Volume 9, Issue 5 March 2015

EBP *briefs*

A scholarly forum for guiding evidence-based practices in speech-language pathology

Improving Speech Intelligibility in Children With Childhood Apraxia of Speech: Employing Evidence-Based Practice

Keegan M. Koehlinger

EBP Briefs

Cite this document as:
Koehlinger, K. M. (2015). Improving speech intelligibility in children with childhood apraxia of speech: employing evidence-based practice. *EBP Briefs, 9*(5), 1–10. Bloomington, MN: Pearson.

PEARSON

PsychCorp

NCS Pearson, Inc. 5601 Green Valley Drive Bloomington, MN 55437 800.627.7271 www.PearsonClinical.com

Produced in the United States of America.

1 2 3 4 5 6 7 8 9 10 11 12 A B C D E

Improving Speech Intelligibility in Children With Childhood Apraxia of Speech: Employing Evidence-Based Practice

Keegan M. Koehlinger
Children's Center for Therapy

Structured Abstract

Clinical Question: Would a preschool-aged child with childhood apraxia of speech (CAS) benefit from a singular approach—such as motor planning, sensory cueing, linguistic and rhythmic—or a combined approach in order to increase intelligibility of spoken language?

Method: Systematic Review

Study Sources: ASHA Wire, Google Scholar, Speech Bite

Search Terms: childhood apraxia of speech or developmental apraxia of speech AND intervention OR treatment

Number of Studies Included: 11

Primary Results: The greatest volume of evidence was available to support use of a motor-planning approach incorporating integral stimulation and/or Dynamic Temporal and Tactile Cueing (DTTC) approach for children with CAS. Although two studies provided support for a combined approach to treatment, the evidence for motor-planning approaches was more coherent and developed.

Conclusions: Jane elected to adopt a motor-planning approach to address the needs of her client, drawing specific treatment characteristics from the published literature.

Clinical Scenario

Jane is a speech-language pathologist who has worked in a private clinic setting for three years and currently provides speech-language services to children ages birth through 21 years with a variety of speech and language disorders. Jane recently had a new client, Benjamin, assigned to her caseload. Benjamin is a 4-year-old child who was brought to the clinic by his mother due to concerns about his expressive language abilities. At the initial evaluation, Benjamin was using short phrases coupled with gestures to communicate. Once Jane began to interact with Benjamin, she started to notice a unique profile of difficulties. Specifically, Benjamin would often make groping gestures in attempts to correctly produce speech sounds, and he was inconsistent in his abilities to produce sounds and words. Also, Benjamin exhibited an extreme difficulty in transitioning between sounds and syllables. While there is currently no standardized diagnostic criteria, the American Speech-Language-Hearing Association (ASHA) notes that errors in prosody, inconsistent errors on consonants and vowels, and difficulties in transitioning between sounds and syllables are consistent with a deficit in the planning and programming of speech movements, otherwise known as apraxia of speech, or AOS (ASHA, 2007).

Jane quickly began to suspect childhood apraxia of speech over other speech sound disorders (i.e., those related to phonological processes or dysarthria). During the time in which Jane treated Benjamin he made little to no progress in therapy. He struggled significantly with imitating sounds without groping for correct placement of articulators. Furthermore, his vocabulary, speech-sound inventory, and the contexts in which he produced sounds showed no functional growth. At this point in time, Jane realized that a change in plan of care was needed.

Background

Childhood apraxia of speech (CAS), also referred to as developmental apraxia of speech and dyspraxia, is a neurological disorder in which the central motor-planning associated with voluntary oral-motor movements is affected. In its position statement, ASHA explains that CAS can be the "result of [a] known neurological impairment, in association with complex neurobehavioral disorders of known or unknown origin, or as an idiopathic neurogenic speech sound disorder" (2007). There has been some debate over the existence of apraxia of speech as a disorder. Despite this controversy, CAS has an estimated prevalence of around 1 to 10 children per 1,000 (Shriberg, Aram, & Kwiatkowski, 1997), and characteristics of CAS are established. For instance, Peter and Stoel-Gammon (2005) describe CAS characteristics to include:

> "a limited phonemic inventory; omission errors; vowel distortions; inconsistent articulation errors; altered suprasegmental characteristics such as disordered prosody, voice quality, and fluency; increased errors on longer units of speech output; difficulty imitating words and phrases; predominant use of simple syllable shapes; impaired volitional oral movements; reduced expressive vs. receptive language skills; and reduced diadochokinetic rates" (pp. 67–68).

