Effects of a Conversation-based Intervention on the Linguistic Skills of Children with Motor Speech Disorders who Use Augmentative and Alternative Communication

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Abstract

Purpose: This study was conducted to evaluate the effects of a conversation-based intervention on the expressive vocabulary and grammatical skills of children with severe motor speech disorders and expressive language delay who use augmentative and alternative communication (AAC).

Methods: Eight children aged from 8 to 13 participated in the study. After a baseline period, a conversation-based intervention was provided for each participant where they were supported to learn and use linguistic structures essential for the formation of clauses and the grammaticalization of their utterances, such as pronouns, verbs, and bound morphemes, in the context of personally meaningful and scaffolded conversations with trained clinicians. The conversations were videotaped, transcribed and analyzed using the Systematic Analysis of Language Samples.

Results: Results indicate that participants showed improvements in their use of spontaneous clauses, and a greater use of pronouns, verbs, and bound morphemes. These improvements were sustained and generalized to conversations with familiar partners.

Conclusion: The results demonstrate the positive effects of the conversation-based intervention for improving the expressive vocabulary and grammatical skills of children with severe motor speech disorders and expressive language delay who use AAC. Clinical and theoretical implications of conversation-based interventions are discussed and future research needs are identified.

Effects of a Conversation-based Intervention on the Linguistic Skills of Children with Motor Speech Disorders who Use AAC

For children who have little or no intelligible speech as a consequence of severe motor speech disorders (MSDs), the use of augmentative and alternative communication (AAC) systems can prove invaluable in supporting and developing language and communication abilities (Clarke & Price 2012; Sutton, Soto & Blockberger, 2002). AAC refers to any form of communication that supplements or replaces natural speech. This may include 'unaided' aspects of communication such as the use of kinesic modalities, as well as the use of 'aided' communication resources such as communication books or charts, and communication technologies like speech generating devices (SGDs). SGDs are electronic communication aids with synthesized speech output capabilities that can permit the storage and retrieval of thousands of words and phrases.

Many children with severe MSDs are known to experience significant delays in their language development, in particular in relation to their expressive vocabulary and production of grammatically complete utterances, even when provided with AAC (Binger & Light, 2008). There are a number of intrinsic and extrinsic factors that, in combination, are proposed to be associated with their expressive language delays including children's limited exposure to language learning opportunities and the long term restricted patterns of interpersonal interaction (Sutton et al., 2002). In brief, marked asymmetries are consistently observed in the number and type of contributions made by children and their naturally speaking partners during naturally occurring conversations. The use of question-answer exchanges is a primary way in which theses children's contributions to conversation are 'co-constructed' (Clarke & Wilkinson, 2007; Solomon-Rice & Soto, 2011;); that is, where the contributions of children via aided and unaided

forms, which are overwhelmingly characterized by the use of single word responses to others' initiations, are developed and expanded gradually over a sequence of turns. For instance, in the following example the child uses her SGD to provide single word responses to adult questions and comments: Adult: I see you have a tattoo in your arm, where did you get that?; Child: *party*; Adult: you went to a party; Child: *yes*; Adult: oh whose party was it? Child: *Fatima*; Adult: you went to Fatima's party. Was it Fatima's birthday party? Child: *yes*; Adult: did you all go somewhere special? Child: *home;* Adult: the party was at her home?; Child: *yes*; Adult: So it was Fatima's birthday and she had a party at her home, and you got a tattoo there; Child: *yes*.

Sequences such as these are also observed in conversations between adults and young typically developing children (Scollon, 1976). In the context of those interactions, co-construction of child contributions involving scaffolding of child language (e.g. through immediate exposure to enhanced language forms provided by adults as illustrated in the example above) is considered a major language learning facilitator for children (Scollon, 1976). As typically developing children mature, they incorporate the grammatical constructions that they have heard and learned into their own expressive language. As the length of their utterances increases, the range of grammatical structures that children use in their utterances also increases in complexity. However, for children with expressive language delays who use AAC, these early, naturally occurring, patterns of everyday interaction commonly persist into adulthood, and would appear not to support language development in the same way as they do for typically developing children. In fact, these children tend to use mostly nouns in single word utterances or short grammatically incomplete messages that lack morphological and syntactic elements, such as verbs, prepositions, pronouns and articles, even when these are available on their communication devices (Binger & Light, 2008; Soto & Hartmann, 2006; Sutton et al., 2002).

There is now a large body of research that reports positive effects of employing verbal scaffolding procedures within *conversation-based interventions* on language skills development in children with communication disorders who are not users of AAC systems, including children with autism (Scherer & Olswang, 1989), specific language impairment (Camarata & Nelson, 2006; Nelson, et al., 1996; Plante et al., 2014), language learning disabilities (Stiegler & Hoffman, 2001) and language delay (Ruston & Schwanenflugel, 2010). In these interventions, verbal scaffolding procedures are delivered by an adult immediately after a child produces an utterance that is incomplete, immature or ungrammatical, and that provides an opportunity for presentation of an enhanced version of the target form (Eisenberg, 2013, 2014). Scaffolding techniques afford the child opportunities to hear the target form being used in a meaningful way, and to contrast his or her own utterance with a more complex or grammatically correct one.

While evidence exists for the facilitative effect of adult verbal scaffolding during conversations for children with a wide range of language disorders, this approach has not been systematically investigated for children with severe MSDs and expressive language delay who use AAC. The purpose of the current study was to investigate the impact of adult scaffolding within a conversation-based intervention on the expressive vocabulary and grammatical skills of children in this group. The study examined changes in the participants' use of linguistic structures that are essential to the formation of early clauses, such as verbs, pronouns and bound morphemes, and whether gains made in intervention were generalized and sustained.

Method

Experimental Design

A multiple probe design across participants (Gast & Ledford, 2010) was used to examine the effect of a conversation-based intervention on the expressive vocabulary and grammatical

skills of 8 children with severe MSDs and expressive language delay who use AAC. The study design is a variation of a multiple baseline design in which baseline data are probed at different points in time rather than monitored continuously. After a period of baseline measurement, intervention was applied sequentially to 4 participants (Set A) who were randomly assigned to intervention order. Intervention for the 2nd, 3rd, and 4th participant started after the preceding individual had demonstrated sustained improvement over 3 consecutive intervention sessions (see description below) (Gast & Ledford, 2010). Once the participant to receive intervention demonstrated an improvement in production of the experimental control variable (i.e., production of spontaneous clauses) of at least 25 % over baseline levels for three consecutive intervention sessions, intervention began for the next participating child. To examine the generalizability of the findings, intervention procedures were replicated across a second set of four older participants (Set B).

Subjects

Participating children. Eight children (3 girls and 5 boys) were selected to participate in the study and met the criteria that they: (a) were between the ages of 8 and 14 yrs; (b) used a high-tech speech generating device (SGD) with software allowing for grammaticalization of utterances; (c) demonstrated functional communicative competence at Level III on *the Augmentative and Alternative Communication Profile* (AACP) (Kovach, 2009)[1];(d) used a form of direct selection techniques to formulate their messages (e.g., touching the SGD screen); (e) had English as their dominant language; (f) communicated mostly through single word utterances with little evidence of grammaticalization in unstructured interaction; (g) presented with hearing and vision within normal limits, with or without correction; (h) presented with a severe motor speech disorder (Duffy, 2013) which affected their ability to speak intelligibly; (i)

had minimal functional speech with an intelligibility score of less than 50% on the Index of Augmented Speech Comprehensibility in Children to familiar partners in unknown contexts (Dowden, 1997); (j) had no diagnosis of intellectual impairment according to their educational and clinical records; and (k) attained age equivalent scores on measures of receptive language skills of at least 6 yrs of age and above. Child characteristics are presented in Table 1.

Insert Table 1 about here

Participants were administered a battery of tests to document their receptive language skills (see Table 1). All testing was conducted in English as this was the dominant language for all children. Participants' age equivalent scores for single word receptive vocabulary were lower than their chronological age, and their performance on the comprehension of grammatical morphemes was extremely poor across all participants. Given their age equivalent scores for single word receptive vocabulary the children should, in theory, have been using grammatically complete sentences quite competently. However, school records reported that the participants were nonverbal or minimally verbal and communicated mostly through unaided means of communication (e.g., facial expressions, vocalizations, eye gaze, and pointing) and device generated single word utterances consisting mostly of nouns. These observations were confirmed during baseline and pre-intervention generalization sessions. Formal tests of cognition were not administered. All children attended programs designed for children with AAC needs in urban public schools, and used their own SGD during the study.

