Critical Review: Is DTTC an effective therapy approach for improving intelligibility in children with apraxia of speech?

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This critical review examines the evidence regarding the efficacy of Dynamic Temporal and Tactile Cueing (DTTC) a therapy treatment approach for treating childhood apraxia of speech (CAS). The six studies included in this review were: are a mixture of single-case (2) and single-subject (4) designs which targeted school-age children with moderate to severe CAS. Most studies (4) demonstrated positive change in participants following DTTC treatment. The two studies by Maas et. al found mixed results with one participant not displaying improvement. Sample sizes in each study were limited and continued research is recommended. Future recommendations, limitations and general discussion are presented.

Introduction

Childhood apraxia of speech (CAS) is a motor speech disorder defined by motor planning difficulties, particularly in the movements required for speech production (Strand, 2006). Some features typically observed in children with CAS include inconsistent errors on vowels, consonants and syllable structure, difficulty with coarticulation, difficulty with transitions between vowels, and varied prosody most typically presenting as inappropriate stress patterns (ASHA, 2007).

Dynamic Temporal and Tactile Cueing (DTTC) is a therapy approach rooted in the principles of motor learning. It was specifically designed for severe speech sound disorders (SSDs), especially CAS (Strand, 2020). DTTC focuses on sensorimotor planning/programming by facilitating correct movement of selected stimuli (Strand, 2020). DTTC is a treatment approach based on integral stimulation, which emphasizes auditory and visual models through imitation modelled by the clinician (Strand & Skinder, 1999). The combination of auditory and visual models helps to shape the articulatory movements through slowed rate and tactile cues. Cues and specific feedback pertaining to the movement can be provided to help facilitate learning of correct movements.

DTTC is built on a temporal hierarchy, that is, the amount of time between the provided model and the child's imitation is changed over time (Strand, 2020). Following this hierarchy eventually allows for the child to learn to produce the movements spontaneously. Typically, this hierarchy moves through simultaneous production, direct imitation, delayed imitation and spontaneous production as a response to a question (Strand, 2020). Cueing strategies are also utilized to help the child work their way up the hierarchy. Gradual transition from slowed to normal rate, variations on prosody and use of gestures/tactile cues are all utilized and gradually faded as the child progresses and becomes more independent in their productions (Strand, 2020).

Objectives

The primary objective of this paper is to critically evaluate the existing literature on the effectiveness of Dynamic Temporal and Tactile Cueing (DTTC), and to determine whether or not this type of intervention is an effective therapy approach to treat individuals with severe childhood apraxia of speech.

Methods

Search Strategy

The studies reviewed were accessed using online databases including PubMed, Google Scholar, PsychINFO, Scopus, and speechBITE. Search terms included:

[(childhood apraxia of speech) OR CAS] AND [(dynamic temporal and tactile cueing) OR DTTC] AND [(treatment) OR therapy] AND [effectiveness].

Selection Criteria

To be included in this critical review, studies selected must have investigated children who were diagnosed with, or met criteria consistent with, childhood apraxia of speech and who received DTTC treatment. DTTC surfaced around 1999-2000 due to Dr. Edythe Strand's research. This review includes all research papers on the topic to date.

Data Collection

The literature search yielded six articles that were included in this review: two single case study designs

and four single-subject, multiple-baseline and alternating treatment designs.

Results

Single-Subject Designs

CAS does not have a standardized diagnostic tool, which can make it difficult to find enough participants for large studies. Single-subject designs are an appropriate design for small sample sizes as the subject acts as their own control. This design contains systematic manipulation of variables. Generalization to larger populations may be difficult as the results are based on an individual's performance.