Several different treatment approaches focused on increasing speech production and intelligibility are used to treat CAS. Common treatment paradigms include linguistic approaches, motor-planning approaches, sensory cueing approaches (Hall, 2000), rhythmic or prosodic approaches, and combined approaches that couple motor and linguistic approaches (ASHA, 2007). Augmentative and Alternative Communication (AAC) is another treatment option that is sometimes recommended for children with CAS. It should be noted, however, that ASHA does not endorse any particular approach.

Linguistic approaches treat CAS as a language learning disorder and focus on improving groups of sounds with similar errors. The Cycles approach (Hodson & Paden, 1983, 1991) and integrated phonological awareness intervention are two such approaches. Motor planning or programming approaches focus on the need for accurate speech movement. Such approaches take into account types of sensory input or cues, feedback schedules, and conditions of practice. Examples include Kaufman Speech to Language Protocol (K-SLP) and Integral Stimulation. Sensory cueing is an approach that targets sensory input as a way to teach a child the correct way of producing a sound. Sensory cues can be visually or auditorially focused as well as proprioceptive or tactile in nature. Sensory cues can be used individually or coupled together to arrive at a multi-sensory approach. The PROMPT® (Prompts for Restructuring Oral Muscular

Phonetic Targets) approach is one such sensory cueing approach (Hayden, 2006, 2008; Hayden, Eigen, Walker, & Olsen, 2010). Finally, rhythmic or prosodic facilitation uses intonation to improve speech production of children with CAS. Melody, rhythm, and stress are the main components used in the facilitation of correct production of common phrases and utterances. An example of this approach is melodic intonation therapy (MIT; Albert, Sparks, & Helm, 1973).

The Clinical Question

Jane noted that Benjamin presented with many of the symptoms of CAS as outlined by Peter and Stoel-Gammon (2005), including a limited phonemic inventory, inconsistent articulation errors, increased difficulties with multisyllabic words, and difficulty imitating words. She was unclear, however, of the optimal approach to use in therapy. Jane wanted to find an approach that would help Benjamin to increase his phonemic inventory as well as the overall intelligibility of his words and phrases. With this in mind, Jane used the PICO (population, intervention, comparison, and outcome) framework (Sackett, Richardson, Rosenberg, & Haynes, 1997) to develop the following clinical question:

P – preschool-school age child with CAS

I – singular approach, such as motor planning, sensory cueing, linguistic, and rhythmic

C – combined approach

O – increase speech sound inventory and intelligibility of spoken language

Precisely, Jane posed her question as, "Would a preschool-aged child with childhood apraxia of speech (CAS) benefit from a singular approach—such as motor planning, sensory cueing, linguistic and rhythmic—or a combined approach in order to increase intelligibility of spoken language?"

Search for the Evidence

Jane searched for evidence pursuant to this question with ASHA's National Center for Evidence-Based Practice in Communication Disorders (N-CEP) in order to determine whether any systematic reviews on interventions for CAS had already been conducted. This search yielded four results; however, two of the four articles were discarded due to their focus on apraxia of speech in adults and not children. Of the remainder, one study focused on a single intervention approach, MIT (Roper, 2003), while the second did not identify any studies that met predetermined inclusionary criteria and therefore did not provide a clinical recommendation. As these reviews did not directly address Jane's question, she chose to continue her search for evidence via other sources, namely ASHAWire (the search engine for ASHA journals), Google Scholar, and Speech Bite, the latter a relatively new database for speech-language interventions and treatment efficacy.

