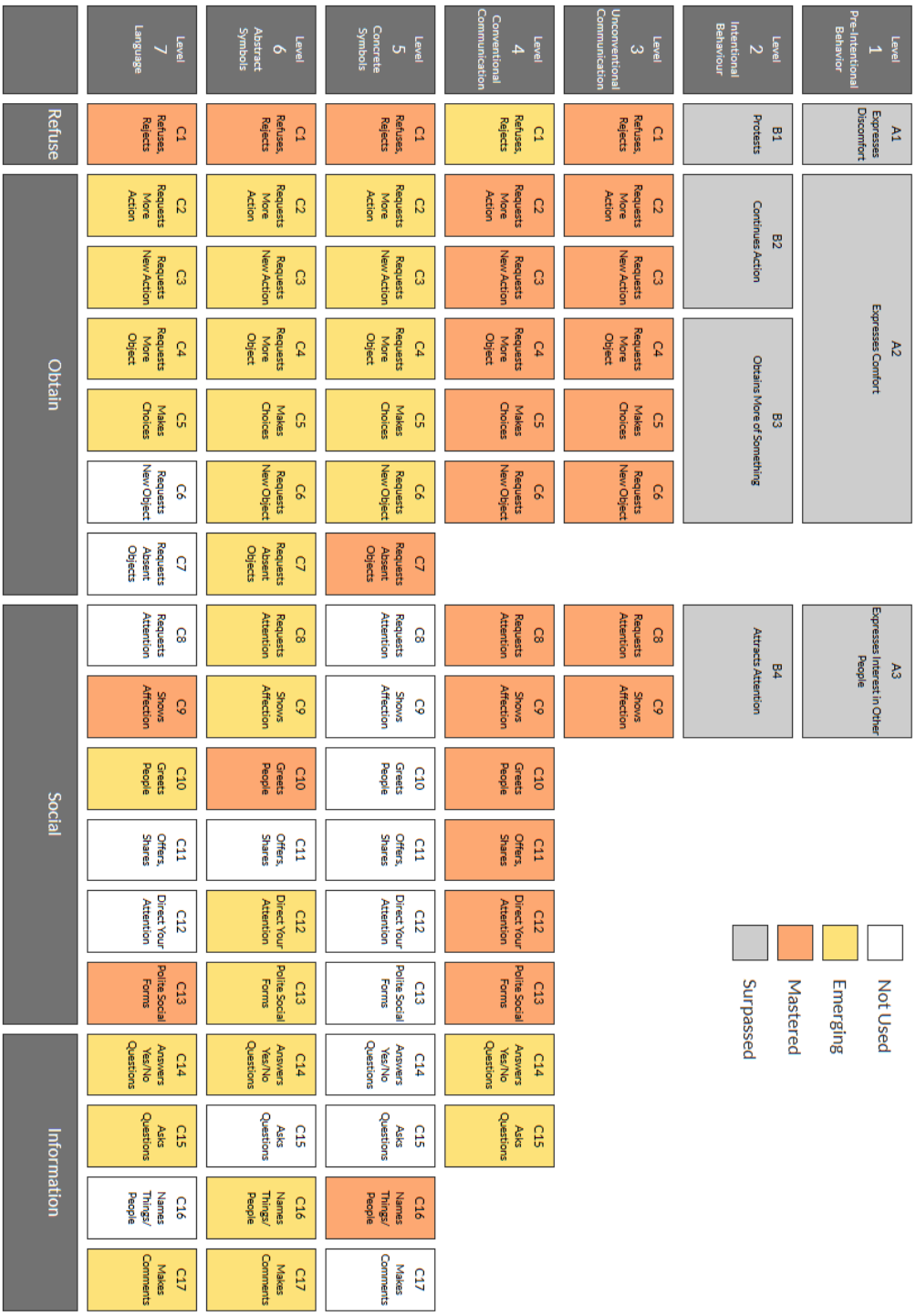
Appendix M

Post Intervention Communication Matrix Results: Frank



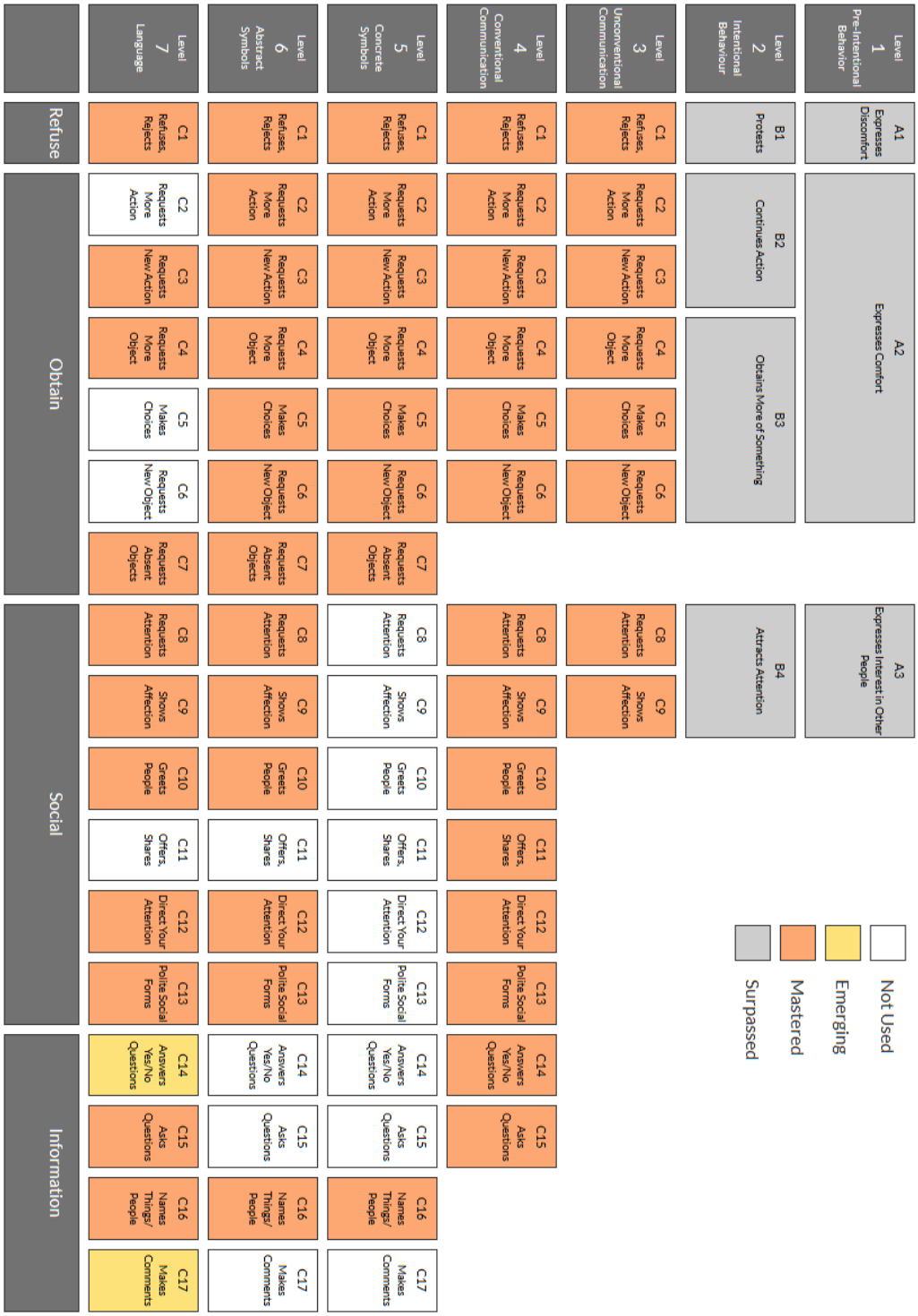
Appendix N

Pre-Intervention Communication Matrix Results: Dennis



Appendix O

Post Intervention Communication Matrix Results: Dennis



Appendix P

Communication Matrix: Seven Levels of Communication

#	Type	Description
1	Pre-Intentional	The child's behavior is not under his own control – but it reflects his general state (such as hungry or wet or sleepy). Parents interpret the child's state from his general behaviors, such as body movements, facial expressions and sounds.
2	Intentional	The child's behavior is now intentional (under the child's control), but she does not understand that "If I do this, Mom or Dad will do that for me"– in other words she does not communicate intentionally yet. Parents continue to interpret the child's needs and desires from her behavior, such as body movements, facial expressions, vocalizations and eye gaze.
3	Unconventional	The child uses pre-symbolic behaviors intentionally to express his needs and desires to other people. The behaviors used to communicate are pre-symbolic because they do not involve any sort of symbol. They are called "unconventional" because they are not socially acceptable for us to use as we grow older: they include body movements, vocalizations, facial expressions and simple gestures (such as tugging on people).
4	Conventional	The child uses pre-symbolic behaviors intentionally to express her needs and desires to other people. The behaviors used to communicate are pre-symbolic because they do not involve any sort of symbol. "Conventional" gestures include behaviors such as pointing and nodding the head "yes". The meanings of