Strand et al. (2006) used a single subject, multiple baseline design across behaviours to examine the efficacy of a dynamic temporal and tactile cueing (DTTC) treatment approach based on integral stimulation. The design was replicated across four 5-6-year-old children with severe CAS. Participant inclusion criteria solely included a diagnosis of severe CAS which led to some variation in patient population—two of the four children had mild coexisting dysarthria. Therapy was delivered frequently (twice a day, 5 days per week for 30 minutes). Mass practice was implemented with a small set of 5-6 utterances used for each child. Specific feedback was given to each child, gradually decreasing in frequency. Probes for trained and non-trained stimulus were taken periodically over 6 weeks. Inter-judge reliability measurements were completed across three judges to ensure reliability, with no more than 1 point difference in disagreements. Results of this study showed that three of four children demonstrated positive change following therapy.

The authors stated that, overall, this was an effective therapy approach for ¾ participants. They explained that the one child who did not show measurable change, following treatment, was typically unmotivated to participate in therapy despite reinforcing rewards.

Strand et al. (2006) clearly presented the temporal hierarchy used in their study, and outlined their therapy process, allowing for future studies to replicate their results. The authors designed the treatment to be specific to the client, allowing for variability in the feedback provided to each child. Generalization data for two of four participants was collected and they demonstrated maintenance of therapy. Generalization data is beneficial in analyzing maintenance over time. This is a positive sign as it indicates that the therapy was effective, even over time. Unfortunately, because they were not able to collect data on all participants, the generalizability of the data collected was reduced. Additionally, the authors wrote specific details of each participant's results as they each had varying attributes aside from severe CAS. Information on each participant may be helpful in a clinical setting as it provides additional information which may be helpful for clinicians with similar clients. A limitation of this study was its small sample size of 4 individuals. As mentioned, the inclusion criteria consisted of only children with severe CAS. The authors did not control for other variables which could have an effect on the results. Additionally, the authors state they did not control for frequency of practice trials per session, use of blocked vs. random, or feedback frequency. This study was one of the first to examine DTTC across participants and it provides suggestive evidence of its efficacy. Their findings only demonstrate implications that DTTC can assist speech production in children with severe CAS; and they recommend additional studies study each parameter individually to determine the highest efficacy of treatment.

Maas and Farinealla (2012) used a single-subject design to determine if there was an advantage in retention and transfer for random versus blocked practice of DTTC therapy in children with CAS. Following a two-phase alternating treatments design, the intervention used a DTTC approach to treat four children (age 5 to 7 years) diagnosed with CAS. Every session contained both random and blocked practice, with the order of each type counterbalanced across sessions. Speech targets were individually selected for each child based on their error profile, comparable difficulty, and target independence. A two-week maintenance period to assess retention followed each treatment phase, and throughout the study, weekly probes were administered to track retention. A variable number of randomly selected sessions were scored by a second blinded analyst to assess inter-rater reliability. The sessions ranged from 19% to 44% between children, and mean inter-rater reliability ranged from 79% to 87%. Due to the lack of interpretive data for effect sizes in the CAS treatment literature, improvement was operationally defined as an effect size greater than 1.00 (ie: when the magnitude of change was greater than the standard deviation). The study results were mixed, with two children showing improvements with blocked practice with and without transfer effects, one child showing more improvement with random practice with transfer effects and one child showing no clear improvement or transfer from either type of practice.

Maas, Butalla and Farinealla (2012) used a single-subject design to determine if feedback frequency

(high versus low) affected the retention and transfer of speech motor learning, during DTTC therapy, in children with CAS. Following a two-phase alternating design, feedback was manipulated in the context of DTTC to treat four children (age 5 to 8 years) diagnosed with CAS. The children participated in two four-week phases of DTTC intervention, followed by a two-week maintenance period to assess their retention and transfer. Speech targets were individually selected for each child based on their error profile, comparable difficulty, and independence of targets, but each child underwent both a low-frequency feedback treatment (60% of all trials) and a high-frequency feedback treatment (100% of trials). Data was analyzed for pretreatment, baseline, treatment, and posttreatment sessions. A percentage of correct productions was calculated for each set of probes administered in each treatment condition by dividing the number of correct productions by the total number of attempts. The data was tracked for each session and plotted to show progress from session to session. Each child's data was analyzed by one primary analyst who was blind to the treatment targets, and all the sessions were analyzed in random order to prevent familiarity with a child's speech. Reliability was assessed by a second blinded analyst for a randomly selected number of sessions. Due to the lack of interpretive data for effect sizes in the CAS treatment literature, improvement was operationally defined as an effect size greater than 1.00 (ie: mean difference exceeded SD). The study results were mixed, with two children showing more improvement during low-frequency feedback, one child showing more improvement during high-frequency feedback and one child showing no apparent changes over both treatment periods.