Jane used the following inclusionary/exclusionary criteria in her search in order to limit articles to those most relevant to her clinical question:

- Studies involving children 8 years old and younger meeting criteria for childhood apraxia of speech and no other types of developmental speech disorders.
- Studies including outcome measures related to intelligibility and motor behavior or phonemic inventories (i.e. exclusion of AAC).
- Studies implementing a motor planning, linguistic, sensory cueing, rhythmic or a combined approach.

Evaluating the Evidence

Jane's search retrieved 11 studies eligible for consideration, all of which were based on single case studies. Jane subsequently examined each study with respect to the specific intervention approach used. Table 1 identifies the number of studies using each approach, and Table 2 provides details regarding characteristics of each of these studies.

Linguistic Approaches

Two studies investigated the impacts of an integrated phonological awareness approach for children with CAS on children's intelligibility (as well as other outcomes). Moriarty and Gillon (2006) examined effects of this intervention for three children with CAS ages 6:3–7:3 who participated in three 45-minute sessions per week for 3 weeks. In each session, activities focused on identifying phonemes in isolation, identifying initial and final phonemes in words, segmenting and blending phonemes, and manipulating phonemes with letter blocks.

Intelligibility goals included increasing the percentage of correct phonemes in trained items by decreasing target speech error patterns. In this study, all speech-production practice occurred within phonological awareness activities, and there was no direct verbal practice of trained items through imitation or drill-based activities. Two out of the three participants showed improvements in the percentage of correct phonemes for targeted speech error patterns.

In a separate study, McNeill, Gillon, and Dodd (2009) employed a single-subject design in which 12 children ages 4 through 7 years took part in two 6-week intervention blocks with a withdrawal block between the two intervention blocks. The intervention was designed to improve children's letter-sound knowledge, phoneme identification skills, and phonemic segmentation and blending. Results of intervention indicated that 9 out of 12 participants suppressed the use of speech error patterns in trained words, while 6 out of 12 participants suppressed speech error patterns in untrained words. In connected speech, 9 participants suppressed error patterns (at least 90% accuracy with target sounds) for one target, while only 4 participants suppressed errors for both targets.

Together, these studies suggest that an integrated phonological awareness approach may be beneficial at the single-word level and possibly in conversational speech for children with CAS who have patterned phonological errors.

Motor Planning Approaches

Six studies investigated the use of motor planning approaches for treatment of CAS, with the majority focused on integral stimulation (IS) and Dynamic Temporal and Tactile Cueing (DTTC). The two approaches are very similar, with the latter adapted from the former. The integral stimulation approach involves varying the temporal relationship between the target produced by the child and the response provided by the clinician (see Rosenbek, Lemme, Ahern, Harris, & Wertz, 1973; Strand & Skinner, 1999). Maximum, simultaneous cueing is provided initially, but is then faded out as the child's speech intelligibility improves. IS is often referred to as the "listen to me, watch me, do what I do" approach. The DTTC approach adds on layers of cueing to improve children's production accuracy.

Three studies identified in Jane's search investigated the impacts of the IS approach for children with CAS. Strand and Debertine (2000) examined the impacts of IS in improving experimental and control stimuli at the utterance level for a child (69 months of age) with CAS in a case study during which the child received treatment four times per week. Experimental and control probes were scored on a binary scale (right vs. wrong) as well as scaled (0 = did not meet criteria for 1 or 2, 1 = production intelligible but with minor errors, 2 = no errors). A greater degree of change was observed for experimental probes than for control probes.

Edeal and Gildersleeve-Neumann (2011) also studied effects of the IS approach. In a study involving two children with CAS (ages 76 and 38 months), researchers varied the amount of targets produced within 15 minutes of therapy as well as the length of treatment phase (high frequency = 3x weekly/11 weeks, moderate frequency = 2x weekly/5 weeks). During the moderate frequency treatment, the IS approach was used to provide auditory, visual, and tactile cues in 30–40 elicitations per session. The same treatment protocols were used for the high frequency treatment except that 100–150 targets were elicited. Results indicated that high-frequency practice of speech targets within sessions led to better in-session performance, quicker acquisition of speech sounds, and higher generalization to untrained probe words.

