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Communicating care

La communication à coeur

CLINICAL DECISION-MAKING FOR YOUNG CHILDREN WITH SEVERE SPEECH AND EXPRESSIVE LANGUAGE DELAYS AND SUSPECTED MOTOR PLANNING DIFFICULTIES

PROCESSUS DE DÉCISION CLINIQUE POUR LES ENFANTS AYANT UN RETARD SÉVÈRE DE LA PAROLE ET DU LANGAGE EXPRESSIF ET CHEZ QUI L'ON SOUPÇONNE DES DIFFICULTÉS DE PLANIFICATION MOTRICE

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From the Editor-in-Chief

David H. McFarland

SPECIAL ISSUE

I am very pleased to present this Special Edition of the Canadian Journal of Speech-Language Pathology and Audiology focusing on childhood apraxia of speech (CAS). Those of us working with young children know very well that CAS is a devastating speech-motor programming disorder that is extremely difficult to both diagnose and treat. We are on the front lines of providing evidence-based practice to children impacted by CAS using scientific literature, our understanding of the characteristics of our young clients and our clinical expertise.

Drs. Hodge and Gaines have assembled an impressive collection of Canadian clinician-scientists to contribute to our scientific knowledge on the evaluation and treatment of CAS. The diversity of the articles and the approaches used to evaluate and treat CAS, all reflect the great challenges faced by clinicians when addressing this disorder.

My sincere wish is that this Special Edition will not only help advance our knowledge base but will also encourage the scientific and clinical dialogue as to how to better serve your clients faced with this very difficult speech disorder.

David H. McFarland,
Editor-in-Chief,
Canadian Journal of Speech-Language Pathology and Audiology

Mot du rédacteur en chef

David H. McFarland

NUMÉRO SPÉCIAL

C'est avec grand plaisir que je vous présente ce numéro spécial de la revue canadienne d'orthophonie et d'audiologie qui porte sur la dyspraxie verbale. Ceux et celles parmi nous qui travaillent avec de jeunes enfants savent très bien que la dyspraxie verbale est un trouble de programmation motrice de la parole dévastateur pour lequel il est extrêmement difficile de poser un diagnostic et d'intervenir. Nous sommes aux premières lignes pour offrir une pratique basée sur les données probantes aux enfants ayant une dyspraxie verbale, et ce, en utilisant la littérature scientifique, notre compréhension des caractéristiques de nos jeunes clients ainsi que notre expertise clinique.

M^{mes} Hodge et Gaines ont réuni un groupe impressionnant de cliniciens/chercheurs canadiens afin de contribuer aux connaissances scientifiques reliées à l'évaluation et l'intervention auprès des enfants ayant une dyspraxie verbale. La diversité des articles, ainsi que les approches utilisées pour évaluer et intervenir auprès de cette clientèle, reflètent les grands défis auxquels sont confrontés les cliniciens qui interviennent auprès de ce trouble.

J'espère sincèrement que ce numéro spécial ne se bornera pas à faire avancer notre base de connaissances sur le sujet, mais qu'il encouragera également le dialogue scientifique et clinique sur la façon de mieux servir nos clients qui sont aux prises avec ce difficile trouble de la parole.

David H. McFarland,
Rédacteur en chef,
Revue canadienne d'orthophonie et d'audiologie

Guest Editors' Introduction Note

Megan Hodge and Robin Gaines

Clinical decision-making for young children with severe speech and expressive language delays and suspected motor planning difficulties

SPECIAL ISSUE

In this special issue of CJSLPA, Canadian clinicians/researchers share their front line challenges in trying to understand and treat children suspected of having childhood apraxia of speech (CAS). Several articles describe the challenges faced in identifying children with CAS from the much larger population of children with severe speech and expressive language delays. Other articles describe severe speech production delays, in addition to discussing ways to improve children's speech production abilities through individual and group therapeutic approaches.

This collection of articles highlights considerable differences in the criteria used to make interim and later confirmed diagnoses of CAS. Murray, McCabe, Heard, and Ballard (2015) observed that "most researchers agree that the core deficit for children with CAS is a reduced or degraded ability to convert abstract phonological codes to motor speech commands, referred to as motor planning and/or programming" (p.43). However, Murray et al. (2015) also observed that there is longstanding disagreement regarding the criteria used to classify children with this diagnostic label, even for children who can complete a standardized assessment protocol. As noted by Strand (2017), CAS typically occurs along with delays or impairment in phonology, which makes it challenging to "tease out" phonologic (linguistic) and motor-speech deficits.

As illustrated in the article by Pukonen, Grover, Earle, Gaines, and Theoret-Douglas, children with severe speech production delays demonstrate diverging speech production abilities as their speech and language behaviours develop, with only a small number manifesting clear signs of speech motor planning difficulties. These children's response to early intervention is an important factor in making clinical judgments about the presence of CAS. This special issue includes descriptions of several principled and practical approaches to treatment for young children with severe speech production delays that Canadian speech-language pathologists have found useful in making clinical decisions about the nature of a child's speech and language difficulties as well as appropriate next steps in intervention.

Pukonen et al. describe how a clinical working group in Ontario sought out a way to identify very young children with "suspicious" signs of motor planning difficulties. The authors describe a decision-making model based on response to intervention (RTI) for identifying and providing intervention to young children with severe speech sound disorders. Their model provides guidelines for selecting developmentally appropriate interventions and indicators to monitor over the course of intervention when CAS is suspected, allowing clinicians to provide a systematic approach to care for these children.

Three articles (Hodge & Gaines; Kiesewalter, Vincent, & Lefebvre; Lefebvre, Fiorino, Johannsen, Tait, Tkalec, & Sutton) describe examples of treatments that "fit" within the RTI model described by Pukonen et al. for younger children with severe speech production delays or persisting speech sound disorders who may show signs of motor planning difficulties. Hodge and Gaines describe a treatment that was undertaken by clinicians to determine if it better served this small group of young preschool children with suspected motor speech concerns than their existing program for these children. Building on their experience with the intervention model described by Hodge and Gaines, Kiesewalter et al. present a parent group program (*Wee Words*™) developed for young preschool children with severe speech sound difficulties (some with limited imitation skills) as well as their observations of the success of children in the program. Lefebvre et al. describe an interactive approach that uses story books as a focus of speech therapy with two school-aged children and describe some of the clinical outcomes for these individuals.

Three additional articles (Davis & Hodge; Rvachew & Matthews; Lefebvre, Gaines, Staniforth, & Chiasson) report the work of investigators trying to understand and describe the profiles of children with severe speech production delays or persisting speech sound disorders of unknown origin, with suspected motor planning difficulties. Davis and Hodge report the reliability and validity of the *TOCS-30*, which involves collecting and phonetically transcribing a sample of 30 imitated words. They show how it can be a clinically useful tool for describing the speech behaviors of young children with severe speech and expressive language delays. Rvachew and Matthews explain how a diagnostic tool (the Syllable Repetition Task or SRT) can be used to help identify children with phonological and speech motor planning difficulties. These authors present results from children with several different clinical profiles to illustrate how the SRT can be used in an assessment battery to ascertain deficits in underlying speech processes. Lefebvre et al. report an investigation into the possible concerns children with suspected CAS may have in the emergent literacy domain, including phonological awareness and fine motor function.

The co-editors of this special edition, Robin Gaines and Megan Hodge, thank the authors for their contributions as well as for their perseverance and dedication in completing their articles. The co-editors also thank the reviewers for their thoughtful and constructive critiques of the submitted manuscripts, Dr. Paola Colozzo for serving as editor for the article authored by Hodge and Gaines and the CJSLPA editorial staff, especially past and current Editors-in-Chief Dr. Elizabeth Fitzpatrick and Dr. David McFarland, for their support and patience in allowing us to bring this issue to publication. Clinicians are continually searching for better ways to serve this difficult-to-define population of children. Participation in the peer-review process involved in publishing provides opportunities for clinicians to benefit from scholarly feedback about their ideas and practices. The co-editors hope that the collected works presented in this special issue provide readers with new insights about young children suspected of having CAS and stimulate further clinical conversations, actions and investigations that this topic clearly deserves.

References:

Murray, E., McCabe, P., Heard, R., & Ballard, K. J. (2015). Differential diagnosis of children with suspected childhood apraxia of speech. *Journal of Speech, Language, and Hearing Research, 58*, 43–60. doi:10.1044/2014_JSLHR-S-12-0358

Strand, E. (2017). Appraising apraxia: When a speech-sound disorder is severe, how do you know if it's childhood apraxia of speech? *Asha Leader,* 22, 51-58.