Procedures

Setting. Ten graduate student clinicians participating in clinical training at a local University conducted baseline and intervention sessions. The student clinicians were enrolled in a grant-supported Masters level program in Speech Language Pathology with an emphasis in

AAC. All student clinicians had completed two seminar courses in AAC; two 180-hour practica in schools and off-campus clinics serving students with AAC needs; a one week hands-on summer camp for children who use AAC, and two on-campus AAC clinics. As part of their graduate training, the student clinicians had received extensive clinical training on the use of responsiveness and language elicitation techniques such as the use of open-ended questions, conversational recasting (i.e., grammatically correct reformulation of a child's utterance), provision of vocabulary models (i.e., presentation of a target prior to the child's utterance), and use of oral cloze procedures.

The language testing and all the experimental sessions (baseline, intervention, and generalization) were completed in a quiet area at each child's school (e.g., therapy room or unoccupied library), except in the case of Julian who completed part of his sessions at home due to scheduling conflicts.

Materials. Parents and teachers of study participants provided photographs of the children at recent events such as birthday parties, field trips and family outings. These photographs were used during intervention to help the child choose a preferred topic of conversation. However, at different points during intervention, some participants declined to talk about the events in the photographs, and, at their own request, used other visual props such as picture books, video game catalogues, iPad Apps and video clips. Intervention procedures remained identical across different classes of visual prop (see Supplementary Material 1).

Baseline Assessment. During baseline sessions the participating children met with a student clinician and engaged in a 30-40 min conversation about a mutually agreed topic of personal relevance to the child, such as family, vacations, favorite activities and so on. Throughout these conversations the clinicians used appropriate conversational responses such as

open-ended questions, expectant pause, verbal redirection and contingent queries to stimulate the conversation (e.g., King, Hengst, & DeThorne, 2013). However, during baseline condition, clinicians were not permitted to use any therapeutic technique such as gestural or verbal prompts, aided modeling (modeling of the AAC system use), explicit instruction, or any form of corrective feedback; that is, during baseline conditions, clinicians did not acknowledge correct or incorrect production, or use any correction procedures to shape the participants' productions. Baseline sessions were conducted before clinicians received intervention training and served to establish children's profiles of expressive language skills in conversational interaction. Each participant completed 5 baseline sessions to determine stability/variability of measured skills. Following Gast and Ledford (2010), thresholds for acceptable baseline variability were determined by dividing the mean frequency of the observed language skill (e.g., mean number of verbs used across 5 data points) by 2, and adding and subtracting that figure to/from the mean (mean/2 + or - mean). Baselines were considered stable when the last 3 baseline points fell within that range (Gast & Ledford, 2010).

Generalization Probes. As recommended by Schlosser and Lee (2000), generalization probes were conducted throughout all phases of the study for each participant: (i) at least once prior to the start of intervention, (ii) every six intervention sessions, and when possible (iii) at two, four and eight week-intervals post intervention. These probes consisted of a conversation between each child and one member of the child's educational team. Mateo and Dante conversed with their respective special education teachers; Carmen and Geli with their AT/AAC specialists; Jesse, Joe, and Kareem with their instructional assistants; and Julian with his older adult sister (all child names are pseudonyms). Each child had the same conversation partner across all generalization probes. The adults were masked to the procedures of the intervention, and

received no instructions on how to talk to the child, or what to talk about. The conversations were about topics both the child and the adult agreed on and typically lasted between 30-40 mns. Therefore, these generalization probes occurred under conditions that were different from those of baseline and intervention sessions.

Training of Clinicians. Once the baseline sessions were completed, the clinicians received specific information about the intervention procedures. Because the training procedures were relatively straightforward and the clinicians had received extensive training in AAC discourse-based intervention during their clinical AAC program, a 40-50 min session was typically sufficient to complete the training procedures with the clinicians. Training included both verbal instructions by the first author and video models of child productions and appropriate clinical responses. The clinicians were also provided with a procedural checklist, which included intervention steps and strategies. Clinicians reviewed the checklist before each session. Clinicians worked with the participants either in baseline or treatment stages. That is, no clinician was simultaneously working in baseline with one participant while working in intervention with another.

Intervention. The targets of our intervention were key linguistic structures essential to early clause formation and grammaticalization which include, verbs, pronouns, bound grammatical morphemes (e.g., third person –s, plural –s, past –ed, and present progressive –ing), and other frequently used words such as prepositions, articles, adjectives, and adverbs (see Supplementary Material 1). For children with severe MSDs and expressive language delay who use AAC, becoming fluent users of structural language components (i.e., pronouns, articles, verbs) and bound grammatical morphemes is an intervention priority because these not only form the basis of English language but also have high combinatorial power and are essential to

grammaticalization (Smith, 2015). Occasionally, the clinician also modeled words that were child-specific and relevant to the conversation (e.g., *prince, handsome*). This approach is supported by reported association between individualized adult input in response to the child's initiations, and linguistic gains in children with communication disorders (see Hadley et al., 2011; Camarata & Nelson, 2006; Nelson et al., 1996; Warren, Fey & Yoder, 2007).

During intervention a student clinician met individually with each child twice a week, with each session lasting between 40-50 minutes (e.g., Ruston & Schwanenflugel, 2010). Each session consisted of a conversation between the clinician and the child. The clinician first presented the child with 3 photographs depicting the child at 3 different events, such as a birthday party, a field trip or a vacation. The clinician then asked the child to choose a photograph he or she wanted to converse about and describe the event depicted. Upon receiving a response (e.g. "party"), the clinician elicited further information (e.g., using who, where, what questions).

The clinician then recast the child's responses into a grammatically correct sentence and followed the recast with explicit instruction and prompts (verbal and gestural) for the child to reformulate his or her original utterance. When the child produced the target response, the clinician used positive remarks to comment on the child's appropriate use of complete sentences, and continued the conversation with a contingent comment or question to encourage further communication (see sample interaction in Supplementary Material 1) (Camarata & Nelson, 2006; Eisenberg, 2013; Ruston & Schwanenflugel, 2010). At each session the participants were presented with new photographs unless the participants explicitly requested to continue a topic they had chosen at an earlier session.

During each session, the clinician delivered a minimum of 10 intervention episodes

(question + recast + prompt), and targeted at least 5 words and 2 bound morphemes not observed during baseline. Since many of the vocabulary targets were part of a limited set (i.e., personal pronouns, copula, prepositions, frequently used verbs), some of the same words (e.g. my, was, go, went, like, get) were practiced across multiple sessions providing for natural redundancy (Rice & Wilcox, 1995).

Intervention was provided at a rate of twice a week for 12 weeks for up to 24 sessions. The length, frequency and total number of sessions was chosen to reflect the average number of sessions children with significant communication disorders are likely to receive when attending intensive discourse-based language intervention programs in the USA (cf. McGregor, 2000; Ruston & Schwanenflugel, 2010).

Data Analysis

Fidelity. Clinicians read a procedural checklist before each baseline and intervention session to remind them of study procedures, and they rated the extent to which they felt they had implemented the procedures after each session, (e.g., Gillam et al, 2015). Throughout baseline and intervention, the lead author also observed every fourth session to determine clinicians' compliance with the implementation of procedures, including comparing the clinicians' behavior against the procedural checklists. If clinicians fell below 85% compliance for any session (which happened infrequently and only at the beginning of the intervention phase), they were provided with written feedback about the step(s) that were omitted. If written feedback was not sufficient for the clinician to adhere to intervention procedures, the lead author met with the clinician and provided verbal feedback, while jointly reviewing the videotape of the session when necessary. In most cases, written feedback was sufficient to return the clinician to 100% compliance with intervention procedures.

In addition, two independent observers viewed 20% of randomly selected videotaped baseline and intervention sessions per child and rated clinician performance against the procedural checklists. Clinician compliance with procedures ranged from 88%-100%. The delivery of intervention episodes occurred at an average of 15 per session (range=8-18). Inter-rater reliability was estimated by calculating the Cohen's Kappa, which yielded a score of 0.94.

Transcription and Coding. All baseline, intervention sessions and generalization probes were videotaped and transcribed using the format and transcription conventions required for analysis via the Systematic Analysis of Language Transcripts program (SALT, Miller & Chapman, 1990). Research assistants trained in transcription of multimodal AAC and masked to the phases, procedures and purposes of the study transcribed each session. Intelligible verbalizations, the gloss of conventional manual signs and device-generated utterances were included in the transcription and analysis. Participants' device mishits and unintentional repetitions were not included. Adults' contributions to the conversation were also transcribed but not analyzed for the purposes of this study.

Reliability. Several steps were taken to ensure that the transcripts and results were accurate. Two separate independent observers transcribed and coded 25% of randomly selected video data across all phases of the study. They viewed the sessions in randomized order and were masked to the procedures of the different study phases. Transcription discrepancies were resolved through both independent transcribers identifying transcript differences, viewing discrepant utterances and reaching consensus on form (Kovacs & Hill, 2015). Inter-judge consensus was achieved for all discrepancies. SALT^{TM} automatically coded and calculated number of verbs, pronouns, and bound morphemes from the final agreed transcript. Inter-rater reliability for the coding of spontaneous clauses was established by calculating the Koehn's

Kappa coefficient. Assuming 0.5 as the probability of chance agreement, a Kappa coefficient of 0.96 was calculated, indicating excellent agreement.