Maas, Butalla, and Farinella (2012) evaluated the effects of IS within the context of feedback frequency for four children with CAS (ages 5 through 8 years). The children participated in 50-minute treatment sessions three times per week for a 16-week program that rotated four weeks of therapy with two weeks of maintenance. Each child participated in a low-frequency treatment period (feedback on approximately 60% of trials) and a high-frequency treatment period (feedback on 100% of trials). Targets varied amongst children in that some children had single-word targets and others phrases, depending on the developmental appropriateness for any given child. Results showed that two children showed an advantage for low-frequency feedback (i.e., higher accuracy on treated items when provided with low-frequency feedback), whereas a third child showed an advantage for high-frequency feedback (i.e., higher accuracy on treated items when provided with high-frequency feedback). The fourth child made no apparent changes over the treatment periods. Limited transfer to control probes was observed for all children in the study.

Two studies identified in the search process examined the use of Dynamic Temporal and Tactile Cueing, a treatment approach derived from integral stimulation. DTTC emphasizes the shaping of movements associated with speech production that begins with simultaneous production of targets between clinician and child, and includes various approaches to cueing the child to improve production accuracy.

In the first study, Strand, Stoeckel, and Baas (2006) examined the effectiveness of DTTC for four children who received therapy twice daily in short sessions five times per week. A temporal hierarchy was utilized in sessions, as shown in Table 3. Three out of 4 children benefited from the DTTC approach in that rapid change was seen after initiation of treatment. Limited transfer of skills to probe items was observed for all children. For two children, maintenance data was collected and most utterances showed good maintenance.

In the second study, Maas and Farinella (2012) extended the work of Strand et al. (2006) by determining the influence of random versus blocked practice on the accuracy of speech sounds in target probes, within an alternative approach to the DTTC treatment (see Table 4). A two-phase alternating treatment design was implemented for four children (ages 5 through 7 years). Each session contained both blocked and random practice with the order of each type counterbalanced across sessions. Targets varied across children but all were single words that varied by number of syllables, initial clusters, final fricatives, and final liquids. Untreated item probes of the same type were also selected for each child. The results of the intervention were mixed with two participants showing greater benefit from blocked practice, one participant showing greater benefit from mixed practice, and one participant showing no clear improvement from either condition. While the authors were unable to determine an absolute advantage of practice type, their results did indicate that DTTC or integral stimulation techniques are efficacious in improving speech production of children with CAS.

Finally, Skelton and Hagopian (2014) evaluated the effectiveness of randomized variable practice, a motor learning approach, in improving the production of four phonemes (s, z, f, v) for three children (ages 4 through 6 years). All sessions included practice tasks focused on the four target sounds, and feedback was provided (see Table 5). Target sounds were considered to be established once a criterion of 8 out of 10 was met for a single word. Participants attended sessions two times a week for 30 minutes until criterion levels of at least 80% were achieved for each speech sound across three treatment sessions. Criterion was met in 12, 28 and 26 weeks by the three participants. In terms of generalization to probes, all three participants showed improvements in single word and three-word productions. Accuracy in probes ranged from approximately 70% to near 100% for the four target phonemes. This outcome is in contrast to other motor planning approaches that found modest generalization outcomes when IS framework was implemented.

Sensory Cueing

A single study targeting the use of sensory cueing was identified for review. Dale and Hayden (2013) evaluated the effectiveness of PROMPT (Hayden, 2006, 2008) with and without tactile-kinesthetic-proprioceptive (TKP) cues in improving focal oromotor control and sequencing and improvement of articulation in untrained probes (generalization) and on standardized tests. Four children (ages 3 through 4 years) were randomly assigned to one of two groups; one group received 8 weeks (16 sessions) of full PROMPT (no TKP cues) and the second group received approximately 4 weeks of full PROMPT and 4 weeks of PROMPT with the addition of TKP. Results showed that all four participants benefited from participating in the treatment, and there was some evidence that the TKP cues provided additional benefit.