Note d'introduction des rédactrices invitées

Megan Hodge et Robin Gaines

Processus de décision clinique pour les enfants ayant un retard sévère de la parole et du langage expressif et chez qui l'on soupçonne des difficultés de planification motrice

NUMÉRO SPÉCIAL

Dans ce numéro spécial de la RCOA, des cliniciens/chercheurs canadiens partagent les défis qu'ils rencontrent en essayant de comprendre et d'intervenir auprès des enfants chez qui l'on soupçonne une dyspraxie verbale. Plusieurs articles décrivent les défis rencontrés pour distinguer les enfants ayant une dyspraxie verbale de ceux inclus dans la grande population d'enfants ayant un retard sévère de la parole et du langage expressif. D'autres articles décrivent les retards sévères de production de la parole, en plus de discuter de la façon d'améliorer les habiletés de production de la parole de ces enfants par l'entremise d'approches d'intervention individuelle et de groupe.

Cette série d'articles souligne les différences considérables observées dans les critères utilisés pour poser un diagnostic d'hypothèse de dyspraxie verbale, ainsi que ceux utilisés pour poser un diagnostic confirmant la présence de ce trouble. Murray, McCabe, Heard et Ballard (2015) ont observé que « la plupart des chercheurs s'entendent sur le fait que le principal déficit des enfants ayant une dyspraxie verbale est une habileté réduite ou détériorée à convertir les représentations phonologiques abstraites en des commandes motrices de la parole, faisant référence à la planification et/ou programmation motrice » (p.43). Néanmoins, Murray et al. (2015) ont également observé que les critères utilisés pour classer les enfants avec ce diagnostic fait depuis longtemps l'objet d'un désaccord, et ce, même auprès des enfants en mesure de compléter un protocole d'évaluation standardisé. Tel que noté par Strand (2017), un retard ou un trouble phonologique accompagne généralement le diagnostic de dyspraxie verbale, ce qui fait en sorte qu'il est difficile de déterminer les déficits phonologiques (linguistiques) et moteurs.

Tel qu'illustré dans l'article de Pukonen, Grover, Earle, Gaines et Theoret-Douglas, les enfants ayant un retard sévère de production de la parole montrent des habiletés de production qui varient au fur et à mesure que leurs habiletés de langage et de la parole se développent. Uniquement un petit nombre d'enfants manifestent des signes évidents de difficultés de planification motrice de la parole. La réponse à l'intervention de ces enfants est un facteur important pour effectuer un jugement clinique à propos de la présence d'une dyspraxie verbale. Ce numéro spécial inclut la description de plusieurs principes et approches pratiques concernant l'intervention auprès des enfants ayant un retard sévère de la production de parole. Ces principes et approches étaient considérés comme utiles par les orthophonistes canadiens pour prendre une décision clinique sur la nature des difficultés de langage et de la parole des enfants, ainsi que pour déterminer les étapes subséquentes appropriées à l'intervention.

L'article Pukonen et al. décrit comment une équipe clinique de l'Ontario a cherché un moyen d'identifier les jeunes enfants présentant des indices « suspects » de difficultés de planification motrice. Les auteurs décrivent un modèle de prise de décision basé sur la réponse à l'intervention afin d'identifier et d'intervenir auprès des enfants ayant un trouble sévère du développement des sons de la parole. Ce modèle fournit des lignes directrices pour sélectionner une intervention adaptée au niveau du développement, en plus de fournir des indicateurs permettant d'effectuer un suivi en cours d'intervention lorsqu'une dyspraxie verbale est soupçonnée. Ce modèle permet aux cliniciens d'utiliser une approche systématique pour intervenir auprès des enfants.

Trois articles (Hodge et Gaines ; Kiesewalter, Vincent et Lefebvre ; Lefebvre, Fiorino, Johannsen, Tait, Tkalec et Sutton) décrivent des exemples d'intervention qui « respectent » le modèle de réponse à l'intervention proposé par Pukonen et al. pour les enfant ayant un retard sévère de production de la parole ou un trouble persistent du développement des sons de la parole avec des indices de difficultés de planification motrice. Hodge et Gaines décrivent une intervention appliquée par des cliniciens ; ils ont regardé si cette intervention répondait mieux aux besoins d'un petit groupe d'enfants d'âge préscolaire chez qui l'on soupçonne des difficultés motrices de la parole que le programme qui était disponible pour ces enfants au moment de l'étude. En s'appuyant sur leur expérience personnelle avec le modèle d'intervention proposé par Hodge et Gaines, Kiesewalter et al. présentent un programme de groupe s'adressant aux parents (*Wee Words*™) ayant été développé pour les enfants d'âge préscolaire ayant des difficultés avec la production des sons de la parole (certains ayant également des habiletés d'imitation limitées). Les auteurs présentent aussi les observations effectuées quant au succès des enfants inclus dans le programme. Lefebvre et al. décrivent une approche interactive utilisant des livres d'histoires comme intervention pour la parole. Cette approche a été appliquée auprès de deux enfants d'âge scolaire ; les auteurs présentent les résultats cliniques pour ces individus.

Trois articles supplémentaires (Davis et Hodge ; Rvachew et Matthews ; Lefebvre, Gaines, Staniforth et Chiasson) rapportent le travail de chercheurs essayant de comprendre et de décrire les profils d'enfants ayant un retard sévère de production de la parole, ou encore, un trouble persistent du développement des sons de la parole d'origine inconnue et chez qui des difficultés de planification motrice sont soupçonnées. Davis et Hodge rapportent la fiabilité et la validité du *TOCS-30*, lequel implique la collecte et la transcription phonétique d'un échantillon de 30 mots produits en imitation. Ces auteurs montrent que le *TOCS-30* peut être un outil utile en clinique pour décrire la production de parole des enfants ayant un retard sévère de la parole et du langage expressif. Rvachew et Matthews expliquent comment un outil diagnostique, soit la tâche de répétition de syllabes (TRS), peut être utilisé pour aider à identifier les enfants ayant des difficultés phonologiques et ceux ayant des difficultés de planification motrice de la parole. Ces auteurs présentent les résultats obtenus auprès d'enfants ayant des profils cliniques distincts, et ce, afin d'illustrer comment la TRS pourrait être utilisée dans une batterie d'évaluation pour vérifier les déficits dans les mécanismes sous-jacents du traitement de la parole. Lefebvre et al. étudient les possibles difficultés d'éveil à l'écrit qui peuvent être présentes chez les enfants ayant une dyspraxie verbale, ce qui inclut les difficultés de conscience phonologique ainsi que celles au plan des habiletés motrices fines.

Les deux rédacteurs de ce numéro spécial, Robin Gaines et Megan Hodge, souhaitent remercier les auteurs pour leur contribution, leur persévérance et leur dévouement dans la réalisation de leur article. Les rédacteurs souhaitent également remercier les réviseurs pour les critiques réfléchies et constructives effectuées sur les manuscrits soumis, Mme Paola Colozzo qui a agi à titre de rédactrice pour l'article de Hodge et Gaines, ainsi que l'équipe de rédaction de la RCOA pour leur support et leur patience ayant permis la progression et la publication de ce numéro, avec une mention particulière aux rédacteurs en chef passé et présent, Mme Elizabeth Fitzpatrick et M. David H. McFarland. Les cliniciens cherchent continuellement de meilleurs moyens pour intervenir auprès de cette population d'enfants difficiles à cerner. La participation de cliniciens dans les processus de révision par les pairs et de publication leur permet de bénéficier d'une rétroaction sur leurs pratiques et idées. Les rédacteurs espèrent que les travaux présentés dans ce numéro spécial vont fournir de nouvelles connaissances aux lecteurs à propos des enfants chez qui l'on soupçonne une dyspraxie verbale, en plus de susciter des discussions cliniques, des actions et des investigations supplémentaires sur ce sujet méritant.

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Murray, E., McCabe, P., Heard, R. et Ballard, K. J. (2015). Differential diagnosis of children with suspected childhood apraxia of speech. *Journal of Speech, Language, and Hearing Research, 58*, 43–60. doi:10.1044/2014_JSLHR-S-12-0358

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A Proposed Model for Identification of Childhood Apraxia of Speech in Young Children

Proposition d'un modèle pour l'identification de la dyspraxie verbale chez les jeunes enfants

KEY WORDS
CHILDHOOD APRAXIA OF SPEECH
MOTOR SPEECH DISORDERS
DIFFERENTIAL DIAGNOSIS
INTERVENTION

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Abstract

Clinicians may suspect Childhood Apraxia of Speech (CAS) in young children whose verbal expression is significantly below their receptive abilities. However, there are no definitive diagnostic markers for CAS and there is an overlap of symptoms between children with CAS, other types of Speech Sound Disorders, and children who are Late Talkers. The purpose of this article is to describe a decision-making process based on Response to Intervention principles for identifying and providing intervention to young children with severe speech sound disorders. It provides clinicians with guidelines for selecting developmentally appropriate interventions as well as indicators to monitor over the course of intervention when CAS is suspected. Differential diagnosis and identification of CAS are based on the quality and quantity of change in the child's overall communication profile in response to intervention as well as the presence of specific indicators that are associated with CAS.

