**Tables**

**Table 1:** Treatments used in the studies for nonverbal and minimally-verbal children with ASD.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Author & Year** | **N (m/f)****Age**  | **Dependent Measures** | **Pre-post Measures** | **Treatment** | **Outcome** |
| Almirall D, et al. [[10](https://www.ncbi.nlm.nih.gov/pubmed/26954267)] | 61 (51, 10)5-8 | Five DVs: # Total spontaneous communicative utterances from naturalistic language sample# Number of different word root# Initiating joint attention (IJA) and # initiating behavioral regulation (IBR) from ESCS# Total number of unique play from structure playExpressive: Total number of spontaneous communicative utterances (TSCU), number of different word roots (NDWR), | # Leiter - R# ADOS# 20-min naturalistic language sample (NLS): Total number of spontaneous communicative utterances (TSCU), % spontaneous communicative utterances, number of different word roots, MLU, word per minute (WPM), total number of comments (TCOM), unique word combination (UWC), and total number of spontaneous requests (SPRQ) # ESCS: IJA and IBR# Structure Play Assessment: Total number of unique play action (UPA) | SMART design that includes two stages of tx. The first stage assigned children to JASP + EMT or JASP + EMT + SGD, second stage quick responders and slow responders were identified. Quick responders stay in the same treatment while slow responders were assigned to either intensified JAST + EMT or augmented JASP + EMT + SGD. | Sig differences in slopes (at Stage 1 or Stage 2) among the three adaptive interventions on two of the five outcomes considered: TSCU (p < 0.01) and IJA (p = 0.046)Authors concluded among the three adaptive interventions, the (SGD, SGD) adaptive intervention was found to lead to improved spontaneous spoken communicative utterances and initiating joint attention relative to (No SGD, No SGD) and (No SGD, SGD). |
| Chenausky K, et al. [[30](https://www.ncbi.nlm.nih.gov/pubmed/27829034)] | 30 (27, 3)3;5-9;8 | ﻿% Syllables Approximated ﻿% Consonants Correct ﻿% Vowels Correct | Probe assessments of repeating 15 high frequency (30 total) bisyllabic words or phrases, trained and untrained.  | Auditory Motor Mapping Training (Listening/unison, unison fade, imitate, and cloze) compared with AMMT + Speech Repetition Treatment (SRT) | ﻿After 25 sessions, AMMT participants increased by 19.4% syllables approximated, 13.8% consonants correct, and 19.1% vowels Correct, compared to best baseline. In the matched AMMT-SRT group, after 25 sessions, AMMT participants produced 29.0% more syllables approximated (SRT 3.6%);17.9% more consonants correct (SRT 0.5); and 17.6% more vowels correct (SRT 0.8%). |
| DiStefano, et al. [[11](https://www.ncbi.nlm.nih.gov/pubmed/26824676)] | 55 (Not reported)5-8 | Total number of different words, total spontaneous communicative utterances, total # of comments (“as well as other variables) | 10 min samples at entry and 1x per month of intervention | Half received play and engagement intervention that incorporated SGD for 6 months; 45-60 mins 2x/week months 1-3. Slow responders switched to increased intensity or original condition | Those higher at BL did betterJASPER-EMT + SGD did slightly betterChildren in both groups improved in long interchanges; site differences in short interchangesEntry # of interchanges correlated with exitTDWR (words at entry correlated with exit)Spontaneous (TSCU) utterances at entry not predictor of TDWR at exit however entry # of interchanges and TSCU significant indicator of exit TSCU not measuredby spontaneous language sample only during intervention |
| Drash PW, et al. [[14](https://www.ncbi.nlm.nih.gov/pubmed/22477156)] | 3 (3, 0)2;6-3;6 | ﻿% of mands (any vocal response to prompt, excluding inappropriate vocal behavior); % of correct echoic responses; % of error responses; % of no responses and inappropriate behavior combined; % of tact responses | ﻿% of mands (any vocal response to prompt, excluding inappropriate vocal behavior); % of correct echoic responses; % of error responses; % of no responses and inappropriate behavior combined; % of tact responses | Shaping the mand repertoire by using establishing operations and specific reinforcers. | ﻿All 3 children acquired an initial echoic repertoire within the 1st 10 sessions. Two of the children also began tacting; all participants acquired a mand repertoire by the 6th session; negative vocal behavior decreased rapidly  |