these gestures are determined by the specific culture in which they are used. We continue to use conventional gestures as adults to accompany our language. Note that many of these gestures (and especially pointing) require good visual skills and may not be appropriate for children with severe vision impairment.
5	Concrete Symbols	The child uses what we call "concrete" symbols that physically resemble what they represent in a way that is obvious to the child—they look like, feel like, move like or sound like what they represent. Concrete symbols include picture symbols, objects used as symbols (such as a shoelace to represent "shoe"), certain "iconic" gestures (such as patting a chair to say "sit down") and sounds (such as making a buzzing sound to refer to a bee). Children with severe physical impairments may access picture and object symbols through the use of a mechanical device or by pointing, touching or eye gaze. Note that children who are already able to use abstract symbols (Level VI) do not need to use concrete symbols: most children skip this stage. For some children who have not learned to use abstract symbols, however,

		concrete symbols (Level V) may serve as a bridge to using abstract symbols (Level VI).
6	Abstract Symbols	The child uses abstract symbols such as speech, manual signs, or Brailed or written words. These symbols are NOT physically similar to what they represent. They are used one at a time.
7	Language	The child combines symbols (any sort of symbols) into ordered two- or three-symbol combinations ("want juice", "me go out"), according to grammatical rules. The child understands that the meaning of word combinations may differ depending upon how the symbols are arranged.

Adapted from Communication Matrix (2011)