Abrégé

Les cliniciens peuvent être amenés à soupçonner une dyspraxie verbale chez les jeunes enfants dont l'expression verbale est significativement plus faible que les habiletés réceptives. Néanmoins, il n'existe aucun marqueur diagnostique définitif pour la dyspraxie verbale et on note un chevauchement dans les symptômes retrouvés chez les enfants avec une dyspraxie verbale, les enfants avec un autre type de trouble du développement des sons de la parole et les enfants qui parlent tard (« late talker »). L'objectif du présent article est de décrire un processus de prise de décision fondé sur les principes de réponse à l'intervention afin d'identifier et d'intervenir auprès des enfants avec un trouble du développement des sons de la parole sévère. Il fournit des lignes directrices aux cliniciens pour choisir une intervention adaptée au niveau de développement de l'enfant, en plus d'offrir des indicateurs permettant d'effectuer un suivi en cours d'intervention lorsqu'une dyspraxie verbale est soupçonnée. Le diagnostic différentiel et l'identification de la dyspraxie verbale sont basés sur la qualité et la quantité des changements observés dans le profil communicatif global de l'enfant en réponse à l'intervention, ainsi que sur la présence d'indicateurs spécifiques associés à la dyspraxie verbale.

Introduction

In 1996, Ontario introduced the Preschool Speech and Language (PSL) initiative to support early identification and intervention for children from birth to age five years. A key mandate of the initiative was to identify children with speech-language delays and disorders as early as possible so they could receive intervention to develop the skills needed for success in school (Ontario Government, 1996).

The focus on early identification resulted in a downward shift in the age of children on the caseloads of PSL speech-language pathologists. As a result, clinicians began identifying more children under the age of three years whose verbal expression was notably poorer than their receptive abilities. When presented with this profile, clinicians often queried whether they were working with a child with Childhood Apraxia of Speech (CAS) and sought direction on how to provide intervention given the child's young age. Concerns emerged about the over-identification of CAS and that different approaches were being used across the province to support this group of children. As well, some PSL staff felt more confident in serving these children than others. The Ministry of Children and Youth Services responded to these concerns by establishing a PSL Motor Speech Work Group in early 2009 to:

- survey current practices and challenges in service delivery to young children with suspected or identified motor speech difficulties in Ontario;
- review the evidence base and best practices for assessment and intervention for this population;
- develop recommendations for a service model to guide practice and support service equity across the province.

The Work Group developed a survey, which consisted of a series of questions about service delivery for preschool children with suspected motor speech difficulties. It was completed by the coordinators for each of the 32 regions in the province. Analysis of the responses revealed two major trends. First, there was large variability in the number of children with motor speech difficulties identified across the various regions. Estimates ranged from less than 1% to over 20% of children on clinicians' caseloads. Secondly, many clinicians reported a need for ongoing education and training to develop their knowledge base and comfort level in working with this population. Specifically, they requested information on differential diagnosis of motor speech disorders and best practice intervention guidelines especially for young children (Pukonen, Earle, Gaines, Grover, & Theoret-Douglas, 2011).

The Work Group reviewed the literature to develop guidelines for the identification and treatment of CAS in the age range of children seen by the PSLs, which is typically 18 to 48 months of age. Key reference documents were the ASHA Technical Report on CAS (2007) and an article by Davis and Velleman (2000) on the differential diagnosis of CAS in infants and toddlers under 36 months of age.

In the ASHA Technical Report, CAS is defined as a neurological pediatric Speech Sound Disorder (SSD) in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits. There is no validated list of diagnostic features that differentiates CAS from other types of childhood speech disorders. The core impairment in CAS is planning and/or programming spatiotemporal parameters of movement sequences. Therefore, a clinician must look for features that are consistent with a deficit in planning speech movements such as:

- inconsistent errors producing consonants and vowels in repeated productions of syllables and words;
- lengthened coarticulatory transitions between sounds and syllables;
- inappropriate prosody, especially in the realization of lexical or phrasal stress. (ASHA, 2007, p. 3)

Differential diagnosis of CAS from other SSDs is clinically challenging for a number of reasons. In addition to the fact that there is no validated list of features, the signs of CAS may vary among children and can change as children mature (ASHA, 2007). CAS also shares a number of features with other SSDs such as delayed speech onset, limited vocal output, reduced intelligibility, limited phonetic inventory and syllable shapes, and a tendency to rely on gestures over vocal communication (Flipsen & Gildersleeve-Neumann, 2009). Most of these clinical signs are also seen in the early stages of linguistic development (e.g. use of simple syllable shapes, variability in production patterns at onset of development) (Davis & Velleman, 2000), raising the possibility that the speech patterns observed may reflect a delay rather than a disorder in development. Furthermore, young children may not have sufficient verbal skills to produce polysyllabic words or be willing to attempt the increasingly complex productions required for differential diagnosis.

Despite all of these challenges, differential diagnosis is an important task since it guides selection of an intervention approach. Children with CAS benefit from intervention that includes an intensive therapy schedule, motor learning principles, and multisensory treatment strategies (ASHA, 2007). In addition, the behaviours associated with CAS place children at an increased risk for early and persistent problems in the areas of speech, expressive language, and the phonological foundations of literacy (ASHA 2007). In order to optimize outcomes it is important to identify this subpopulation of children in a timely manner and provide appropriate and effective intervention. The child's "potential for normalization of speech and prosody may be substantially reduced if not addressed during early periods of growth and development" (ASHA, 2007, p. 41).

Over diagnosis, however, is a prevalent issue in the field (ASHA, 2007; also see Murray, McCabe, Heard, & Ballard, 2015). CAS is a low incidence disorder with population prevalence estimates of 1 in a 1000 (Shriberg & Kwiatkowski, 1994) but the label tends to be applied at a much higher rate. According to Shriberg, Paul, Black, and van Santen (2011) "several sources internationally indicate false positive rates for CAS of 80%-90%, reflecting the lack of consensus on the inclusionary and exclusionary criteria for this disorder, especially as suspected in toddlers, preschool, and early elementary age children" (p. 411).

The nature of early childhood development also complicates the process of identifying CAS. According to a set of developmental concepts identified in ASHA's "Roles and responsibilities of speech-language pathologists in early intervention: Technical report" (2008), it is important to recognize that in infants and toddlers:

- there is a broad range of individual differences, which often makes it difficult to distinguish normal variations and maturational delays from transient disorders and persistent impairments;
- development unfolds along individual pathways whose trajectories are characterized by continuities and discontinuities, as well as by a series of significant transitions;
- development is shaped by a dynamic and continuous interaction between biology and experience (Overview, para. 1).

Therefore, even if a child presents with some early features suggesting CAS, the child's profile will change with development and experience. Continued signs of CAS may or may not persist.

Appropriate identification of CAS is important since a premature and potentially inaccurate label of CAS can distress families needlessly. It may also shift a clinician's focus prematurely to intensive speech skill intervention before the child has developed the language, attention, and metacognitive skills to support the speech therapy process. Intervention that does not engage a child and support successful communication experiences may result in therapy weary/resistant children and may actually have a negative impact on children's participation in future therapy and ultimately on progress. Another concern with premature diagnosis of CAS is that it may influence how clinical resources are directed. The literature indicates that children with CAS require intensive therapy and an inaccurate label may result in children receiving an intensity of treatment that is not required. Since publicly funded services are stretched and private services are expensive for many families, it is important to determine that a child actually requires and is ready for increased treatment intensity.

Davis and Velleman (2000) recommended that:

> "Clinical diagnosis of CAS should be approached with extreme caution in the infant-toddler population. Instead, CAS may be more appropriately utilized as a diagnostic label after a period of intervention allowing a larger window of time to (a) view the child's emergence into consistent use of oral communication, (b) observe the presence and persistence of differential diagnostic indicators and (c) assess the child's response to intervention in areas critical to diagnosis (p.183)."

Service Model Development

The Work Group's decisions flowed from the above recommendations as well as the Response to Intervention (RTI) literature (Sampson-Graner, Faggella-Luby, & Fritschmann, 2005). RTI is an approach used in education to identify and support students with different learning needs. A central feature is the concept of tiered instruction. All children are provided with a quality, evidence-based program in a core area and the rate, quantity, and quality of change is monitored. As the nature of any learning difficulties become more apparent, the specificity and intensity of the intervention is increased to address the children's needs.

The Work Group determined that:

- identification of CAS should be viewed as a process that occurs over time;
- identification, intervention, and decision making processes should be based on RTI principles such as tiered intervention, progress monitoring, and data-based decision making.