Dependent Measures. The children's language samples were analyzed for the rate of use of verbs, pronouns, bound morphemes and spontaneous clauses within a 60-minute observation period. These represent a variety of morpho-syntactic structures that are essential to early clause formation and typically used to assess grammatical development in children (see Manhardt & Rescorla, 2002; Thordardottir, Chapman, & Wagner, 2002). As a child's language develops, the number of clauses produced during discourse increases (Scott and Stokes, 1995). Rate was used to convert the target behavior counts to a constant scale since observation times varied slightly across sessions (Gast, 2010). A spontaneous clause was defined as a basic sentence containing a subject, a verb and a predicate, that was capable of functioning alone, even if missing the article or another part of speech (e.g., I have doctor appointment; I want pet rabbit), and was produced as an initiation or in response to a preceding question or contingent comment, and not following an imitative prompt.

Visual and Statistical Analysis. The analysis of the baseline probes, intervention sessions, and generalization probes was conducted visually and statistically. The visual analysis was based on inspection of the plotted data, which has traditionally been the primary method to determine whether there is a functional relation between the independent and dependent variables, and the magnitude of any such relation (Kratochwill, Hitchcock, Horner, Levin, Odom, Rindskopf & Shadish, 2010; Gast, 2010; Kennedy, 2005). As recommended by leading Single Subject Researchers and adopted by the Federal What Works Clearinghouse (Kratochwill et al., 2010), visual analysis involved the examination of within and between-phase data patterns across six variables: (i) mean scores for data within each phase (commonly referred to as *level*);

(ii) *trend* of the data across baseline and intervention phases, including analysis of *stability* of change; (iii) variability of data within each phase; (iv) *overlap* in the data points between baseline and intervention phases; (v) *immediacy* of effect; and (vi) *consistency* of data patterns across phases and participants.

Effect size estimates were calculated using 'non-overlap' procedures. While a number of non-overlap procedures are available, a recent review by Rakap, Snyder and Pasia (2014) recommended the combined use of Tau-U (Parker, Vannest, Davis, & Sauber, 2011), and calculation of improvement rate difference (IRD; Parker, Vannest & Brown, 2009). Both measures are suitable for AB designs, are non-parametric so do not require data assumptions associated with parametric tests, and have proposed benchmarks for evaluating size of intervention effect. Both procedures also allow for the calculation of confidence intervals. The Tau-U is drawn from Kendall's Rank Correlation and the Mann-Whitney U-Test between groups and, essentially, considers pair wise comparisons of data points between and within phases to quantify the extent of non-overlap between the baseline and intervention and trend within the intervention phase. It can also control for positive baseline trend. An IRD represents the difference between improvement rates (IRs) in baseline and intervention. The IR is calculated by dividing the number of "improved data points" (Parker et. al., 2009) in a phase by the total number of data points in that phase. Improved data points in baseline are defined as being equal to or greater than any data point in intervention. During the intervention phase, data points are considered improved if they exceed all data points in baseline. The IRD is represented by the difference between the two IRs. The Tau-U and IRD were obtained for each child for each dependent measure. An online calculator (www.singlecaseresearch.org) was used to calculate the Tau-U and the IRD was calculated by hand. Given the applied clinical focus of the study, and

following Parker et al. 2009, confidence intervals were set at 85% for both measures. Confidence intervals for the Tau-U were calculated online, and for the IRD they were calculated using the two proportions test (with bootstrapping) with NCSS software (Parker et al., 2009).

Results

Visual and statistical analyses of the data indicate that all participants demonstrated a very limited use of verbs, pronouns, bound morphemes and almost no spontaneous clauses during baseline sessions. The use of all four linguistic measures increased for all participants during intervention sessions and was generalized and maintained above pre intervention levels once the intervention had ended. The rate of production of verbs, pronouns, bound morphemes and spontaneous clauses used by the participants in Set A (Carmen, Geli, Joe and Dante) and Set B (Jesse, Mateo, Julian and Kareem) during baseline, intervention and generalization probes are shown in Figures 1-8.

Insert Figures 1-8 around here

Visual inspection of the figures suggests that experimental control was maintained for all dependent variables across both sets of participants, as increases of these variables were not observed until the intervention procedures were implemented. Mean values for Baseline and Intervention sessions are presented in Table 2. Mean values from generalization probes prior, during and post intervention are presented in Table 3. A summary of the results follows.

Insert tables 2 and 3 about here

Participants Set A

Carmen. Carmen's use of all four linguistic measures increased during intervention as indicated by the change in means between baseline and intervention sessions (change in means: verbs=62.1, pronouns=46.6, bound morphemes=58.3, and spontaneous clauses=4.5). Carmen

also generalized her use of all linguistic targets, as indicated by a change in means between pre-intervention and during intervention probes (verbs=71.7, pronouns=22.1, bound morphemes=29, spontaneous clauses=10). Her gains were sustained above pre-intervention levels, and in the cases of bound morphemes and spontaneous clauses continued to grow after the intervention had ended.

Geli. Geli's use of all linguistic targets also increased between baseline and intervention (change in means: verbs=55.6, pronouns=43.4, bound morphemes=51.4, spontaneous clauses=8.5). She also showed consistent generalization of skills across all dependent measures during the intervention phase (change in means: verbs=37.1, pronouns=31.7, bound morphemes=36.9, and spontaneous clauses=4.9). Although her scores decreased slightly after intervention had concluded, they all stayed above pre-intervention scores (see Table 3).

Joe. Joe's change in means between baseline and intervention was 32.5 for verbs, 31.6 for pronouns, 4.8 for bound morphemes, and 3.5 for spontaneous clauses. While his gains took a little longer to generalize (see Figures 1-4), he demonstrated generalization of all linguistic targets as indicated by a change in means between pre-intervention and during intervention probes (verbs=33.3, pronouns=24.5, bound morphemes=2.5, spontaneous clauses=3.2). His use of verbs, bound morphemes and spontaneous clauses continued to increase post intervention as shown in Table 3. The rate of use of pronouns decreased slightly but remained above pre intervention levels.

Dante. Dante participated in only 6 intervention sessions due to an unexpected relocation. Nevertheless, he demonstrated increases in the use of all linguistic measures during intervention (change in means: verbs=32.1, pronouns =17.7, bound morphemes =13.5, spontaneous clauses=3.4). He also participated in 2 generalization probes, 1 prior to and another

during intervention. He showed generalization of all dependent measures as indicated by changes in means of 19.2 for verbs, 21.6 for pronouns, 4.8 for bound morphemes, and 7.2 for spontaneous clauses.

Participants Set B

Jesse. During intervention, Jesse showed an increase in the use of all dependent measures (change in means: verbs=42.9, pronouns=55.4, bound morphemes=24.2, spontaneous clauses=8.2). As shown in Table 3, Jesse showed consistent generalization of skills across all dependent measures during the intervention phase (change in means: verbs=35.9, pronouns=20.4, bound morphemes =6.5, and spontaneous clauses=10). Her use of verbs continued to increase after intervention had ended. For the remaining dependent measures, the rate of use decreased slightly (see Figures 5-8) but the rate of production of these structures was higher than pre intervention levels as seen in Table 3.

Mateo. Mateo showed an increase in the use of all linguistic measures once he started intervention (change in means from baseline to intervention: verbs=40.7, pronouns=43.8, bound morphemes=26.6, spontaneous clauses=5.4). These gains were generalized during the intervention phase (change in means: verbs= 44.5, pronouns=27.3, bound morphemes=21.1, spontaneous clauses=9.7), and maintained above pre intervention levels for all linguistic measures.

Julian. Scores on all four measures also increased for Julian once he had began intervention (change in means: verbs= 29.6, pronouns=20.7, bound morphemes=13.8, spontaneous clauses=6.6). These gains also generalized (change in means: verbs= 23.6, pronouns=13.1, bound morphemes=17.3, spontaneous clauses=4.6), and his use of verbs,

pronouns and bound morphemes continued to increase after intervention had ended, while his use of spontaneous clauses remained above pre intervention levels.

Kareem. While more modest than other participants in the set, there were consistent increases in Kareem's use of the linguistic targets during intervention (change in means: verbs= 10.2, pronouns=18.3, bound morphemes=2.6, spontaneous clauses=3.6). During generalization probes, he demonstrated an increase in the rate of use of all linguistic targets (change in means: verbs= 7.2, pronouns=5.1, bound morphemes=6.8, spontaneous clauses=5.1). His use of verbs and pronouns continued to grow even after intervention had ended, while the use of bound morphemes and spontaneous clauses remained above pre intervention levels.