| Esch JW, et al. [[31](https://www.ncbi.nlm.nih.gov/pubmed/22477430)] | 2 (2, 0)2;6 & 7;1 | # Frequency of varied vocalization: Varied vocal response defined as a speech vocalization that was different from the response of the preceding trial and that occurred within 5s of the experimenter’s model (coded as D) | Pre-intervention assessment include a phoneme imitation task, play sample, and Kaufman speech Praxis test for children | Discrete Trial Training: Reinforcer ﻿delivered when a response is different from the response immediately preceding it | Authors concluded “systematic increases in varied vocalization” in both children but because of the large variability |
| Franco JH, et al. [[22](https://www.ncbi.nlm.nih.gov/pubmed/23813208)] | 6 (5, 1)5;1-8;3 | ﻿# the number of acts that the children used to maintain social interaction during each routine# rate/minute of child initiated intentional communication (total number of child-initiated communication acts divided by total number of minutes in the session)HYBRID: Included vocalizations into a larger communication variable. The reported measure was a combination of verbal and nonverbal | Single subject designNo pre-post testsBaseline was omnibus communication variable | Prelinguistic Milieu Teaching using techniques including prompts, models, and natural consequences in a naturalistic play context  | participants did not demonstrate intentional communication at baseline. During intervention, all six children increased in the rates of initiation of intentional communication compared to baseline. Improvement rate difference (IRD) was used as effect size: %90 for ﻿acts to maintain social interaction; %87 for rate/minute of child initiated intentional communication. Pooled vocalizations with nonverbal social communication measures |
| Green J, et al. [[15](https://www.ncbi.nlm.nih.gov/pubmed/20494434)] | 152 (124, 28)2;0-4;11 | Primary: Severity of the symptoms of autismSecondary: (1) Parent-child interaction during naturalistic play in a non-therapy setting (2) Child language and social communication (3) Adaptive functioning in school beyond the family.Hybrid: ADOS social communication does include verbal words and verbal communication. But, the growth in verbal skills could not be ascertained. | Primary measure: ADOS-G social communication algorithm score (scoring procedure modified to improve sensitivity to change)Secondary measures: (1) Video tapes from the study were assessed for proportion of parental communications with the child that were synchronous, proportion of child communications with the parent that were initiations, and proportion of time spent in mutual shared attention (2) Assessed by the researcher using the Preschool Language Scales and reported by the parent according to the MacArthur Communicative Development Inventory (MCDI, infant form raw scores) and the Communication and Symbolic Behavior Scales Developmental Profile (CSBS-DP, caregiver questionnaire) social composite raw scores (3) Assessed by Vineland Adaptive Behavior Scales (VABS), Teacher Rating Form, and rated at endpoint by face-to-face interview with teachers in nurseries, reception class, or other appropriate caregiver who was not a member of the family | Preschool Autism Communication Trial (PACT)parent-mediated communication-focused intervention | Primary: No significant improvement in severity of autism symptoms in comparison to control groupSecondary: (1) Intervention effects were strong for assessor-rated parent-child interactions (parent synchronous responses and child communication initiations, although less for shared attention). (2) No significant effect on directly assessed language (3) No significant effect on adaptive functioning in school.Unknown whether there were changes in vocalizations/verbal skills (not reported) |
| Gevarter C, et al. [32] | 6 (5,1)3;6-5;3 | Independent and prompted vocalizations, approximation of target word, full words | No pre-post testssingle subject design | Whole words targeted. Any vocalization was rewarded. Rewards for DT for word production | 5/6 showed increased vocalizations |
| Gordon K, et al. [[33](https://www.ncbi.nlm.nih.gov/pubmed/21787048)] | 84 (73, 11)4-10 | initiations, requesting, use of PECS picture cardsHybrid: Included nonverbal and verbal initiations. Vocalizations as a separate measure.(Spontaneous initiation using speech/vocalization (IC-S) | The primary outcome variable was frequency of child-initiated communication (IC). Frequencies of different communication modalities used (such as the number of times a child used a picture card (P) and/or speech/vocalization (S) to communicate) were also recorded; communication functions were recorded by counting each time a child communicated for the purpose of requesting objects (R) and for the purpose of requesting a social interaction or commenting (D). In this way, a single communication act might produce 3 or more codes, e.g. as a spontaneous initiation (IC), of the use of a picture card (P) and for the purpose of requesting (R). | PECS phase 1 with clinician verbal modeling of words | There were positive moderated treatment effectsRequesting (mands) for objects. Social communication did not improve 21 participants (those who were more severe at baseline) showed no gains  |