The Work Group reviewed literature on assessment and treatment of children's motor speech disorders with a focus on CAS as well as existing programs for this population of children in Ontario. In addition to the key articles already mentioned, the literature review included articles on the nature of early development (ASHA, 2008; Moore, 2004; National Scientific Council on the Developing Child, 2007), Late Talkers (Rescorla & Dale, 2013), motor-based therapy approaches, techniques and goal setting (Caruso & Strand, 1999; Hayden, Eigen, Walker, & Olsen, 2010; Hayden & Square, 1994; Strand, Stoeckel, & Baas, 2006), and motor learning principles (Maas et al., 2008). Intervention programs reviewed were Target Word™ (Earle & Lowry, 2011), Wee Words (Kiesewalter, Vincent, & Lefebvre, 2017), Play and Say (Pukonen & Grover, 2005), Let's Start Talking™ (Hodge, 2007), and a motor-based program developed at The Speech and Stuttering Institute (Namasivayam et al., 2013).

The programs were analyzed according to factors such as target population, focus of intervention (e.g., facilitation of expressive communication skills, targeting early speech sound development, motor speech therapy), whether the parent or the child was the primary recipient of the service, the intervention context (play, daily routines, or structured therapy activities), and the length and intensity of the program. Program content was compared with recommendations in the literature to assess consistency with recommended practices. This information was used to develop the intervention guidelines for the proposed service model.

A decision was made to develop a multi-level model that would provide clinicians with a framework for identifying children with SSD and suspected CAS while providing developmentally appropriate intervention. The proposed model consists of three levels that span the age range of children seen through PSL services. A division was made between under and over 36 months to align with the demarcation between early intervention and preschool services. Two levels were included within the under 36 month level since some children enter the system at 18 to 24 months of age and even after a block of intervention are still under 36 months of age. The intervention models at each level were selected based on developmentally appropriate practices for the various age groups. The Work Group recommended parent training-coaching models for children less than 36 months of age and direct intervention with parent participation models for children older than 36 months of age.

In keeping with a diagnostic perspective and the concept of tiered intervention, the interventions and labels in the model become refined in a successive manner and follow a developmental progression. In Level 1, Diagnostic Expressive Communication (under 30 months of age), the focus is on facilitating expressive communication development. Level 2, Early Speech Intervention (30 to 36 months of age), brings increased attention to early speech sound development within language-based activities and social interactions. At Level 3, Motor Speech Therapy (over 36 months), the emphasis shifts to motor-based speech therapy. Appendix A presents a flow chart illustrating the various clinical activities and decision points in the identification and treatment selection processes within the proposed model.

Ideally, a child is identified with primary expressive communication concerns under 30 months of age and his/her progression through the levels is determined by the presence of indicators suggesting more specific difficulties in speech development as well as by his/her readiness to participate in the recommended intervention (e.g. attention and skills to participate in increasingly structured, adult directed activities). The indicators to be monitored appear in Appendix B and are based on characteristics identified in the literature that suggest a more persistent speech sound difficulty, motor speech involvement, or CAS, depending on the intervention level. When a child does not meet criteria for the next level or a parent is unable to participate in a specific treatment model, an appropriate alternative intervention is recommended. Children older than 30 months may enter the proposed service model at higher levels when they present with the specified target profile.

The following section provides a description of the various levels of the proposed service model including child characteristics, intervention focus and approach, and indicators to monitor that will facilitate differential diagnosis.

Level 1: Diagnostic Expressive Communication (typically under 30 months)

Clinicians might begin suspecting CAS when they assess a child under 30 months of age who is an intentional communicator and presents with good social communication skills, no signs of cognitive, structural, sensory, or neurodevelopmental disabilities, age appropriate receptive language skills, and limited expressive vocabulary and vocal output. The child may have been a quiet baby with limited babbling, late emergence of first words and possibly have a family history of speech, language, or learning difficulties. It is premature to apply the CAS label since these characteristics are also true for children who are Late Talkers and children with other types of SSD. At this stage, all that can be determined with confidence is that the child's expressive communication is delayed and speech development should be monitored.

The focus of intervention at this age and stage is to support the development of the child's expressive communication skills. Goals include increasing the child's frequency of vocalizations and verbal approximations in communicative interactions, developing vocal/verbal imitation skills, expanding functional expressive vocabulary, and developing word combinations. The child's attempts to communicate by nonverbal means (e.g. facial expression, gaze, and gesture) continue to be supported.

The parent is the primary recipient of the intervention since s/he has the greatest influence over the child's communication environment and children at this age learn best through adults with whom they have a relationship (ASHA, 2008). Parents are provided with information as well as opportunities to practice and be coached in strategies that help them provide a responsive, supportive communication environment throughout the child's day.

An example of a Level 1 program is Target Word™ (Earle & Lowry, 2011). This parent training program includes a preprogram assessment, five parent group sessions, and two individual consultation sessions. Group sessions are offered once every 2 weeks and are spread over a 10 to 12 week time period in order to provide parents with time to practice strategies and observe the impact on their child's communication development. Ten, individual words that are motivating for the child to say and use specific speech movements are chosen with the parents.

In addition to documenting changes in expressive language and play skills, the clinician monitors the child's progress over the course of intervention to identify the rate and quality of change in the child's speech sound system. The clinician specifically observes the pattern of speech development to determine whether it is following a typical or atypical progression. Williams and Elbert (2003) suggested that, around 33 months of age, limited phonetic inventory, limited diversity of syllable structures, simple syllable structures, greater number of sound errors, greater variability and inconsistent substitution errors, atypical error patterns, and slower rate of resolution are potential predictors of long term phonological delay. Early speech intervention is recommended when several of these indicators are observed in a child's speech.

Level 2: Early Speech Intervention (typically 30 - 36 months)

When speech concerns begin to emerge, it is important to consider the full range of factors that may be influencing speech development. Speech sound disorders may be due to any combination of difficulties with perception, motor production, and/or the phonological representation of speech sounds and segments (ASHA, n.d.). All of these processes are under development during this stage of childhood so it is important to consider and support each of them.

The focus of intervention at this level is on developing skills that support speech learning such as listening, watching, attending and imitating, as well as expanding the child's speech system through functional expressive vocabulary. Target vocabulary is selected to increase the child's repertoire of consonants, vowels, and syllable shapes. The motor complexity of the words is carefully considered in order to select vocabulary with sound and movement sequences that are easier to produce and facilitate correct sound production. Understanding the movement parameters of a word also provides clinicians with a framework for observing and monitoring the development of a child's speech motor control.

Parents continue to play a primary role in this intervention model and the parent-child dyad is considered to be the "client". The clinician works directly with the child to identify effective strategies and to demonstrate them for parents. The clinician also coaches parents to apply these strategies when communicating with their child. This model can be delivered in a group format or with a single parent-child dyad.

An example of a program at this level is Wee Words (Kiesewalter et al., 2017). This group-based parent and child program is 10 weeks in length and includes a pre-evaluation appointment, two parent education sessions, six mediated therapy sessions, and a follow up appointment.

To support ongoing, systematic identification of CAS, indicators for motor speech involvement are monitored throughout the intervention. It is still premature to identify CAS although clinicians may begin to suspect it. The Work Group recommended that clinicians maintain a broader perspective and monitor indicators suggesting motor speech involvement (i.e., watch for signs of CAS and mild dysarthria). This approach identifies a group of children, including those with CAS, who could benefit from a motor-based treatment approach. Indicators suggesting motor speech difficulties include restricted consonant and vowel repertoires, atypical speech errors (e.g. more omissions than substitutions, atypical sound substitutions, and/or distortions), limited variety/high variability of speech motor movements during speech production (i.e. jaw and lip movements), as well as atypical strength/range of speech motor movement, atypical lexical stress, or prosody (Davis & Velleman, 2000; Shriberg, Lohmeier, Strand & Jakielski, 2012; Vick et al., 2014). The following indicators typically associated with CAS are also included in the list: groping for sounds/words; words/phrases that are used and then are not heard again; frequently used utterances are produced more accurately than novel ones (Davis & Velleman, 2000).

Motor speech therapy is recommended when a child presents with a profile that includes a moderate to severe SSD at the single word level, poor speech intelligibility in spontaneous speech, and multiple indicators suggesting motor speech involvement.

Level 3: Motor Speech Therapy (typically over 36 months)

There are numerous intervention approaches for children with SSD and each targets different aspects of the speech production process (Williams, McLeod, & McCauley, 2010). The literature suggests that for children with motor-based disorders including CAS, it is important to select an approach that focuses on improving verbal motor skills and incorporates principles of motor learning (Strand, 2013). Important components of motor-based therapy include:

- selecting goals that are appropriate for and develop a child's motor speech control while also expanding the child's repertoire of phonemes, syllable shapes, and transitions between articulatory postures (Hayden & Square, 1994; Davis & Velleman, 2000);
- using hierarchical and multisensory cueing strategies to support more accurate speech production (Strand et al., 2006; Hayden et al., 2010);
- organizing practice according to motor learning principles (Caruso & Strand, 1999; Maas et al., 2008).