Non-overlap Measures: Tau-U and IRD

Tau-U and IRD data are presented in see Supplementary Material 2. Tau-U scores range from 0 to 1.0 and the range of IRD scores is from -1.0 to 1.0. A score of 1.0 on Tau-U and IRD is gained when all intervention scores surpass baseline scores. Tentative benchmarks have been proposed to interpret effect sizes provided by the Tau-U (questionable <0.65; effective 0.66-0.92; very effective >0.92) and IRD (questionable <0.5; effective 0.5-0.7; very effective >0.7). The Tau-U and IRD scores show good correspondence with each other with all scores being indicative of 'very effective' intervention except for use of bound morphemes by Julian and verbs and bound morphemes by Kareem. Some caution is warranted of course where confidence intervals are wide, due possibly to the number of data points used in analysis. Nevertheless, actual scores closely reflect visual analysis, and together these are indicative of a strong positive outcome of intervention.

Discussion

The purpose of our study was to examine the effects of a conversation-based intervention

program targeting the grammaticalization of utterances produced by children with severe MSDs and expressive language delay who use AAC. The findings indicate that during intervention, all participants showed improvement in their production of verbs, pronouns, and bound morphemes. The use of these linguistic structures afforded participants the ability to form spontaneous clauses where these were not being consistently used before intervention. Importantly, these gains were generalized to conversations with familiar adults who were blind to the intervention procedures. In some cases these skills continued to grow up to eight weeks after the end of the intervention.

The findings support earlier research demonstrating the effectiveness of adult scaffolding during conversation to increase the production of a range of linguistic structures in children with communication disorders (Nelson, et al., 1996; Plante et al., 2014; Scherer & Olswang, 1989). The current study provides strong new evidence that conversation-based intervention models can also be effective for children with severe MSDs and expressive language delay who use AAC.

The structured conversation employed as treatment in this study may have been successful in improving the children's language skills for several reasons. First, the intervention provided numerous, controlled opportunities for presenting extremely salient exemplars of the target structures within engaging conversations (Eisenberg, 2013; Scherer & Olswang, 1989). Targeting high frequency words such as pronouns, copula, articles, frequently used verbs, and so forth made it possible to achieve a high concentration of exposures and production attempts across different sessions and different child-directed conversation topics. This may also explain why these gains were generalized to conversations with familiar partners outside the intervention context.

This approach is broadly consistent with previous research demonstrating that the

frequency of occurrence of words across several contexts predicts word learning (Adelman, Brown, & Quesada, 2006). For example, Hoff (2006) reports that words heard by children in a variety of sentence structures are acquired more rapidly than words heard equally frequently but in a more restricted range of sentence structures. Further, the fact that such similar results were noted in both Set A and Set B despite differences in age, indicates that similar learning patterns may be expected for a range of children with severe MSDs and language delays and who use AAC.

Second, the structure of conversational discourse paired with conversational recasting used in this study served to provide meaningful contrast and highlight the saliency of the target structures, while simultaneously allowing for the accomplishment of a more naturalistic and authentic interaction (Eisenberg, 2013; Scherer & Olswang, 1989). In the current study, vocabulary targets were mostly linguistic structures that denoted non-object and function words. In contrast to object words, which can be taught by association to the referent, the meaning of function words can only be learned in relation to other words within discourse (Tomasello, 2003; Levy & Nelson, 1994; Bloom, 2000). These findings are consistent with previous research indicating that for children with severe MSDs and expressive language delay who use AAC, contrast (provided by the adult recasts) is critical to the acquisition of grammatical morphemes (Binger, Maguire-Mashall, & Kent-Walsh, 2011).

Third, the clinicians' use of open-ended questioning, recasting, and prompting provided the necessary conversational structure to engage the children and elicit language in conversations concerning topics of their interest. This aspect of the intervention reflects evidence that children interacting in social environments with engaging and responsive communicative partners who

use rich vocabulary, acquire language more rapidly than children in social environments that provide fewer of these supports (Hoff, 2006).

The features of the intervention as described above mirror the ethos of dynamic systems theories that propose that learning is a consequence of complex and dynamic interactions between multiple components that must converge at specific levels of intensity for learning to be achieved (Nelson & Arkenberg, 2008; Nelson & Welsh, 1998). Evidence of rapid word learning and syntactic growth in typical and atypical populations has been found from clinical interventions grounded on such theories (see Nelson & Arkenberg, 2008 for an extensive review). Our intervention incorporated a number of these clinical properties including individualized, monitored intervention sessions, well-tailored adult input, multiple targets in each intervention session, high expectations for meaningful communication, and rich transactional learning conditions. Giving the children the option to choose the photograph was an essential component of the intervention. Research evidence suggests that when children are presented with choices over certain aspects of a language intervention activity, such as the intervention materials, they exhibit higher levels of attention and engagement that are associated with multiple and significant linguistic skill advantages (Khan, Nelson & White, 2013).

Study Limitations and Future Research Directions

The results of the present study should be interpreted with respect to the study limitations. As with all single-subject experimental designs, the size of the sample was relatively small (i.e., 8). Although, our analysis did not reveal differences between both sets of participants, the relationship between the intervention procedures and the grammatical skills of children with MSDs and expressive language delay who use AAC should be further explored with a larger number of participants and using experimental designs that include randomization and control

groups. Also, we note that the present investigation included only familiar adults as generalization partners. Future studies would benefit from including a wider range of conversational partners such as typical peers, or unfamiliar partners.

The study included both conversational recasts and imitative prompts within a conversation-based intervention, and therefore it is not possible within the current design to assess the relative effectiveness of each. It remains unclear whether the whole intervention program or only certain aspects of it are responsible for the production of the target structures by children. A systematic comparison between conversation-based procedures with and without prompted imitation is therefore warranted. In addition, future studies employing different types of recasts and different levels of recast density are also needed. Finally, while high levels of inter-rater reliability for treatment fidelity were obtained, the raters were not blinded to the phases they were observing and this could have affected their rating. Future studies should include raters that are blinded to both the purposes of the study and to the type of session they are observing.

Additional work is also required to define further the populations that can benefit from this type of intervention. This would include a more extensive description of the cognitive and linguistic skills of study participants and systematic replication of study procedures with children with different profiles, including those with more significant receptive language delays due to moderate to severe cognitive impairment. For example, in the present study we are unable to ascertain fully whether observed improvement relates to increased operational competence in SDG use or language acquisition, or both. Future studies might therefore include frequent probes of language comprehension at different study phases to examine this.

Conclusion

The findings from this study provide strong evidence of the effectiveness of short-term, one-to-one, conversation-based intervention, for improving the expressive vocabulary and grammatical skills of children with severe MSDs and expressive language delays who use AAC. While initially adult driven, the conversations grew to be varied, complex and directed by the children's own initiative, as they became increasingly active in choosing conversational topics and the props they wanted to talk about. The repertoire of language support strategies used by clinicians in conversations of topical salience for children engendered a dynamic yet regulated interactional context for language learning in which the expectations for children's language use were high. As such, this approach challenges the proposition that intervention approaches that are naturally interactive and conversationally driven are inherently "unstructured" (Ruston & Schwanenflugel, 2010).

Children using AAC are frequently described as passive in their interactions with others; as being minimally responsive and reciprocal, and may present with a host of impairments that threaten participation in authentic conversations. The current study established that the use of a format for language intervention, which is conversation-based, interactive, structured and with an expectation for grammaticalization can lead to successful language outcomes.

[1] The AACP measures skills in four areas of AAC communicative competence: operational, linguistic, social and strategic (Light, 1989). Skills are grouped hierarchically in five levels, from simple and early functioning to independent use and AAC system mastery. A person using AAC at Level III purposefully selects targeted symbols with few prompts (operational); is beginning to engage in dialogue and combines words to create simple phrases (linguistic); is using AAC for

social interaction purposes such as making comments, greeting friends; and, is familiar with and can retrieve vocabulary and messages on the AAC device to communicate more effectively; may use telegraphic messages, but understands the importance of selecting correct vocabulary to be an effective communicator and is actively learning vocabulary (strategic).