Combined Approaches

Two studies featuring the combination of approaches to deliver treatment to children with CAS were identified for review. Martikainen and Korpilahti (2011) assessed the effectiveness of coupling MIT (Helfrich-Miller, 1984) with the touch-cue method (TCM; Bashir, Graham-Jones, & Bostwick, 1984) to improve the percentage of vowels and consonants produced correctly on untreated probes for one child (4 years old) with CAS. The participant received treatment in this order: A baseline period of 6 weeks, 6-week treatment with MIT, 6-week break period, 6-week treatment with TCM, and a follow-up 12 weeks post-intervention. For this child, percentage of vowels produced correctly increased after the MIT and TCM blocks with percentage of vowels correct equaling 93% at the end of the study period. Percentage of consonants produced correctly presented with a different pattern, decreasing over the MIT period. However, improvements were seen after the MIT block, which continued through the TCM block with percentage of consonants produced correctly totaling 73.1% at week 36.

Iuzzini and Forrest (2010) combined a stimulability training protocol (STP) with a modified core vocabulary treatment (mCVT) approach to treat four children with CAS. The STP approach was selected because of its ability to increase phonetic inventories (Powell, 1996), whereas Core Vocabulary Treatment has been shown to increase the consistency of productions in children with CAS (Crosbie, Holm, & Dodd, 2005). Over a 10-week treatment period (twice-weekly sessions), the first 10 minutes of each session was devoted to STP while the remaining 45 minutes focused on mCVT. After treatment, all four participants demonstrated growth in the percentage of consonants produced correctly (range: 9–32%) in addition to gaining, on average, 5 new phonemes (range: 1–10). In terms of consistency of productions, three out of four participants exhibited increased consistency. However, one participant demonstrated decreased consistency. The combination of motor and linguistic (phonological) principles through mCVT and STP appeared to increase the phonetic inventories, phonemic accuracy and consistency of productions in participants with CAS.

Making an Evidence-Based Decision

Jane began this review in order to determine whether a singular or combined treatment approach would be most beneficial in treating childhood apraxia of speech. In her review of the evidence, Jane found that several treatment types produced positive outcomes in terms of increased intelligibility, accuracy of production, and increased phonemic inventories. This included, for instance, both IS and DTTC. With only two studies available examining the impacts of a combined approach, Jane did not feel there was sufficient evidence to support a combined approach over a singular approach (or vice versa), particularly given that no studies included for review explicitly compared singular approaches to combined approaches.

In considering the 11 studies she examined, Jane concluded that the greatest volume of evidence supported the motor learning approaches of IS and DTTC, which are highly similar. While the combined approach studies also presented positive outcomes (Iuzzini & Forrest, 2010; Martikainen & Korpilahti, 2011), IS and DTTC approaches were able to show positive outcomes across studies—even when systematically altering components, such as production frequency and feedback frequency (Edeal & Gildersleeve-Neumann, 2011; Maas et al., 2012; Maas & Farinella, 2012; Strand & Debertine, 2000; Strand et al., 2006). To this end, Jane's evidence-based decision for how to address Benjamin's intelligibility issues and other CAS symptoms was to utilize the IS/DTTC treatment protocols, noting that while these are considered singular approaches, the studies showing their positive effects emphasize the use of sensory cues (visual, auditory, and tactile). In developing the specifics of her therapeutic plan for Benjamin, Jane incorporated these characteristics of treatment implementations as seen across the studies she reviewed on use of IS/DTTC:

1. Use of a temporal hierarchy (Edeal & Gildersleeve-Neumann, 2011; Maas & Farinella, 2012; Strand & Debertine, 2000; Strand et al., 2006).
2. High production frequency (approximately 100–150 trials) within sessions (Edeal & Gildersleeve-Neumann, 2011).
3. Low frequency feedback (approximately 60% of trials) within sessions (Maas et al., 2012).
4. A mixture of visual and verbal feedback within the temporal hierarchy.