An example of a program that includes these components is Let's Start Talking™ (Hodge & Gaines, 2017).

Motor learning problems make it challenging for a child to develop new motor patterns, retrieve them, and use them functionally. Therefore, increased intensity of service is an important component of intervention for supporting speech motor skill acquisition and developing automaticity of new motor speech movements. ASHA (2007) recommends three to five therapy sessions per week for children with CAS, but this intensity of service is difficult to achieve within the Canadian models of speech/language service delivery. There is evidence to suggest positive gains with two sessions per week (Gaines & Hodge, 2008; Namasivayam et al., 2014), therefore a minimum of two sessions of individual therapy per week, for 8 to 10 weeks, was recommended by the Work Group.

Individual therapy is recommended because it offers more opportunities for intensive practice and child and parent feedback. Group therapy is a complex learning environment with more potential distractions and fewer opportunities for practice of speech targets with individualized cueing and feedback. Young children with suspected CAS may have difficulty focusing on the clinician and may not have sufficient practice opportunities to develop and establish new speech motor patterns within a group setting.

To engage in motor speech therapy children should be at a developmental level where they are able to attend and participate in adult-initiated activities, produce multiple repetitions of target words, monitor their productions, and remain engaged in the therapy process for extended interactions. Each child's individual profile should be considered to determine the appropriateness of this approach for the child at a particular point in time.

In motor speech therapy, the child is the primary client and the parent is an important partner in the process. The clinician works with the child to support improved production quality and provides opportunities to practice new speech patterns. The parent is provided information and opportunities to practice strategies with his/her child and be coached by the clinician. This ensures that the parent understands and is able to support the child's speech practice at home. In addition, the parent participates in the goal selection process and has regular discussions with the clinician regarding the effectiveness of strategies, the child's progress, and any concerns or questions that arise between sessions (Hodge, 2007). This allows the program to be individualized for each child and parent.

At this point in intervention it often becomes more evident whether a child is demonstrating difficulties with motor planning. Due to the focused nature of the therapy, the clinician is able to observe the type of speech and movement difficulties the child demonstrates, identify facilitative strategies that improve speech production, and monitor the quality and rate of change. Indicators to monitor that are indicative of CAS include more than four of the following characteristics across several different speech production contexts (Shriberg, Potter & Strand, 2011):

- difficulty achieving initial articulatory configurations and transitions into vowels
- syllable segregation
- lexical stress errors or equal stress
- vowel or consonant distortions including distorted substitutions
- groping
- intrusive schwa
- voicing errors
- slow rate
- slow diadokokinetic rate
- increased difficulty with longer or more phonetically complex words

If the child is identified as presenting with CAS, it is recommended that the child receive a consecutive block of intensive (i.e. at least twice weekly) motor speech intervention since speech intelligibility often continues to be quite limited after only one block of treatment (Namasivayam et al., 2014). When a child continues to present with speech difficulties but does not meet criteria for CAS, an intervention appropriate for meeting the child's needs is recommended.

Children with CAS are at elevated risk for literacy related problems therefore expressive language, phonological awareness, and early literacy goals should also be incorporated into the treatment plan. For example, specific expressive language goals can be targeted when practicing speech production accuracy in longer and more complex utterances. Phonological awareness skills can be supported by drawing a child's attention to the location of the sound in a word (i.e. whether it is at the beginning, middle, end of the word) or when asking a child to judge whether they achieved a production target. Sound-symbol associations are strengthened by using graphemes or other representative symbols (e.g. "h" is the windy sound) to cue and/or elicit specific sounds or sound sequences. Simple, repetitive stories can be used as a context for practicing target words or phrases by having the child retell or "read" the story.

Murray, McCabe, and Ballard (2014) conducted a systematic review of the CAS treatment literature and identified three treatments as having evidence to support their efficacy. They concluded that:

> DTTC (Dynamic Temporal and Tactile Cueing) appears to work better for clients with more severe CAS, Integrated Phonological Awareness Intervention appears to work better for children 4-7 years of age with mild to severe CAS, and ReST (Rapid Syllable Transition Treatment) appears to work better for children 7-10 years of age with mild-to-moderate CAS (p.501).

They also indicated that PROMPT (Hayden et al., 2010) and the Nuffield Dyspraxia Programme (Belton, 2006) were two other approaches that had potential suggestive evidence to support their efficacy.

Decision Making Checklist

The Work Group developed the "Decision-making checklist for the identification of CAS" (see Appendix B) to provide clinicians with a tool to support implementation of the proposed model into clinical practice. The checklist is divided into three sections which correspond to the three proposed intervention levels. Each section includes the characteristics of the target population for the level, the focus of intervention, indicators that will assist with progressive differential diagnosis of CAS, and selection of the next intervention.

Case Examples Illustrating Application of the Proposed Model and Decision Making Checklist

The proposed model for identification of CAS and the decision-making checklist have been used since 2010 by clinicians working in the Early Abilities Preschool Speech and Language Services program. Four case studies will be presented to demonstrate how the model and checklist are used to guide clinical observation, select an intervention approach, and identify a child with CAS over successive interventions.

Four children (Child D/B/L/N) entered into service between 18 and 24 months of age and on initial evaluation presented with several of the case history/risk factors for a SSD, which are reported in Table 1. None of the children presented with delayed motor milestones, feeding/drooling issues, or excessive oral sucking habits.

As shown in Table 2, each child met the target profile for diagnostic expressive communication intervention and had an expressive vocabulary of less than 20 words and receptive language skills within the broad range of normal. They all demonstrated a variety of communicative functions and had developed a gestural

Table 1. Comparison of Children's Case History/Risk Factors

Case History/Risk Factors	Child D	Child B	Child L	Child N
Family history of speech/language/ learning difficulties	✓		✓	✓
Reduced quality and/or quantity of babbling as an infant	✓	✓	✓	✓
History of Otitis Media with effusion		✓		
Delayed motor milestones/ difficulties with motor development				
Difficulties reported in feeding				
Drooling reported or observed				
Excessive oral sucking habits (e.g. pacifiers, thumb sucking)				

Table 2. Comparison of Children's Profiles Before Diagnostic Expressive Communication Intervention

LEVEL 1: Diagnostic Expressive Communication Intervention				
Target Profile:	**Child D**	**Child B**	**Child L**	**Child N**
Receptive language skills within the broad range of normal	✓	✓	✓	✓
Limited vocabulary and/or vocal output for communicative purposes	✓	✓	✓	✓
May have developed a gestural symbolic communication system	✓	✓	✓	✓
No social communication concerns	✓	✓	✓	✓

system to communicate. No social interaction issues were identified.

Level 1 – Diagnostic Expressive Communication Intervention

Diagnostic expressive communication intervention was recommended for all four children. The children and their parents participated in a 10-week group parent training/ coaching program. The focus of the intervention was to develop parent understanding and use of strategies that would support their child's expressive language development and:

- increase frequency of vocalization for communicative purposes
- improve verbal imitation skills
- expand expressive vocabulary

On completion of the program the children were placed on a 12-week consolidation block where they did not receive direct intervention and parents were asked to continue using the strategies in daily interactions with their child (e.g. interpret their child's nonverbal messages, use focused stimulation, take balanced turns and provide him/her with opportunities to respond). A follow-up appointment was scheduled to reassess the child,

Table 3. Comparison of Children's Profiles Post Diagnostic Expressive Communication Intervention: Presence of Red Flags for Speech Sound Disorder

Level 1 Red Flags for SSD (reference: Williams & Elbert, 2003)	Child D	Child B	Child L	Child N
Limited increase in frequency of communicative vocalizations/verbal approximations			✓	
Limited expressive vocabulary growth	✓		✓	✓
Limited change in consonant and vowel repertoire	✓		✓	✓
Limited change in syllable shapes	✓		✓	✓
Variability and inconsistent substitution errors			✓	
Atypical speech error patterns			✓	✓

administer the checklist, and evaluate the child's response to the intervention. Table 3 summarizes the children's profiles upon reassessment.

Child D (29 months) demonstrated positive changes in his willingness to imitate and his frequency of vocal/verbal communication attempts. He began combining gestures and vocalizations to convey a variety of communicative messages. His vocabulary growth was small (parents reported a limited vocabulary growth from 20 words to a total of 30 words) and he was not yet combining words. Analysis of the child's vocabulary revealed that he used a limited variety of consonants /b, d, j, w, n, m/, a bilabial fricative, and the vowels /i u a æ ʌ/. Syllable shapes were limited to CV[1] and CV[1]CV[1] and speech motor movements were restricted (i.e., reduced range of jaw excursion and lip movement). Child D demonstrated red flags for a SSD (see Table 3) and met the target profile for Early Speech Intervention as shown in Table 4.