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Table 1
Participants' Demographic Characteristics

Participants	Age	Speech Disorder	Mobility	Speech Generating Device*	SGD Access	Languages Spoken at Home	Receptive Vocabulary Age Equivalent (Percentile)	Morphological Judgment Age Equivalent (Percentile)	Expressive language (from educational records)	Speech intelligibility rating
Carmen	9:5	Dysarthria secondary to Pfeiffer Syndrome	Wheelchair User	Dynavox DV 4 with Gateway Modified 45, 60	Finger Pointing	English Spanish	8:6˜ (37)	6:6˜ (9)	MLU 1-2 mostly nouns and adjectives	0% (non-verbal)
Geli	8:10	Dysarthria secondary to Cerebral Palsy	Wheelchair User	Dynavox Vmax with Eyemax system and Gateway 45	Eye Gaze	English French Italian	6:6˜ (25)	6:3˜ (16)	MLU 1-2 mostly nouns and adjectives	0% (non-verbal)
Joe	8:8	Dysarthria secondary to Cerebral Palsy	Wheelchair User	Dynavox with Gateway 45	Head switches-Step Scanning	English Spanish	6:9˜ (37)	4:10˜ (2)	MLU 1-2 mostly nouns and adjectives	0% (non-verbal)
Dante	8:8	Dysarthria secondary to Cerebral Palsy	Wheelchair User	Vantage Light with Unity 84	Head Mouse	English	7:0˜ (37)	4:3˜ (2)	MLU 1-2 mostly nouns and adjectives	7% (minimally verbal)
Jesse	12:1	Severe Verbal Apraxia – Etiology Unspecified	Ambulant	Vantage Light with Unity 84	Finger Pointing	English Spanish	9:5^{+} (12)	< 8^ (n.a)	MLU 1-2 mostly nouns and adjectives	40%
Mateo	13:7	Dysarthria secondary to Cerebral	Wheelchair User	Vantage Light with Unity 84	Joystick	English Spanish	8:11^{+} (5)	< 8^ (n.a)	MLU 1-2 mostly nouns and	20% (minimally verbal)

		Palsy							adjectives	
Julian	13:9	Dysarthria secondary to Cerebral Palsy	Wheelchair User	Dynavox Maestro 5 with Gateway Modified 45	Finger Pointing	English Spanish	9:9[+] (12)	< 8^ (n.a)	MLU 1-2 mostly nouns and adjectives	7% (minimally verbal)
Kareem	13:3	Dysarthria secondary to Cerebral Palsy	Wheelchair User	Vantage Light Unity 60	Finger Pointing	English Arabic	9:6[+] (7)	< 8^ (n.a)	MLU 1-2 mostly nouns and adjectives	0% (non-verbal)

* Gateway™ and Unity™ are two language-based vocabulary organization systems, that include: (i) core vocabulary words (i.e., most frequently used words), allowing for the creation of spontaneous, and novel messages, and (ii) grammatical markers, allowing for grammaticalization of the utterance).
[~] Test of Auditory Comprehension of Language-3 (Carrow-Woolfolk & Allen, 1999)
[+]Peabody Picture Vocabulary Test-4 (Dunn & Dunn, 2007)
^ Test of Language Development-I:4 (Newcomer & Hammill, 2008)

Table 2

Baseline and Intervention Results

Participants	No. of Sessions		Mean Number of Verbs		Mean Number of Pronouns		Mean Number of Bound Morphemes		Mean Number of Spontaneous Clauses	
	Base*	Inter~	Base	Inter	Base	Inter	Base	Inter	Base	Inter
Carmen	5	23	11.2	73.3	2	48.6	1.6	59.9	0	4.5
Geli	5	23	9.6	65.2	1.2	44.6	4.2	55.6	0	8.5
Joe	5	12	16.8	49.3	3.6	35.2	5.1	9.9	0	3.5
Dante	5	6	1.6	33.7	0	17.7	0	13.5	0	3.4
Jesse	5	23	10.6	53.5	2.5	57.9	.5	24.7	0	8.2
Mateo	5	24	6.9	47.6	4.2	48	3.4	30	0	5.4
Julian	5	23	1.8	31.4	1.2	21.9	4.8	18.6	.6	7.2
Kareem	5	12	7.1	17.3	0.6	18.9	2.4	5	0	3.6

* Baseline
~ Intervention

Table 3

Results for Pre-Intervention, During Intervention and Post Intervention Generalization Probes

Participants	No. of Sessions			Mean Number of Verbs			Mean Number of Pronouns			Mean Number of Bound Morphemes			Mean Number of Spontaneous Clauses		
	Pre	During	Post	Pre	During	Post	Pre	During	Post	Pre	During	Post	Pre	During	Post
SET A															
Carmen	1	4	3	24	95.7	87.7	24	46.1	42	0	29	30.9	4	14	16.4
Geli	1	4	3	15	52.1	35	6	37.7	25	9	45.9	35	0	4.9	6
Joe	1	2	3	12	45.3	66	6	30.5	24	6	8.5	10	0	3.2	5.1
Dante	1	1	--	2.4	21.6	--	0	21.6	--	0	4.8	--	0	7.2	--
SET B															
Jesse	1	4	1	8	43.9	46.3	6	26.4	16	2	8.5	5	0	10	8
Mateo	1	4	3	18.6	63.1	57.5	21.3	48.6	48.3	9.3	30.4	20.6	0	9.7	10.4
Julian	1	4	2	3	26.6	31.5	6	19.1	24.7	0	17.3	19.7	0	4.6	4.2
Kareem	1	1	2	3	10.2	15.4	0	5.1	7.7	0	6.8	6.4	0	5.1	5

Supplementary Materials 1: *Components for Different Study Phases*

	Procedures	**Materials**	**Sample Target Vocabulary**	**Sample Interaction**
Baseline	1. Clinician and child agree on a topic of conversation. 2. Clinician asks open-ended questions, uses expectant pause, verbal redirection and contingent queries to stimulate the conversation. 3. Clinician does not use any gestural or verbal prompts, aided modeling or any form of corrective feedback.	No predetermined materials, unless indicated by child	No specific vocabulary targeted	Clinician: What did you do over the weekend? Child: *Tia Gladys* Adult: What about Tia Gladys? Child: *baby* Adult: She had a baby? Child: {nods yes} Adult: she just had a baby? Child: {nods yes} Adult: Oh my gosh! How is she? Child: *hurt* Adult: hurt? Where is she now? Child: *home* Adult: What is she doing now? Child: *bed* Adult: She is in bed at home? Cause she is not feeling well, Child: {nods yes} Adult: What do you like to do when you don't feel good? Child: *Legos* Adult: Who do you play with*?* Child: *mom*
Intervention	1. Clinician presents the child with photographs depicting the child in different events and asks the child to choose one s/he would like to talk about. 3. The clinician asks the child whether s/he remembers what happened that day and to describe the event by saying: "Tell me what happened that day." 4. As child talks, the clinician provides corrective feedback and verbally expands what the child says by	Some children used personal photographs as originally planned while others preferred to use other visual props to choose from such as: Video Clips iPad Apps, and Videogame Catalogues.	Personal pronouns (me, my, you, your, he, him, his, it, she, her, they, them, their), verbs (ask, know, go, come. put, get, let, bring, take, buy, give, have, turn, get, make, find, call, remember, stay, touch, stay) auxiliary verbs (is, can, could, will, was, did, do, does), adjectives (awesome, weird, pretty, handsome, cold, small, huge, ready, any, every, old, easy), adverbs, (again,	Child: {chooses a picture} Adult: "Tell me what happened that day." Child: *Birthday*. Adult: Whose birthday? Child: *I* Adult: Oh! This is your birthday. Adult: So to make that a little bit more clear, we need a few little words, right? Because it happened in the past you can say: "THIS WAS MY birthday." Can you tell me that? Child: *This was my birthday* Adult: Do you remember how old were you? Child: *Nine*

	recasting simple utterances into more complex ones. 5. Clinician prompts the child to repair his or her original utterance. 6. Clinician asks open-ended questions, uses expectant pause, verbal redirection and contingent queries to elicit different parts of speech and stimulate further conversation. 7. As child talks, the clinician provides corrective feedback and verbally expands what the child says by recasting simple utterances into more complex ones. 8. Clinician prompts the child to repair his or her original utterance.		now, here, more, there, very, after), prepositions (in, on, with, of, for, out, outside, at, up, over), determiners (this, that), conjunctions (and, or, because), interjections, (e.g., yes, no, please, sorry), question words (who, what, when, where, why. how) and nouns (friend, game, backpack, song, morning).	Adult: Oh, You were nine years old. Child: *Nine years old.* Adult: Remember we are working on our sentences. Let's make that a full sentence. You can say "I WAS nine years old" Child: *I was nine years old.* Adult: What else do you remember about that day? Child: *Dad mom* Adult: What about Mom and Dad?
Generalization	Adult and child agree on a topic and converse as they normally would, without any instruction or intervention from researchers. Adult is masked to intervention procedures.	No predetermined materials, unless indicated by child	No specific vocabulary targeted	Adult: What are you going to be doing on Thanksgiving besides seeing your family? I should say, what do you want to do when you are there? Child: *play* Adult: Who will you play with ?...is there a cousin involved? Child: {nods yes} Adult: Who's that? Is that Tia Coco? Child: *Cousin Octonus, Electra* Adult: Right, right, right, and what are you going to be doing in their houses? Child: *play* Adult: What is the type of things you play with? Child*: Doll dress up* Adult: You love that? Child: {nods yes} Adult: Are you going to be bringing your own dolls or do they have the dolls? Child: *My dolls dress up* Adult: Oh, you are going to bring the dolls.