Consequently, Jane's evidence-based decision served to identify the overall approach she would use with Benjamin, but her review of peer-reviewed journal articles also served to identify the specific elements of these approaches that she would use during Benjamin's therapy sessions.

Author Note

Keegan Koehlinger, M.A., CCC-SLP is a practicing clinician at the Children's Center for Therapy in Iowa City, IA, 1552 Mall Drive Iowa City, IA 52240, keegan.koehlinger@childrenscenterfortherapy.org

References

Albert, M., Sparks, R., & Helm, N. (1973). Melodic intonation therapy for aphasia. *Archives of Neurology, 29,* 130–131.

American Speech-Language-Hearing Association. (2007). Childhood apraxia of speech [Position Statement].

Bashir, A. S., Graham-Jones, F., & Bostwick, R. Y. (1984). A touch-cue method of therapy for developmental verbal apraxia. *Seminars in Speech and Language, 5,* 127–137.

Crosbie, S., Holm, A., & Dodd, B. (2005). Intervention for children with severe speech disorder: A comparison of two approaches. *International Journal of Language and Communication Disorders, 40,* 467–491.

Dale, P. S., & Hayden, D. A. (2013). Treating speech subsystems in childhood apraxia of speech with tactual input: The PROMPT approach. *American Journal of Speech-Language Pathology, 22,* 644–661. doi:10.1044/1058-0360(2013/12-0055)

Edeal, D. E., & Gildersleeve-Neumann, C. E. (2011). The importance of production frequency in therapy for childhood apraxia of speech. *American Journal of Speech-Language Pathology, 20,* 95–110. doi:10.1044/1058-0360(2011/09-0005)

Hall, P. (2000). Part IV: Treatment of DAS. *Language, Speech, and Hearing Services in Schools, 31,* 179–181. doi:10.1044/0161-1461.3102.179

Hayden, D. A. (2006). The PROMPT model: Use and application for children with mixed phonological-motor impairment. *Advances in Speech-Language Pathology, 8,* 265–281.

Hayden, D. A. (2008). PROMPT *Prompts for restructuring oral muscular phonetic targets, introduction to technique: A manual*. Santa Fe, NM: The Prompt Institute.

Hayden, D. A., Eigen, J., Walker, A., & Olsen, L. (2010). PROMPT: A tactually grounded model. In A. L. Williams, S. McLeod, & R. J. McCauley (Eds.), *Interventions for speech sound disorders in children* (pp. 453–474). Baltimore, MD: Brookes.

Helfrich-Miller, K. R. (1984). Melodic intonation therapy and developmentally apraxic children. *Seminars in Speech and Language, 5,* 119–126.

Hodson, B. W., & Paden, E. P. (1983). *Targeting intelligible speech: A phonological approach to remediation*. Boston: College Hill.

Hodson, B. W., & Paden, E. P. (1991). *Targeting intelligible speech: A phonological approach to remediation* (2nd ed.). Austin, TX: PRO-ED.

Iuzzini, J., & Forrest, K. (2010). Evaluation of a combined treatment approach for childhood apraxia of speech. *Clinical Linguistics and Phonetics, 24*(4–5), 335–345.

Maas, E., Butalla, C. E., & Farinella, K. A. (2012). Feedback frequency in treatment for childhood apraxia of speech. *American Journal of Speech-Language Pathology, 21,* 239–257.

Maas, E., & Farinella, K. A. (2012). Random versus blocked practice in treatment for childhood apraxia of speech. *Journal of Speech, Language, and Hearing Research, 55,* 561–578. doi:10.1044/1092-4388(2011/11-0120)

Martikainen, A. L., & Korpilahti, P. (2011). Intervention for childhood apraxia of speech: A single-case study. *Child Language Teaching and Therapy, 27*(1), 9–20.