Child B (27 months) made the most progress in the program and did not present with red flags for a SSD at the end of the consolidation period (i.e., treatment off block). He demonstrated excellent gains in both his vocabulary and early expressive language skills. Parents completed a vocabulary inventory and reported that he had a varied vocabulary of over 80 words and was combining two words. Informal observations indicated that his speech was clear and that Child B produced all age appropriate syllable shapes, vowels, and consonants. The parent was given a home program and a 6-month follow-up appointment was scheduled to monitor and ensure the child's continued progress.

Child L (28 months) made limited gains in the expressive communication intervention. Minimal increase was seen in his frequency of vocalizations and the size of his expressive vocabulary (increase of only two new words). His gestural repertoire expanded to over 15 gestures and he was observed to combine 2 to 3 gestures to convey a variety of messages. He remained very reluctant to imitate vocal or verbal models and frequently combined grunts with gestures. Significantly reduced variety of speech motor movements were observed and his speech sound repertoire was limited to /d, m/. The only vowel produced was /ʌ/. At the time of the reassessment, Child L demonstrated all the red flags for SSD and fit the target profile for Early Speech Intervention.

Child N (29 months) made notable gains in his gestural communication and, similar to child D, increased in his frequency of vocal/verbal communication attempts. He demonstrated some growth in his vocabulary (an increase of 23 words to a total of 41 words) but was not yet combining words. He continued to be a reluctant imitator of new words and in fact became very resistant to any strategies used to encourage imitation. Child N was aware of his ineffective communication. On reassessment, Child N's syllable repertoire was limited and both medial and final consonant omissions predominated in his output. Child N's consonant repertoire was restricted to /d, t, j, n/ and most vowels were present except for rounded vowels. Limited lip movement for closure and rounding was observed. Child N continued to present with red flags for a SSD and met criteria for Early Speech Intervention.

The case of Child B demonstrates that children under 30 months of age who initially present with expressive communication delays and have reported risk factors for SSD, do not necessarily develop into children with SSD despite having a profile similar to those children who do.

Level 2 – Early Speech Intervention

Child D, L, and N met the target profile for a more focused speech intervention and were consequently placed in an Early Speech Intervention program (see Table 4).

This group program ran for 8 weeks and included 8 weekly parent-child sessions and 2 parent-only education sessions. The program focussed on teaching parents strategies to help their child:

- develop speech learning skills (listening, watching, attending)
- develop vocal and verbal imitation skills
- expand expressive vocabulary

The children's response to the intervention strategies was monitored throughout the program along with the development of their speech production skills. The checklist was completed immediately after the program to identify red flags for motor speech involvement and to guide the clinicians in determining immediate next steps for each child. All three children made progress in the program but to varying degrees and decisions needed to be made as to whether the children should be placed on a treatment off block to consolidate skills or continue with more intensive speech-focused intervention. In all cases, the children's expressive vocabulary expanded

Table 4. Comparison of Children's Profiles Before Early Speech Intervention

LEVEL 2: Early Speech Intervention (typically under 36 months)				
Target Profile:	**Child D**	**Child B**	**Child L**	**Child N**
Child has a receptive/expressive language gap with no social communication or behavioural concerns	✓		✓	✓
Child is able to incorporate adult participation in play and take multiple turns	✓		✓	✓
Child has made little change in verbal skills in the last 3 months	✓		✓	✓
Limited vocal/verbal output			✓	
Limited expressive vocabulary	✓		✓	✓
Limited verbal imitation skills	✓		✓	✓
Limited syllable shapes	✓		✓	✓
Limited variety of consonants in repertoire	✓		✓	✓

Table 5. Comparison of Children's Profiles Post Early Speech Intervention: Presence of Red Flags for Motor Speech Involvement

Level 2: Red flags for motor speech involvement (references: Davis & Velleman, 2000; Shriberg, Jakielski, & Strand, 2010; Vick et al., 2014)	Child D	Child B	Child L	Child N
Limited variety of vowels and/or vowel distortions in repertoire			✓	
Atypical speech errors			✓	✓
Uses non-speech sounds or non- syllabic vocalizations to communicate				
Limited variety/high variability of speech motor movements			✓	✓
Words are used then disappear			✓	✓
Frequently used utterances are easier to produce than novel ones	✓		✓	✓
Limited/stereotyped intonation patterns or difficulty with prolonged phonation			✓	
Reduced strength of articulatory contacts	✓		✓	
Reduced rate and/or range of speech motor movements			✓	✓

and the clinician was able to evaluate speech production skills and motor control for speech. Table 5 provides a summary of the red flags for motor speech involvement for each of the children.

Child D (32 months) made observable progress in his speech learning skills (i.e. watching-listening-imitating) and responded well to strategies that promoted development of his consonant and syllable repertoire. By the end of the program he had acquired final consonants and all age appropriate syllable shapes were being produced (CV, VC. CVC. CV^1CV^2, CVCVC, VCVC). Most age-appropriate consonants were demonstrated in at least one word position (i.e. word initial, medial, or final position). Mild difficulties were observed in strength of articulatory contacts during production of new words and word combinations. All vowels were present and his speech motor movements were more varied and typical (e.g. control and range of jaw, lip, and tongue movements). Parents reported fair to good clarity of speech at home. Administration of the checklist indicated that Child D did not present with enough red flags to indicate significant motor speech involvement. He was placed on an off treatment block to consolidate and generalize skills and was scheduled to come back for a 6 month follow-up to reassess his speech and language development.

Child L (31 months) made the least progress in the program. He continued to demonstrate significant difficulties with speech development and presented with most of the red flags on the checklist for motor speech involvement. His consonant repertoire had increased but was still limited and he continued to present with vowel distortions and limited syllable shapes. Atypical phonological processes were demonstrated (i.e., unusual assimilations, inconsistent initial and medial consonant omissions) as well as sound distortions, voicing errors, and atypical prosody. Rate of speech was slow and groping was observed. His spontaneous speech continued to be unintelligible. Child L however, was more willing to imitate new words and motor movements when supportive strategies were used by the parent and clinician. He had established some basic control of phonation and jaw movement but tongue, lip, and integrated speech motor control remained poor. Child L presented with multiple indicators suggesting motor speech involvement and went immediately into a more intensive level 3 motor speech program.

Child N (32 months) made fair progress in the program but continued to demonstrate persistence of early phonological processes (final consonant deletion, syllable omissions) and a restricted consonant inventory. Difficulties with airflow control for frication persisted, as did inconsistent production of bilabials. Speech intelligibility was poor and he continued to be highly aware of his difficulties. Consequently, engagement in adult-directed speech activities was inconsistent. While Child N continued to demonstrate red flags for motor speech involvement, his reluctance to participate in more structured speech activities resulted in a decision to recommend a therapy break for 3 to 4 months and have his mother continue using focused stimulation and strategies to support expressive vocabulary development. Child N was reassessed four months later at 36 months of age. The checklist was re-administered and his readiness to participate in more direct intervention was re-evaluated. Child N met the criteria for motor speech intervention and since his ability to tolerate a more intensive and structured speech approach had improved, he was placed into a level 3 motor speech program.

While all three children, (D. L, N), initially presented with red flags for SSD, Child D's progress demonstrates that some children under 36 months of age make good progress when provided with intervention that teaches parents to support early speech development (e.g. drawing child's attention to verbal models, developing imitation skills, providing increased opportunities for the child to use targeted vocabulary in functional/play activities). Over the course of intervention clinicians can monitor children's progress, determine their need for a

Table 6. Comparison of Children's Profiles Before Motor Speech Intervention

LEVEL 3: Motor Speech Intervention (typically over 36 months)				
Target Profile:	**Child D**	**Child B**	**Child L**	**Child N**
Receptive language skills within the broad range of normal			✓	✓
Speech sound disorder on testing (<16th %ile)			✓	✓
Speech is unintelligible approximately half of the time to unfamiliar listener			✓	✓
Child is able to attend and participate in adult directed speech activities			✓	✓
Multiple characteristics suggesting MS Involvement are present:				
Persistence of early phonological processes (e.g. final consonant deletion, reduplication, syllable deletion, consonant harmony) (e.g. goggy - doggy)				✓
Presence of atypical phonological processes (e.g. initial consonant deletion, backing, stops produced as fricatives)			✓	
Restricted consonant inventory			✓	✓

Limited vowel repertoire or vowel distortions			✓	
Imprecise sound production/distortions			✓	✓
Inconsistent errors on consonants and vowels on repeated productions of the same syllables or words			✓	
Increased errors with increased word length and phonetic complexity			✓	✓
Voicing errors			✓	✓
Groping – difficulty in achieving articulatory configurations or transitioning between movement gestures			✓	
Altered suprasegmental characteristics (rate, pitch, loudness, nasality, prosody)			✓	

therapy break, and identify those who present with red flags for motor speech involvement and would benefit from motor speech therapy.