Supplementary Materials 2

Tau-U and IRD

Participants*	Dependent measure	Tau-U	*p*	CI (85%)	IRD	CI (85%)
Carmen	Verbs	0.98	0.0007	0.57< >1.40	0.96	0.5< >1.0
	Pronouns	1.0	0.0006	0.58< >1.42	1.0	1.0< >1.0
	Bound Morphemes	1.0	0.006	0.58< >1.42	1.0	1.0< >1.0
	Spontaneous clauses	1.0	0.0006	0.58< >1.42	1.0	1.0< >1.0
Geli	Verbs	1.0	0.0006	0.58< >1.42	1.0	1.0< >1.0
	Pronouns	1.0	0.0006	0.58< >1.42	1.0	1.0< >1.0
	Bound Morphemes	1.0	0.006	0.58< >1.42	1.0	1.0< >1.0
	Spontaneous clauses	1.0	0.0006	0.58< >1.42	1.0	1.0< >1.0
Joe	Verbs	1.0	0.0016	0.55< >1.46	1.0	1.0< >1.0
	Pronouns	1.0	0.0016	0.55< >1.46	1.0	1.0< >1.0
	Bound Morphemes	0.48	0.13	0.03<>0.92	0.13	-0.5< >1.0
	Spontaneous clauses	1.0	0.0016	0.55< >1.46	1.0	1.0< >1.0
Jesse	Verbs	0.98	0.0007	0.57< >1.40	0.76	0.5< >1.0
	Pronouns	1.0	0.0005	0.58< >1.42	1.0	1.0< >1.0
	Bound Morphemes	0.97	0.0008	0.55< >1.38	0.72	0.5< >1.0
	Spontaneous clauses	1.0	0.0005	0.59< >1.41	1.0	1.0< >1.0
Mateo	Verbs	1.0	0.0005	0.58< >1.42	1.0	1.0< >1.0
	Pronouns	1.0	0.0005	0.58< >1.42	1.0	1.0< >1.0
	Bound Morphemes	1.0	0.0005	0.58< >1.42	1.0	1.0< >1.0
	Spontaneous clauses	1.0	0.0005	0.58< >1.42	1.0	1.0< >1.0
Julian	Verbs	1.0	0.0006	0.58< >1.42	1.0	1.0< >1.0
	Pronouns	1.0	0.0006	0.58< >1.42	1.0	1.0< >1.0
	Bound Morphemes	0.73	0.0111	0.32< >1.15	-0.58	-0.7 < > -0.5
	Spontaneous clauses	1.0	0.0005	0.58< >1.42	1.0	1.0< >1.0
Kareem	Verbs	0.8	0.0114	0.35< >1.26	0.18	-0.2< >0.6
	Pronouns	1.0	0.0016	0.55< >1.46	1.0	1.0< >1.0
	Bound Morphemes	0.77	0.015	0.31< >1.22	0.18	-0.6< > 0.2
	Spontaneous clauses	1.0	0.0016	0.55< >1.46	1.0	1.0< >1.0