| Harris SL, et al. [16] | 11 (10, 1)2;3-4;6 | Two half hour Videotapes (1 week apart) scored for Speech/speech attempts, other, and non-intelligible  | 10-item test of facts about teaching speech, a consumer satisfaction questionnaire (Likert scale), clinical data for behavior modification or speech training | Treatment behavior modificationBrief summary of previous week, 40-min lecture, demonstrations, feedback 5 mins discussing individual academic or behavior progsReading materialSpeech - behavior, nonverbal imitation, shaping sounds, teaching nouns, teaching adjectives & Verbs, generalizationWeekly group meetings; Home visits every 2 weeks | Pre-post analyses MBL design with two matched groupsSignificant increase in knowledge after both trainings. Improvements in speech-oriented language of parents after speech training. Verbal children at pre showed greater improvement than nonverbal children at post |
| Hingtgen JN, et al. [[34](https://www.ncbi.nlm.nih.gov/pubmed/5793681)] | 4 (4, 0)4;0-5;11 | # Number of imitated use-of-body response# Number of imitated use-of-object response# Number of imitated sounds and words. | No pre-post tests | Three to five weeks of intensive imitative training,consisting of five to six hours of daily training sessions, where adults used reinforcers to shape imitative behaviors: Body response, use of objects, and receptive and expressive language (following directions, item identification, naming items) | No quantitative analysis was provided. Qualitative description of number of imitated sounds and words at the end of intensive training were included for all four children: Child 1: Imitated all vowel and consonant sounds, 25 words/word approximationsChild 2: Almost all vowel and consonant sounds, at least 60 words/word approximationsChild 3: Most vowel and consonant sounds, at least 16 words/word approximationsChild 4: Imitated 9 sounds Authors concluded that “﻿intensive training combined with elevated motivational levels can lead to substantial increases in the behavior of mute autistic children” . |
| Jones EA [[17](https://www.sciencedirect.com/science/article/pii/S1750946708000901)] | 2 (2, 0)3;2 & 4;11 | Joint AttentionHybrid. Included nonverbal and coordinated with verbal. | Single case design on several measures of joint attention | PRT for Gaze, Gaze Alternating, Gaze Alternating and Pointing, and Gaze Alternating, Pointing and Verbalization | Both children learned the target behaviorsJA attention alone did not result in improvements in pointing or verbalizations; Pointing and verbalizations improved only after they were specifically targeted |
| Kasari C, et al. [[12](https://www.ncbi.nlm.nih.gov/pubmed/24839882)] | 61 (51, 10)5-8 | From 20 min Natural language sample Total # of spontaneous communicative utterance. Also # different word roots and # of comments | Pre post naturalistic language samples  | JASPER-EMT alone or JASPER-EMT+SGD. First 3 months 2-hour long sessions - increasing to 3 hours per week for slow responders | JASP + EMT + SGT greatest gains |
| Koegel RL, et al. [[35](https://www.ncbi.nlm.nih.gov/pubmed/3610995)] | 2 (Not reported)4;5-5;8 | Number of utterances, spontaneous-imitation | Single subject design No pre-post tests | NLP and Analog (DT) | Improvements in the number of imitated and spontaneous utterances  |
| Koegel RL, et al. [[18](https://www.ncbi.nlm.nih.gov/pubmed/19488847)] | 3 (3, 0)3;0-4;8 | CDI, %Correct Verbalizations | Single subject designNo pre-post tests | PRT (Antecedent Stimulus Control: Using Orienting Cues) | 4, 38 & 245 words (n = 3) |
| Koegel RL, et al. [[19](https://www.ncbi.nlm.nih.gov/pubmed/19357942)] | 3 (3, 0)3;2-3;5 | # Reinforcer strength# Self-initiated social engagement during communication# Nonverbal dyadic orienting# General child affect | Single subject designNo pre-post tests | Embedding social interaction into child-preferred reinforcer in a naturalistic language intervention context | # Reinforcer strengthComparable across both conditionsduringcommunicationImprovement in in self-initiated social engagement, nonverbal dyadic orienting and affect in all three children. |
| Laski KE, et al. [[23](https://www.ncbi.nlm.nih.gov/pubmed/3225256)] | 8 (7, 1)5-9.6 | Parent verbalizations, child vocalizations (imitations, answers, spontaneous speech) | Parent verbalizations, child vocalizations (imitations, answers, spontaneous speech) | Natural language paradigm (NLP) with clinic sessions and parent implementation | Parents increased the frequency with which they required their children to speak (i.e., modeled words and phrases, prompted answers to questions); all participants with autism increased the frequency of verbalizations in 3 non-training settings |