Maas and Farinealla (2012) and Maas, Butalla, and Farinealla (2012) presented a thorough description of the participant eligibility, the initial assessments and results at baselines, and outcome measures and timings. Additionally, the intervention design, target selections, and reliability and fidelity protocols were well described and deemed appropriate. Although all the children in the study had a CAS diagnosis, other characteristics such as age, severity, and comorbid diagnosis were not controlled due to the limited sample size. These conditions make comparison difficult regarding target selection. Due to this variability, it is challenging to know if these results genuinely represent the CAS population and can be broadly generalized. Furthermore, given the absence of interpretive guidelines for effect sizes in the CAS treatment literature, the studies chose to use an operationally defined effect size. Therefore, the effect size used in the two studies cannot be comparable to others. Despite the weaknesses outlined, both studies offer suggestive evidence that DTTC is an effective treatment for children with CAS and that both therapy schedule and feedback frequency should be considered when choosing a delivery method.

Edeal and Gildersleeve-Neumann (2011) used a single-subject design to determine if more practice of speech targets during DTTC lead to increased performance, retention, and transfer of speech motor learning in children with CAS. Two children (3.4 and 6.2 years) were treated with an alternating AB treatment design, with the production frequency differing in the two treatment phases. One child was treated three times a week for 11 weeks, while the other child was treated twice a week for five weeks. Both intervention phases involved DTTC; the moderate frequency therapy requiring 30-40 productions, while the high frequency required 100-150 productions. Speech targets were chosen based on the analysis of the children's play-based speech samples, GTFA-2 scores, developmental appropriateness of speech sound or word shape, and stimulability. The children were probed at the end of every treatment session to determine whether generalization occurred. To further measure performance, after a break from treatment, maintenance data was gathered. The results showed that both treatment designs were effective, evidenced by both children improving on all targets. However, the study also showed that treatments that required a higher production frequency resulted in better in-session performance (retention) and greater generalization to untrained probes (transfer).

Appropriate descriptions of participant eligibility, the initial assessments, results at baseline, outcome measures and timing were given. Additionally, the AB invention design, selection of targets for each child, and effect sizes for each treatment were well described. A thorough explanation to determine fidelity and inter-rater reliability was provided, strengthening the study's validity; however, those assessing the participants were not blind. Like most studies for this population, the variability in the children's characteristics and the number of participants limit the generalization of results. This study offers suggestive evidence that DTTC is an effective treatment for children with CAS, and frequent and intense practice of speech results in a more rapid response to treatment in these children.

Single Case Designs

Case studies are utilized when there is a small population of participants. In a case study, one participant is described in great detail and a therapy

approach is applied. These studies have a weak level of evidence due to their single sample size, but the results of case studies can be taken and implemented into larger studies to help further develop the findings.

Strand and Debertine (2000) conducted a single case design of a 5-year-old female with motor planning difficulties. It is presumed she had CAS though it is not stated within the paper aside from the title. A modified treatment based on integral stimulation was used. A combination of mass and distributed practice was implemented with 30-minute sessions, 4 times a week. A multiple baseline design was implemented across behaviours. Five stimuli were selected and results show that treatment was effective. The authors indicated frequency of intervention and motivation to participate were very important to the success of the treatment. Additionally, they stated that the combination of mass and distributed practice across 5 stimuli was effective because it allowed for maximal movement accuracy and sufficient practice for motor learning. This study suggested that integral stimulation can be used to treat apraxia of speech.

Treatment data was collected from a core set of utterances. Both experimental and control data were collected in the same way each time, with the subject repeating the target utterance after the clinician. Data was collected by two therapists who used a three-point scale to establish inter-judge reliability. The performance ratings were graphed over time to illustrate change.