* Excluding Dante because too few data points available

Figure 1: Set A: Rate of verb use per 60 minutes

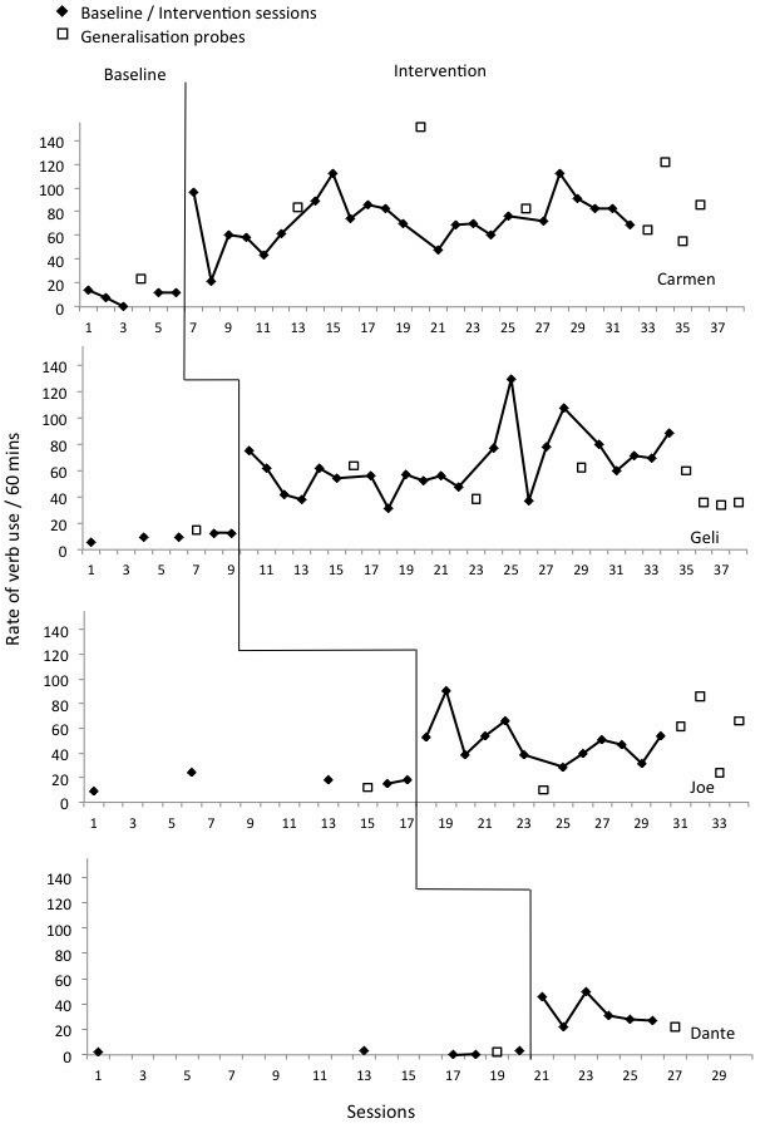

Figure 2: Set A: Rate of Pronoun use per 60 minutes

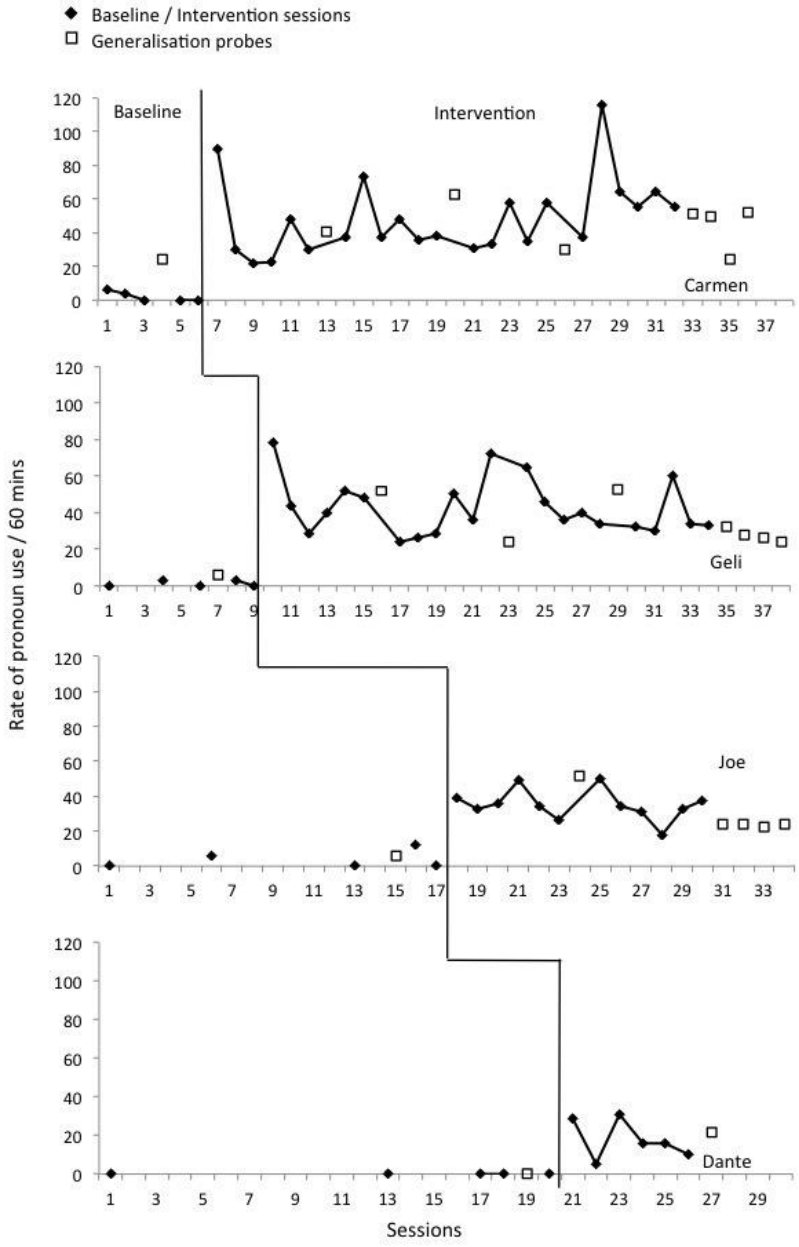

Figure 3: Set A: Rate of Bound Morpheme use per 60 minutes

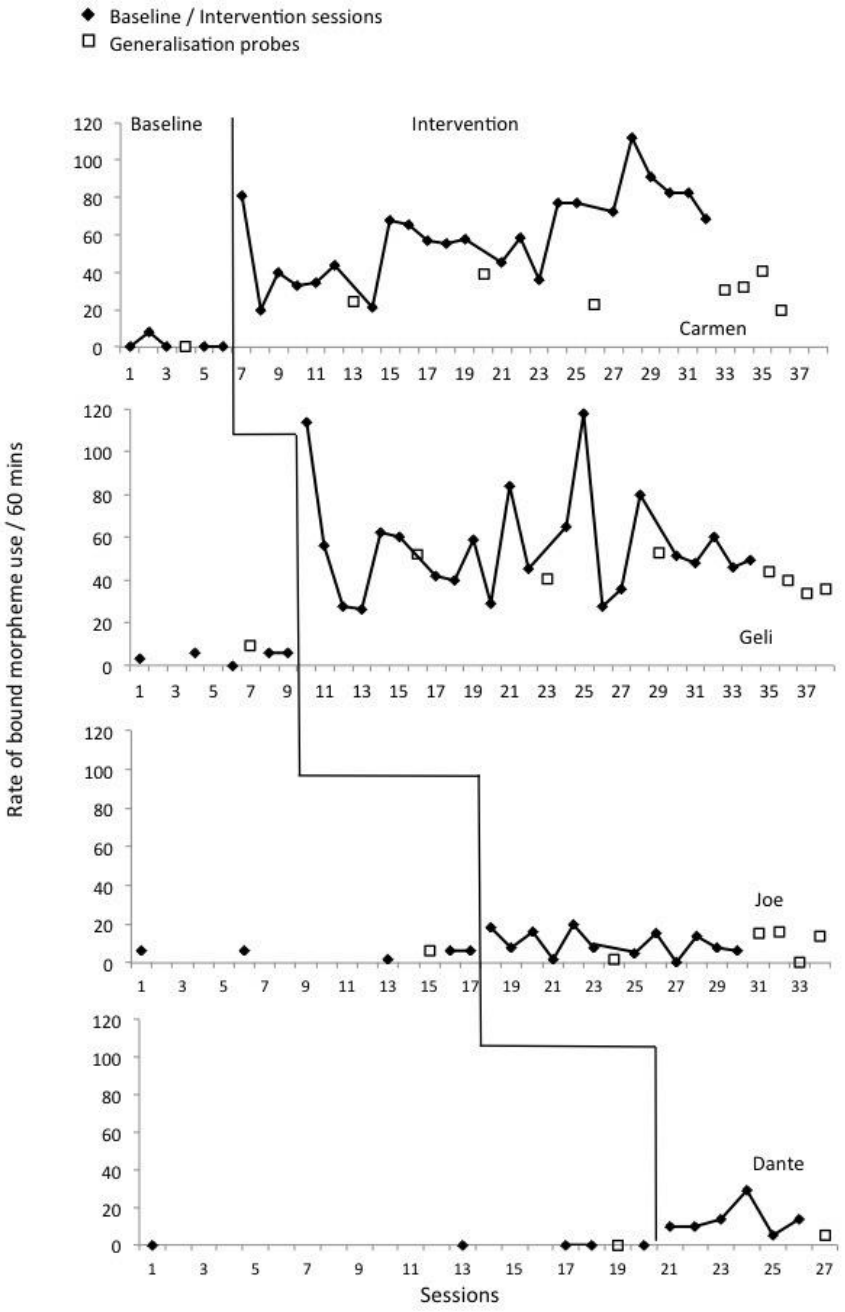

Figure 4: Set A: Rate of spontaneous clause use per 60 minutes