McNeill, B. C., Gillon, G. T., & Dodd, B. (2009). Effectiveness of an integrated phonological awareness approach for children with childhood apraxia of speech (CAS). *Child Language Teaching and Therapy, 25*(3), 341–366.

Moriarty, B. C., & Gillon, G. T. (2006). Phonological awareness intervention for children with childhood apraxia of speech. *International Journal of Language and Communication Disorders, 41*(6), 713–734.

Peter, B., & Stoel-Gammon, C. (2005). Timing errors in two children with suspected childhood apraxia of speech (sCAS) during speech and music related tasks. *Clinical Linguistics and Phonetics, 19*(2), 67–87.

Powell, T. W. (1996). Stimulability considerations in the phonological treatment of a child with persistent disorder of speech-sound production. *Journal of Communication Disorders, 29,* 315–333.

Roper, N. (2003). Melodic intonation therapy with young children with apraxia. *Bridges: Practice-Based Research Synthesis, 1*(3), 1–7.

Rosenbek, J. C., Lemme, M. L., Ahern, M. B., Harris, E. H., & Wertz, R. T. (1973). A treatment for apraxia of speech in adults. *Journal of Speech and Hearing Disorders, 38*(4), 462–472.

Sackett, D. L., Richardson, W. S., Rosenberg, W., & Haynes, R. B. (1997). *Evidence-based medicine: How to practice and teach EBM*. New York, NY: Churchill.

Shriberg, L. D., Aram, D. M., & Kwiatkowski, J. (1997). Developmental apraxia of speech: I. Descriptive and theoretical perspectives. *Journal of Speech, Language, and Hearing Research, 40*(2), 273–285.

Skelton, S. L., & Hagopian, A. L. (2014). Using randomized variable practice in the treatment of childhood apraxia of speech. *American Journal of Speech-Language Pathology, 23,* 599–611.

Strand, E. A., & Debertine, P. (2000). The efficacy of integral stimulation intervention with developmental apraxia of speech. *Journal of Medical Speech-Language Pathology, 8*(4), 295–300.

Strand, E. A., & Skinner, A. (1999). Treatment of developmental apraxia of speech: Integral stimulation methods. In A. Caruso & E. Strand (Eds.), *Clinical management of motor speech disorders in children* (pp. 109–148). New York, NY: Thieme.

Strand, E. A., Stoeckel, R., & Baas, B. (2006). Treatment of severe childhood apraxia of speech: A treatment efficacy study. *Journal of Medical Speech-Language Pathology, 14*(4), 297–307.

Table 1. Number of Studies by Approach

Approach	Number of Studies
Linguistic	2
Motor Planning	6
Sensory Cueing	1
Melodic Intonation Therapy	0
Combined	2