The objective of this single case study was to provide preliminary evidence examining the efficacy of DTTC. The authors report on preliminary data, not generalization data which raises the question of whether or not these results were maintained over time. Basing their therapy approach on various evidence-based principles of motor learning, the authors state that their study provided preliminary implications for the efficacy of an integrated stimulation approach and that additional work examining the specifics of motor learning and DTTC should be examined for additional efficacy evidence. The strengths of this study include their treatment design as they selected highly functional phrases for the child and increased repetition through multiple sessions. A case study is limited as it examines one individual during treatment. Though the authors outlined the skills of this particular participant, they did not specify if this child had CAS or general motor planning difficulties. This study provides somewhat suggestive evidence regarding integral stimulation as an effective therapy approach as seen through the results of one participant.

Elmer et al., (2008) examined the progress of a 12-year old male with CHARGE association during therapy with DTTC. CHARGE is a complex genetic disorder, which stands for C: Coloboma, H: Heart malformations, A: Choanal atresia, R: Retardation, G: Genital hypoplasia in males, E: Ear malformations. This participant experienced varying cognitive impairments and was also diagnosed with apraxia of speech. Prior to therapy, the subject had no intelligible oral words. Communication was primarily exhibited through the AAC device, Vantage™. This single subject, multiple baseline design occurred across 3 phases in 25 months. Phase 1 established a core vocabulary and introduction to proper articulation of syllable shapes (2 months duration). Phase 2 consisted of therapy intervention, 4 sessions a week for a total of 98 sessions (11 month duration) with the goal of improved movement and syllable shape accuracy. In Phase 3, therapy continued once a week for 32 sessions with the goal of reduced rate of speech. Data was collected during random trials of each target word and recorded on a three point scoring criteria (0 = inaccurate, 1 = minor error, 2 = accurate). Additional data for comprehensibility was collected in phase 3 by collecting rate measures from eight spontaneous 60-second speech samples. Two judges analyzed the samples for rate and comprehensibility at different times (6 weeks later) to demonstrate inter-judge and intra-judge reliability for pre and posttreatment. Results show improvement in verbal production over a total of 25 months. The authors equate most success of the treatment effects to continuous practice which is important for motor learning.

The authors laid out the phases, treatment and procedure for the entire study as they measured the progress of the child. As this is a single case study, the authors used a multiple baseline design across behaviours design to measure change of the specific targets and differentiate between dependent variables. While the results of this study indicate that using DTTC is an effective treatment option, the authors indicated that there were limitations to their study. As much of the data collected was by one clinician, this could potentially add bias into the measurements. Additionally, as this is a single case study, the comparison group is the participant themselves. It is not conclusive as to whether another individual would exhibit the same results. Additionally, like similar studies, the results did not examine the effects of frequency, number of trials or type of feedback provided. This case demonstrates that DTTC is an effective therapy approach for individuals with CAS amongst other cognitive delays, but it is agreed that further research is needed to examine generalizability,

sustainability and the efficacy of therapy on older children. This study provides suggestive evidence for the efficacy of DTTC in older children as the individual included presented with CAS among other comorbidities which could not be controlled and may have provided variations in the results.