| Miller A, et al. [[38](https://www.ncbi.nlm.nih.gov/pubmed/4740587)] | 19 (12, 7)5-23 | Expressive and receptive words and signs but not clear how data were collected.Hybrid. Did include spoken words | No pre-post tests | Cognitive-developmental; Participants walked on parallel boards 3-6’ above the ground with obstacles to become aware and decrease “autistic mannerisms”Next, 50 functional ASD signs were taught via signs on the boards, training films, and generalization to everyday contexts;adults taught to elicit signs throughout day paired with spoken word | All improved in receptive and expressive use of responding to signs. Children respond to more signs than used them. 7 of the 19 children produced some spoken words relating to the signs (range 1-50 with only one participant above 7)Duration of training correlated with higher Creak scoresDay school students performed better than residential.  |
| Ozonoff S, et al. [[36](https://www.ncbi.nlm.nih.gov/pubmed/9546299)] | 22 (18, 4)2;7-5;9 | The Psychoeducational Profile-Revised. Hybrid: Words are included in the overall PEP-R score, but actual word use/vocalizations were not included. | The Psychoeducational Profile-Revised subscales: Imitation, Perception, Fine Motor, Gross Motor, Hand-eye Integration, Cognitive-Performance, Cognitive-Verbal and Total PEP-R score | Parent Implemented TEACCH or Control(n = 11 in each group) | TEACCH Group bigger gains than control group on Imitation, Fine Motor, Gross Motor, Cognitive-Performance, and Total PEP-R score |
| Oxman J, et al. [24] | 10 (5, 5)9;1-9;5 | Speech production/imitation categorized by:(1) Willingness/motivation to vocalize(2) Participants’ precise speech abilities | Fisher-Logemann Test of Articulation Competence Test consists of 106 items - three trials given for each test itemspeech pathologists used two measures to score responses: First trial of each test item was scored for presence/absence of a vocal response, regardless of its quality (willingness/motivation to vocalize); vocal responses were scored in terms of their articulatory correctness (or correspondence with the examiner’s speech models) (used to measure participants’ precise speech abilities) | Simultaneous communication training (speaking and signing) compared with a control group that received vocal responding (speech-oriented socialization program) | Simultaneous communication did not result in improvements in any of the nonverbal participants, however control groupSignificant increase in the experimental group’s pre to post-test performance on first trial responses; no improvement in the control group; all children performed at very low levels for the measure of articulatory correctness at both pre/post-testing - no significant differences between the pre- and post-test scores |
| Rogers SJ, et al. [[37](https://www.ncbi.nlm.nih.gov/pubmed/16845576)] | 10 (10, 0)1;8-5;5 | # Novel words or approximations; # novel phrases (also looked at function of communication, and if utterance was prompted or spont; Frequency of speech | ADOS, SCQ, Mullen, VABS, CDI, 15 min speech probes1 press for request and 1 for JA (“look”)FU - speech probe after 3 months | Denver Model (behavioral, developmental, and relationship-oriented intervention) **or** PROMPT (neuro-developmental approach for speech production disorders)1 hour per week for 12 hours | 8/10 children demonstrated functional spontaneous use of 5 or more novel words during therapy and generalization (less during play/gen)9/10 improved on CDIHigher Developmental quotient did betterAge, cognitive abilities, imitation, intentional skills and milder autism symptoms may have moderated successPoorest outcomes: Attention, tolerating demands, participating, jaGood: Mild autism, social orienting |
| Sandiford GA, et al. [25] | 12 (11/1)5;0-7;6 | #Verbal Attempts (Correct Words)#Words Parent Report# Imitative Attempts | Number of verbal attempts, number of correct words, number of words reported by the parent, and number of imitative attempts. In order to measure number of verbal attempts and number ofcorrect words over time, acriterion referenced vocabularytest developed by the first author was given at baseline and the beginning of each treatment week. | Melodic Intonation Tx n = 5Standard Tx n = 5 | Pre-post gains in #VACR, PR & IA for MITPre-post gains in #VACR, No diff between groups on #VACR, #PR or #IA |