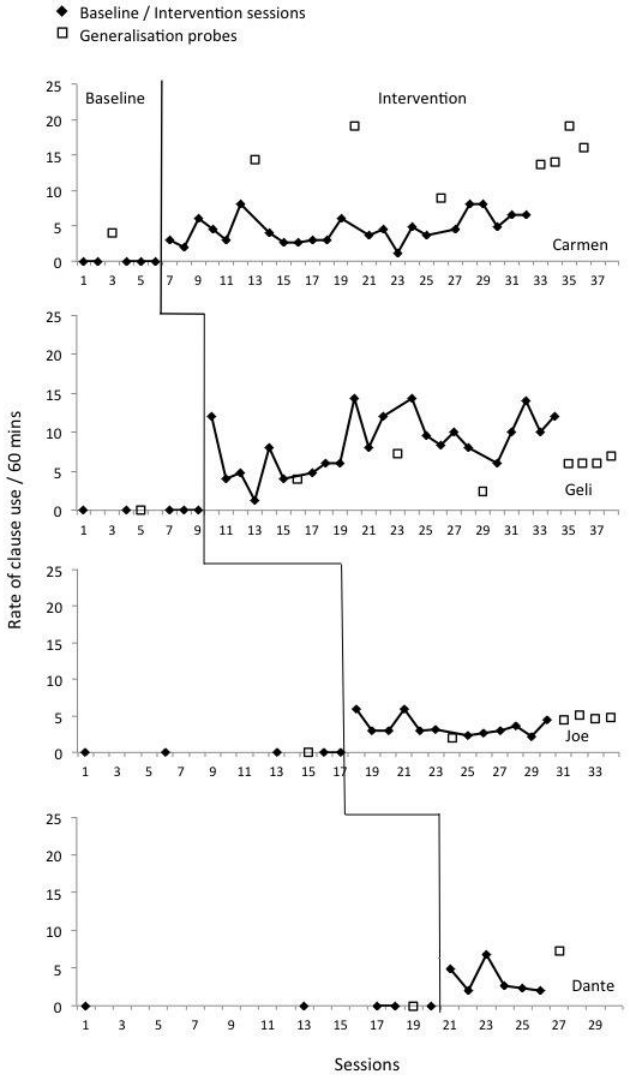

Figure 5: Set B: Rate of verb use per 60 minutes

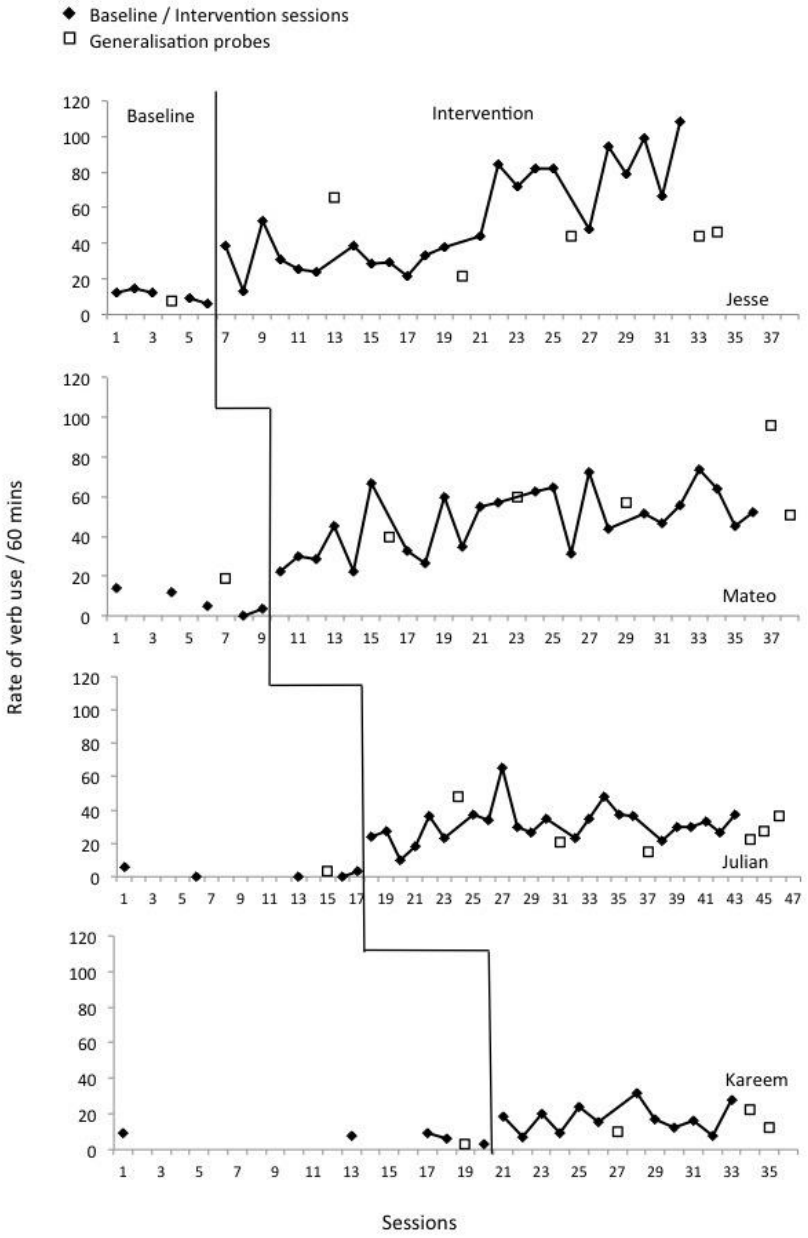

Figure 6: Set B: Rate of pronoun use per 60 minutes

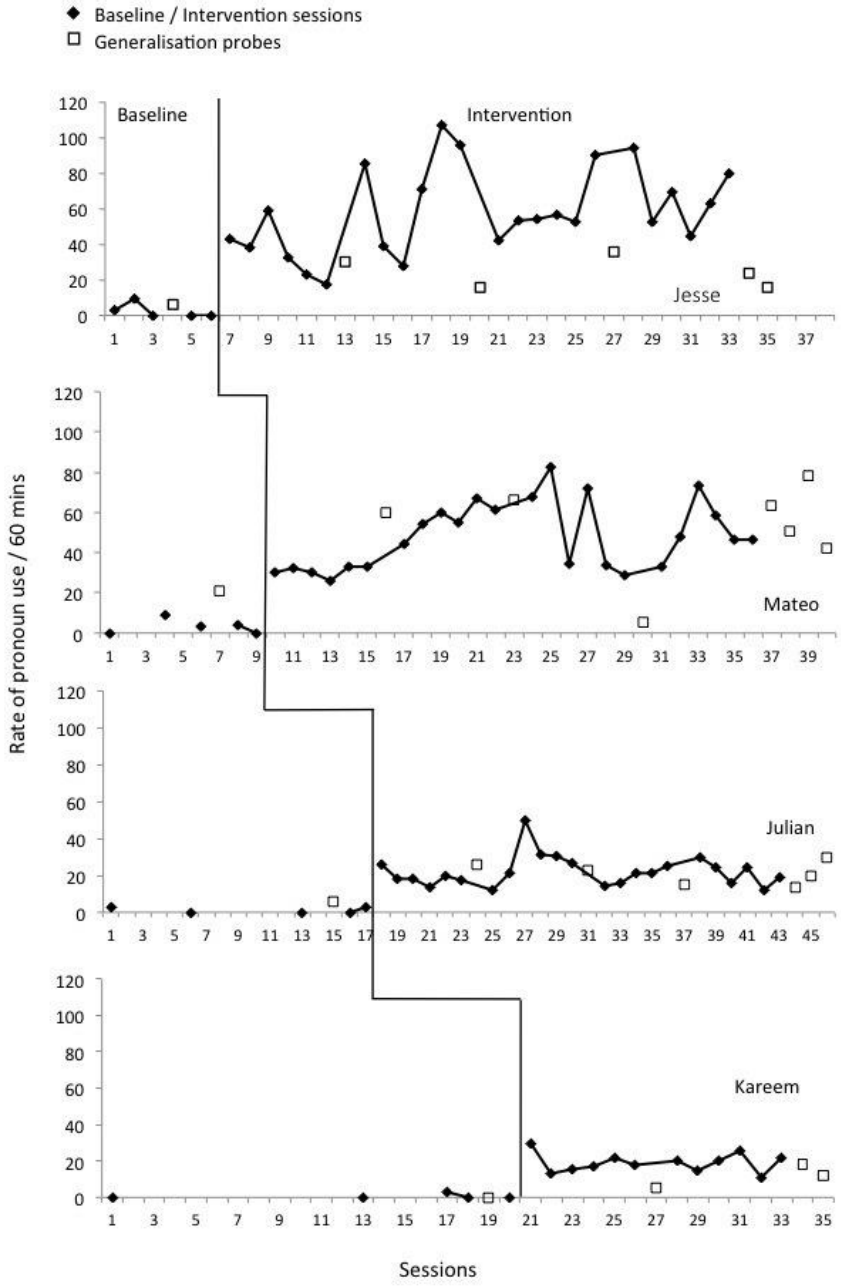

Figure 7: Set B: Rate of bound morpheme use per 60 minutes

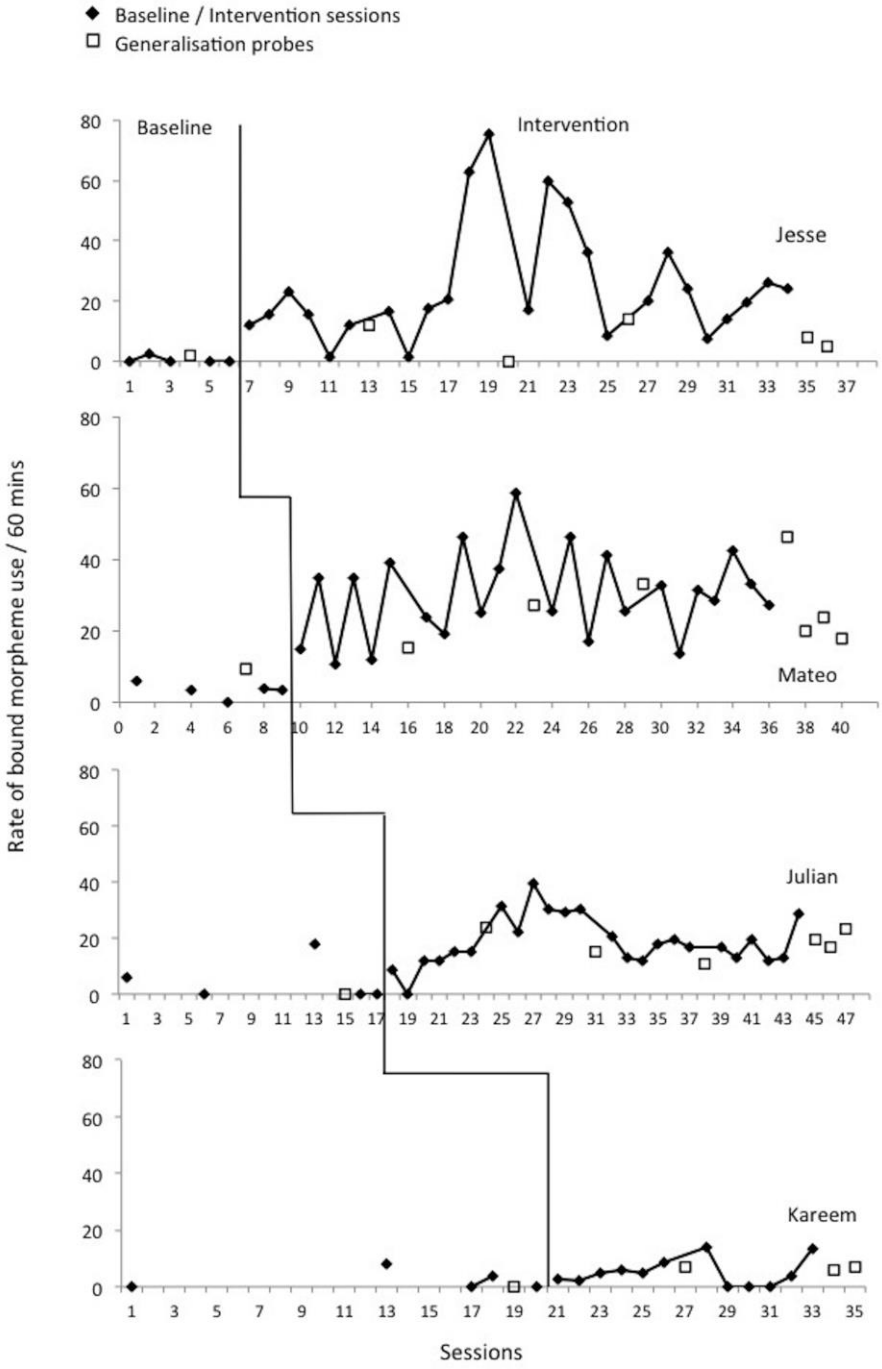

Figure 8: Set B: Rate of independent clause use per 60 minutes