Level 3 - Motor Speech Therapy

Child L and Child N presented with a severe SSD with signs of motor speech involvement and met the criteria for participation in a motor speech intervention program as shown in Table 6.

Both children received individual therapy sessions twice a week for 10 weeks. The parents continued to be involved in session activities and were asked to follow through with specific home practice activities. The focus of the program was to increase the children's speech intelligibility by:

- developing control of motor speech movements and movement sequences
- increasing speech sound repertoire
- increasing syllable and word shapes

The children's response to intervention was monitored and the checklist was administered at completion of the intervention cycle to look for indicators associated with CAS. Both children made progress with intervention and speech intelligibility improved. Consonant repertoires expanded as did syllable shapes.

Child N (39 months) made the greatest gains and his intelligibly improved significantly. Formal speech testing indicated that Child N continued to present with sound substitution errors and difficulties with multisyllabic words. Formal speech testing indicated a severe SSD however, administration of the checklist did not suggest CAS. Therefore, once weekly speech intervention for a second consecutive 10-week cycle was recommended.

Child L (37 months) made progress but it was noticeably slower and his intelligibility continued to be limited. On administration of the checklist at the end of the intervention block, he demonstrated vowel distortion errors and difficulties with transitions between articulatory postures, groping, voicing, and prosody issues. There was noticeable syllable segregation with a staccato speech pattern and very slow rate of speech. Performance on formal speech testing placed him below the first percentile and indicated a severe speech sound disorder. Child L met criteria for CAS, as shown in Table 7, and was placed into a consecutive block of twice weekly motor speech therapy.

In summary, four children entered the service with similar profiles but only one child was identified as presenting with characteristics of CAS after a series of diagnostic interventions. The proposed intervention model and checklist provided clinicians with a systematic approach for identifying the child with CAS while

Table 7. Comparison of Children's Profiles Post Motor Speech Intervention: Presence of Indicators for CAS

LEVEL 3: Motor Speech Intervention (typically over 36 months)				
Indicators for CAS (Shriberg, Potter, & Strand, 2011)	**Child D**	**Child B**	**Child L**	**Child N**
Difficulty achieving initial articulatory configurations or transitionary movement gestures			✓	
Syllable segregation			✓	
Lexical stress errors or equal stress			✓	
Vowel or consonant distortions including distorted substitutions			✓	
Groping			✓	
Intrusive schwa			✓	
Voicing errors			✓	✓
Slow rate			✓	
Slow diadochokinetic rate			✓	
Increased difficulty with longer or more phonetically complex words			✓	✓

providing a series of developmentally appropriate interventions. The checklist, in combination with the child's response to intervention, guided clinical decision making with regard to timing, type, and intensity of therapy while also facilitating differential diagnosis leading to identification of CAS.

Conclusions

CAS is a complex speech disorder and identification is a challenging process especially in young children who are still undergoing development across domains. This article proposes a conceptual model for the identification of CAS that is based on best practices described in the literature. Implementation of such a model, whether at an agency, regional or national level, has several benefits. It provides clinicians with current information on differential diagnosis of CAS and evidence based intervention approaches. This guides their practice, helps them identify areas for professional development, and builds their skills and confidence. The model also provides clinicians with a common framework for clinical decision making, selecting appropriate interventions and recommending next steps. This increases the likelihood that children will receive similar, appropriate intervention regardless of where they live. In addition, it supports consistent communication with parents about the nature of their child's needs and recommendations. The model also provides a framework for problem solving when families are unable to follow through with a specific recommended intervention. Clinicians can consider the elements of the intervention and determine which ones are most important for a child and family and how they can best be delivered given identified constraints. This information along with actual intervention outcomes of the individualized intervention can be collected and used for ongoing review and revision of the model.

The process of moving from a conceptual model to standard clinical practice is a journey. According to the implementation science literature, there are several drivers required to "make it happen" (Fixen, Blase, Metz, & van Dyke, 2013). The practice to be implemented must be clearly described so it can be taught, learned, and implemented in a way that achieves consistent, good outcomes. Training programs need to be in place that not only disseminate information but also provide clinicians with mentorship opportunities to support application of new knowledge into clinical practice. Furthermore, facilitative administrative environments and leadership are required to guide and support the implementation process.

The province of Ontario has embarked on this journey. To date, the content and procedures have been developed for the Level 3 Motor Speech Therapy component of the model. Pilot training and implementation projects are being conducted to inform implementation on a larger scale. Work is also progressing on defining the content and procedures for Level 1 Diagnostic Expressive Communication intervention and training for clinicians in Target Word™ is in place for the province. Although there is much more work to be done, the vision remains clear: to develop a service model that will guide practice and support service equity across the province for all young children with severe speech sound disorders, and particularly those with CAS.

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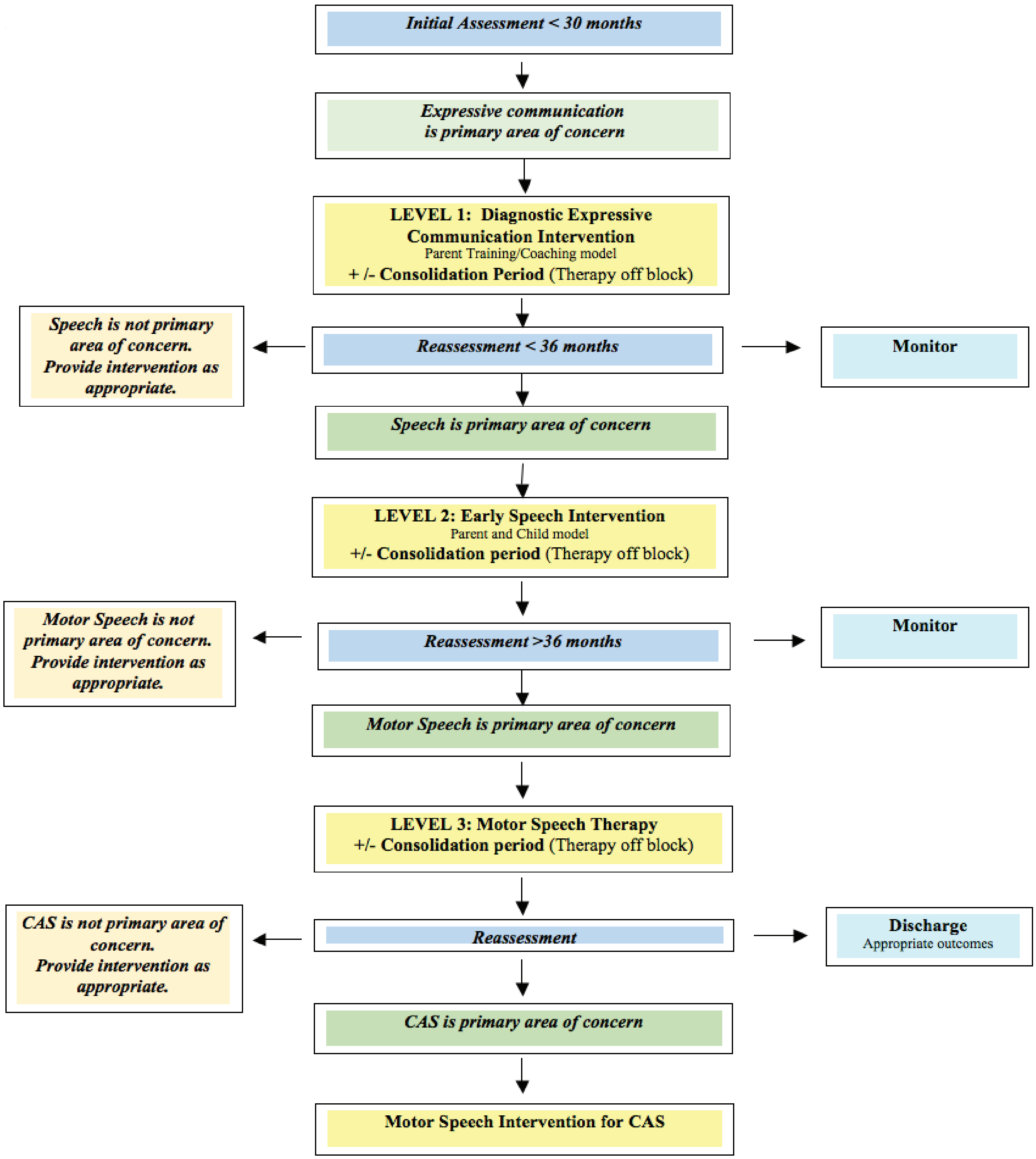
Appendix A

Proposed Decision Making Process for Treatment of Young Children with Speech Sound Disorders and Identification of Childhood Apraxia of Speech