Discussion

The studies included in this critical review suggest that DTTC is an effective treatment approach for CAS. Each of the studies provided appropriate descriptions of participant eligibility, assessments, stimuli selection, variables, treatment procedures, outcome measures and timings. Studies with higher external validity contained greater detail on the participants and procedures of the study, making replication easier in the future (Dollaghan, 2007). External validity can also be used to decide if a study's results can be generalized to other participants outside of the study (Dollaghan, 2007). All six studies reviewed used small sample sizes of one to four participants, limiting the representativeness of participants of their population. Although all children had a confirmed CAS diagnosis, they still differed in other characteristics such as age, severity, and comorbid diagnoses. Therefore, clinicians should demonstrate caution when generalizing to children outside of the research samples. Three of the studies reviewed (Elmer et al., (2008), Strand et al., (2006), and Strand & Debertine (2000)) are co-authored by the developer of DTTC. As humans, we are susceptible to subjective bias. There is a natural tendency to ignore contradicting information and support pre-existing beliefs instead (Dollaghan, 2007). Any subjective bias from the author may have impacted the internal validity of the studies. Due to the lack of interpretive data for effect sizes in the CAS treatment literature, the papers had different outcome measures to evaluate the efficacy of DTTC. The inconsistency may make comparing results to other studies and drawing conclusions difficult for practicing clinicians. Thus, the papers selected do not provide compelling evidence of DTTC due to the small sample sizes and variability with CAS diagnoses, however, suggestive evidence regarding efficacy is apparent in each.

Future Research Considerations

It is recommended that further research be conducted to confirm the most effective delivery model of DTTC for CAS and to address the limitations presented in the studies reviewed. In future studies, the following recommendations should be considered to strengthen the level of evidence:

a) Future studies should employ larger sample sizes to improve external validity and generalizability.
b) Future studies should explore the influence of CAS severity and specific comorbidities on DTTC intervention.
c) Future studies should control for CAS severity, comorbidities, and other miscellaneous variables when determining DTTC intervention's effectiveness.
d) Future studies should develop and utilize agreed-upon outcomes measures for CAS treatment studies

Clinical Implications

Although the studies in this review contain limitations, the evidence suggests that DTTC is an effective CAS intervention. Furthermore, the literature supports the principles of high intensity, random practice, and low-frequency feedback when providing DTTC therapy. The evidence provided by these six papers can be utilized by clinicians to plan, direct, and/or enhance their clinical practice when working with children with CAS. DTTC is a flexible approach for dynamic decision-making in treatment. It is an integral stimulation method that can incorporate any type of cues to facilitate a child's production: visual, tactile, and gestural based on what works best for the child. The dynamic adjustments in temporal characteristics, types of cueing, and targets that are both meaningful and functional, allow for an individualized treatment program that will provide opportunities for the child to take increasing responsibility in their motor learning. Overall, DTTC is recommended to treat CAS.

References

American Speech-Language-Hearing Association. (2007). *Childhood apraxia of speech* [Position Statement]. Available from https://www.asha.org/policy/ps2007-00277/

Dollaghan, C. A. (2007). *The handbook for evidence-based practice in communication disorders*. Paul H Brookes Publishing.

Edeal, D. M., & Gildersleeve-Neumann, C. E. (2011). The importance of production frequency in therapy for childhood apraxia of speech. *American Journal of Speech-Language Pathology*, 20(2), 95–110.

Elmer, L. M., Baas, B. S., Barbaresi, W. J., & Strand, E. A. (2008). Treatment of severe childhood apraxia of speech in a 12-year-old male with

CHARGE association. *Journal of Medical Speech-Language Pathology,* 16(4), 181–191

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(3), 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.

Maas, E., Robin, D. A., Austermann Hula, S. N., Freedman, S. E., Wulf, G., Ballard, K. J., & Schmidt, R. A. (2008). Principles of motor learning in treatment of motor speech disorders. *American Journal of Speech-Language Pathology*, 17, 277–298. doi:10.1044/ 1058-0360(2008/025)

Strand, E. A. (2020). Dynamic Temporal and Tactile Cueing: A Treatment Strategy for Childhood Apraxia of Speech. American *Journal of Speech-Language Pathology,* 29(1), 30–48. https://doi-org.proxy1.lib.uwo.ca/10.1044/2019_AJSLP-19-0005

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

Strand, E. A., & Skinder, A. (1999). Treatment of developmental apraxia of speech: Integral stimulation methods. *Clinical management of motor speech dis- orders 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.

Murray, E., McCabe, P., & Ballard, K. J. (2014). A systematic review of treatment outcomes for children with childhood apraxia of speech. *American Journal of Speech-Language Pathology*, 23(3), 486-504. doi:10.1044/2014_ajslp-13-0035