Table 2. Studies Identified for Review and Inclusion

Study	Research Design	Number of Participants (Age)	Intervention Approach	Outcome
Moriarty and Gillon (2006)	Single-subject design	3 (6:3–7:3)	Linguistic (phonological awareness)	Mixed: 2 children suppressed target phonological process, 1 child did not improve accuracy of target productions.
McNeill, Gillon, and Dodd (2009)	Single-subject design	12 (4–7 years old)	Linguistic (integrated phonological awareness)	6 of 12 children suppressed speech error patterns in trained and untrained words.
Strand and Debertine (2000)	Single-subject design	1 (5:9)	Motor Planning (Dynamic Temporal and Tactile Cueing)	Improvements in intelligibility noted in control probes, but “error-proof” productions were not achieved.
Edeal and Gildersleeve-Neumann (2011)	Single-subject design	2 (3:4 and 6:2)	Motor Planning (Integral Stimulation: high vs. low production frequency)	Both children showed improvements in targets. Targets with higher production frequency were acquired more quickly and demonstrated greater generalization.
Maas, Butalla, and Farinella (2012)	Single-subject design	4 (5:4–8:4)	Motor Planning (Integral Stimulation: high feedback vs. low feedback)	Mixed: 2 children showed advantage for low frequency feedback, 1 for high frequency, and 1 showed no clear advantage.
Strand, Stoeckel, and Baas (2006)	Single-subject design	4 (5:5–6:1)	Motor Planning (Dynamic Temporal and Tactile Cueing)	3 of 4 children developed functional, intelligible utterances after being considered nonverbal at onset of treatment.
Maas and Farinella (2012)	Single-subject design	4 (5:0–7:9)	Motor Planning (modified Dynamic Temporal and Tactile Cueing: random vs. blocked practice)	Mixed: 2 children benefited from blocked practice, 1 from random practice, and 1 made no clear improvements.
Skelton and Hagopian (2014)	Single-subject design	3(4:0–6:1)	Motor Planning Based (randomized variable practice)	Correct productions increased and generalization to non-test targets were observed.
Dale and Hayden (2013)	Single-subject design	4 (3:6–4:8)	Sensory Cueing (PROMPT approach)	All children showed improvements in intelligibility and in generalization of targeted motor movements to single-syllable and poly-syllable words and short phrases.
Martikainen and Korpilahti (2011)	Single-case design	1 (4:7)	Combined melodic intonation therapy and touch cue method	Speech-sound errors were reduced and production of whole words increased.
Iuzzini and Forrest (2010)	Single-subject design	4 (3:7–6:10)	Combined stimulability training protocol and modified core vocabulary treatment	Speech-sound inventory and percentage consonants correct increased.

Note. Studies are listed in the order they appear in this brief.

Table 3. Temporal Hierarchy Used in Strand, Stoeckel, and Baas (2006)

1. Clinician says the utterance while the child watches the clinician's face; child then repeats the utterance. If the child is incorrect: a. Simultaneous production takes place. Tactile and gestural cues added as necessary. b. Auditory and visual stimuli provided with successive trials, rate of simultaneous productions increased gradually. c. Simultaneous productions continued until child can easily produce utterance with the clinician. Slowly fade out simultaneous cue through reduction of volume until the clinician is simply mouthing the model.
2. Transition to immediate repetition if correct on step one. a. Clinician provides an auditory model while child is watching clinician's face. b. Child repeats the model. The clinician mouths the model if additional support is needed for correct production.
3. Addition of imitative delay. a. Clinician produces the target model. b. Delay of 1–3 seconds provided before child imitates. c. Once the child is able to repeat the target utterance after a 2- to 3-second delay, the child repeats the target several times without intervening stimuli.
4. Work to elicit the target utterance in spontaneous language.

Table 4. Temporal Hierarchy Used in Maas and Farinella (2012)

1. "Watch me, listen carefully, and repeat after me."
2. If correct: a. Wait 2–3 seconds, provide feedback or go to the next target word
3. If incorrect: a. Feedback Trial i. Wait 2–3 seconds and then provide feedback. ii. Slow simultaneous production (up to 2x) with tactile cues included. iii. Clinician fades out simultaneous cue to mouthing the model. iv. Immediate repetition takes place. v. Wait 2–3 seconds and provide feedback. b. No Feedback Trial i. Wait 2–3 seconds and say, "Let's do it slowly together." ii. Slow simultaneous production (up to 2x) with tactile cues included. iii. Clinician fades out simultaneous cue to mouthing the model. iv. Immediate repetition takes place. v. Wait 2–3 seconds and say, "Now let's do another one."

Table 5. Error Correct Sequence Used in Skelton and Hagopian (2014)

If an error was produced, the following occurred: 1. The clinician would say, "I didn't hear [target sound]." The participant would then attempt the target again.
2. The clinician modeled the target a second time and asked the participant to directly imitate the target. A cue for correct production would occasionally be provided along with the modeled target (e.g., "keep your teeth together" for /s/).
3. A visual cue was provided by the clinician by miming the target while the child produced it.
4. The clinician and participant would then simultaneously produce the target. If the participant was unable to correctly produce the target after completing the error correct sequence, then the task was discontinued and the next task initiated.