| Scanlan JB, et al. [26] | 8 (7, 1)5;2-9;6 | None reported | No pre-post measures | Treatment emphasized activities that encouraged interaction between the therapist and the child (e.g., using pictures of familiar objects, animals and people). Therapist labeled each picture and encouraged the child to look at the therapist’s mouth. A hearing tube was occasionally used to stimulate verbal communication. Child’s lips and jaw were manually manipulated sometimes to stimulate speech. | Qualitative description: “gains in verbal expression, however, did not nearly approach the gains made in verbal comprehension” |
| Schreibman L, et al. [[20](https://www.ncbi.nlm.nih.gov/pubmed/24272416)] | 39 (34, 5)1;6-3;75  | CDI Mullen Vineland | The Mullen Scales of EarlyLearning (MSEL), ExpressiveOne-Word Picture VocabularyTest-Revised (EOWPVT),MacArthur CommunicativeDevelopmental Inventory (CDI),Vineland Adaptive BehaviorScales (VABS), PECS use levelscore (1 - 6), Parent SatisfactionSurvey | PRT n = 20PECS n = 19 | No difference |
| Shire SY, et al. [13]\*Partial data from 1 site of a multi-site study | 22 (22, 0)5-8 | CCX 10-minute parent interaction - spontaneous language and function (request, comment, other non-social) | 10-minute language samples collected monthly and at follow-up - standard toys parents asked to interact as usualNo other measures | JASPER-EMT alone or JASPER-EMT + SGD | Sig increase in spontaneous requests & commentsNo sig difference bet time and treatment conditionComments “modestly significant” |
| Strasberger SK, et al. [27] | 4 (4, 0)5;8-12;11 | ﻿Frequency of independent 2-step mand sentence sequence; frequency of responses; generalization measures in classroom; ﻿teachers’ ratings on the Behavioral Intervention Rating Scale (BIRS); social validity measure for peers | Frequency of independent 2-step mand sentence sequence; frequency of responses | peer assisted communication application (PACA) on iPod SGD | All 4 participants were able to use an iPod-based SGD for some communicative purpose; 2 participants ﻿generalized and maintained their new communication; ﻿classroom teachers and same-aged peers reported the intervention as being both acceptable and effective |
| Wan CY, et al. [[28](https://www.ncbi.nlm.nih.gov/pubmed/21980480)] | 6 (5, 1)5;9-8;9 | % CV approximations | Single subject designNo pre-post tests | Auditory Motor; Mapping Training | After therapy, all children showed significant improvements in their ability to articulate words; All six subjects increased %CV approximations |
| Wetherby AM, et al. [21] | 82 (71, 11)1;4-1;8 | Social communication, autism symptoms, adaptive behavior, and developmental level | Social, Speech, and Symbolic composites of the CSBS Behavior Sample; Social Affect (SA) and Repetitive Behavior (RRB) domains of ADOS; Communication, Daily Living, Socialization, and Motor scores from the Vineland Adaptive Behavior Scales (VABS-II); Visual Reception, Fine Motor, Receptive Language, and Expressive Language scores from The Mullen Scales of Early Learning (MSEL) | Comparing two interventions within the Early Social Interaction (ESI) Project: Individual-ESI vs. group-ESI | Participants in individual ESI showed significantly greater improvement on the Social composite of CBSB; participants in both groups showed significant improvement in social affect and worsening in RRBs of ADOS; Participants in individual-ESI showed significant improvement in Communication and Daily Life and stability in Socialization on VABS; participants in group-ESI showed no change in Communication and Daily Life and significant decrease in Socialization; participants showed no significant change in Visual Reception of MSEL; participants in the individual-ESI showed significant improvement in Receptive Language but there was no change for participants in group-ESI |
| Yoder PJ, et al. [[29](https://www.ncbi.nlm.nih.gov/pubmed/3410812)] | 60 (Not reported)Range not reported;Mean 5-5;6. SD 1.2-2.1 across groups | Total number of different child-initiated spoken words observed during 40-minute training sessions | Direct observation by language clinician-Recorded utterances as they occurred-Pre-treatment: Verbal imitation was trained and assessed using the sum of correct trials per item (language clinicians asked participants to verbally imitate 11 items) | Simultaneous presentation of speech and signing (4 groups: Sign Alone, Speech Alone, Simultaneous presentation of Sign and Speech, and Alternating Presentation of Sign and Speech) | Sign Alone group used significantly fewer spontaneous words than participants in the other 3 groups; Participants in the other 3 groups did not significantly differ from each other; pretreatment verbal imitation abilities (higher) were predictive of spontaneous oral language use by 57 of the 60 participants |