Appendix B

Decision Making Checklist for the Identification of Childhood Apraxia of Speech

Child's Name: ______________________________ D.O.B. ____________ Age: ________

Clinician: ______________________________ Date: ____________

Case History / Risk Factors *(references: ASHA, n.d.; ASHA, 2007)*	**Yes**	**No**
Family history of speech/language/learning difficulties		
Reduced quality and/or quantity of babbling as an infant		
History of otitis media with effusion		
Delayed motor milestones/difficulties with motor development		
Difficulties reported in feeding		
Drooling reported or observed		
Excessive oral sucking habits (e.g. pacifiers, thumb sucking)		

LEVEL 1: Diagnostic Expressive Communication Intervention (typically under 30 months)

Target Profile	**Observations**	**Yes**	**No**
Receptive language skills within the broad range of normal			
Limited vocabulary and/or vocal output for communicative purposes			
May have developed a gestural symbolic communication system			
No social communication concerns			

Focus of Intervention

- Increase frequency of vocalization for communicative purposes
- Improve vocal/verbal imitation skills
- Expand functional expressive vocabulary
- Expand word combinations

Red flags for SSD *(reference: Williams & Elbert, 2003)*	**Observations**	**Yes**	**No**
Limited increase in frequency of communicative vocalizations/			
verbal approximations			
Limited expressive vocabulary growth			
Limited change in consonant and vowel repertoire			
Limited change in syllable shapes			
Variability and inconsistent substitution errors			
Atypical speech error patterns			

Comments: *e.g. quantity and rate of change, quality of change, changes in overall profile*

Recommendations:

- ☐ Level 2 Early Speech Intervention
- ☐ Other ____
- ☐ Monitor

Ontario MCYS Motor Speech Working Group, revised 2015

Appendix B

Decision Making Checklist for the Identification of Childhood Apraxia of Speech

Child's Name: ______________________ D.O.B. __________ Age: ______

Clinician: ______________________ Date: __________

LEVEL 2: Early Speech Intervention (typically under 36 months)

Target Profile	Observations	Yes	No
Child has a receptive/expressive language gap with no social communication or behavioural concerns			
Child is able to incorporate adult participation in play and take multiple turns			
Child has made little change in verbal skills in the last 3 months			
Limited vocal/verbal output			
Limited expressive vocabulary			
Limited verbal imitation skills			
Limited syllable shapes			
Limited variety of consonants in repertoire			

Focus of Intervention

- Develop speech learning skills (listening, watching, attending)
- Develop vocal and verbal imitation skills
- Expand expressive vocabulary
- Increase speech sound repertoire (consonants and vowels)
- Increase syllable shapes

Red flags for motor speech involvement *(references: Davis & Velleman, 2000; Shriberg, Jakielski, Strand, 2010, Vick et al, 2014)*	Observations	Yes	No
Limited variety of vowels and/or vowel distortions in repertoire			
Atypical speech errors			
Uses non-speech sounds or non-syllabic vocalizations to communicate			
Limited variety/high variability of speech motor movements			
Words are used then disappear			
Frequently used utterances are easier to produce than novel ones			
Limited/stereotyped intonation patterns or difficulty with prolonged phonation			
Reduced strength of articulatory contacts			
Reduced rate and/or range of speech motor movements			

Comments: *e.g. quantity and rate of change, quality of change, changes in overall profile*

Recommendations:

- □ Level 3 Motor Speech Intervention
- □ Other ____
- □ Monitor

Ontario MCYS Motor Speech Working Group, revised 2015

Appendix B

Decision Making Checklist for the Identification of Childhood Apraxia of Speech

Child's Name: ______________________ D.O.B. __________ Age: ______

Clinician: ______________________ Date: __________

LEVEL 3: Motor Speech Intervention (typically over 36 months)			
Target Profile	**Observations**	**Yes**	**No**
Receptive language skills within the broad range of normal			
Speech sound disorder on testing (<16th %ile)			
Speech is unintelligible approximately half the time to unfamiliar listener			
Child is able to attend and participate in adult directed speech activities			
Multiple characteristics suggesting MS Involvement are present:			
Persistence of early phonological processes (e.g. final consonant deletion, reduplication, syllable deletion, consonant harmony (e.g. goggy - doggy))			
Presence of atypical phonological processes (e.g. initial consonant deletion, backing, stops produced as fricatives)			
Restricted consonant inventory			
Limited vowel repertoire or vowel distortions			
Imprecise sound production/distortions			
Inconsistent errors on consonants and vowels on repeated productions of the same syllables or words			
Increased errors with increased word length and phonetic complexity			
Voicing errors			
Groping– difficulty in achieving articulatory configurations or transitioning between movement gestures			
Altered suprasegmental characteristics (rate, pitch, loudness, nasality, prosody)			

Focus of Intervention

- Increase child's speech intelligibility by developing:
  - control of motor speech movements and movement sequences in words and phrases
  - speech sound repertoire
  - syllable and word shapes

Identify Indicators for CAS *(Shriberg, Potter, & Strand, 2011)*	Observations	Yes	No
Child exhibits four or more of the following characteristics:			
Difficulty achieving initial articulatory configurations and transitionary movement gestures			
Syllable segregation			
Lexical stress errors or equal stress			
Vowel or consonant distortions including distorted substitutions			
Groping			
Intrusive schwa			
Voicing errors			
Slow rate			
Slow diadochokinetic rate			
Increased difficulty with longer or more phonetically complex words			

Child presents with features of CAS: Yes ______ No ______

Recommendations:

- □ Continue with Motor Speech Intervention
- □ Other ____
- □ Discharge

Ontario MCYS Motor Speech Working Group, revised 2015

Pilot Implementation of an Alternate Service Delivery Model for Young Children with Severe Speech and Expressive Language Delay

Mise en œuvre d'un projet pilote portant sur un modèle alternatif de prestation de services pour les enfants ayant un retard sévère de la parole et du langage expressif

Megan Hodge
Robin Gaines

KEY WORDS
INTERVENTION
PRESCHOOL CHILDREN
SEVERE SPEECH DELAY
CLINICAL PRACTICE

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Abstract

Selecting a service delivery model to meet the needs of young preschool children with age-appropriate receptive language development and severe speech delay of unknown origin presents a challenge for many agencies. Speech-language pathologists (S-LPs) at the First Words Preschool Speech and Language Program in Ottawa recognized that this subgroup of children was not making expected gains in speech production within the agency's existing parent-focused group program for young children with speech and language delays (Gaines & Gaboury, 2004). They wanted to determine the feasibility of an alternative service delivery model for this subgroup and undertook a pilot implementation of the *Let's Start Talking (LST)* program (Hodge, 2003) to individual parent-child dyads on their caseloads who met eligibility criteria. Following a one-to-one parent education and goal setting session, treatment was delivered twice weekly over an 8-week period. Significant changes in several speech behaviours, obtained from pre- and post-treatment recordings of an imitated word task and connected speech sample, were observed at the end of treatment for the 10 child participants (aged 34-43 months); these findings were in agreement with parents' observations. Based on the changes observed and the experiences of the S-LPs, the agency determined that this service delivery model was feasible, better met the needs of this subgroup of children, and subsequently added it to its clinical programs. The project used a case series pre-post treatment design. It lacked sufficient controls to determine if the treatment was responsible for changes observed in the children and parents and what other factors may have accounted for these changes. Well-designed research studies with appropriate and sufficient controls and blinding to eliminate clinician and investigator bias are needed to answer these questions.

Abrégé

Choisir un modèle de prestation de services, qui répond aux besoins des enfants d'âge préscolaire ayant un développement normal des habiletés de langage réceptif et un retard sévère de la parole d'origine inconnue, présente un défi pour plusieurs agences. Les orthophonistes du programme Premiers mots, un programme de services de rééducation de la parole et du langage pour les enfants d'âge préscolaire d'Ottawa, ont reconnu que ce sous-groupe d'enfants ne faisait pas les progrès attendus sur le plan de la parole lorsqu'ils étaient intégrés au sein du programme de groupe de l'agence s'adressant aux parents d'enfants ayant un retard de la parole et du langage (Gaines et Gaboury, 2004). Ils ont voulu déterminer la faisabilité d'un modèle alternatif de prestation de services pour ce sous-groupe d'enfants. Ils ont ainsi entrepris la mise en œuvre du programme *Let's Start Talking* (Hodge, 2003) auprès de dyades parent-enfant au sein de leur charge de travail respective et répondant aux critères d'admissibilité. Après une rencontre d'information où seul le parent était présent et où les objectifs étaient établis, une intervention était offerte 2 fois par semaine sur une période de 8 semaines. À la fin de l'intervention, des changements significatifs ont été observés sur plusieurs aspects de la production de la parole chez les 10 enfants participants (âgés entre 34 et 43 mois). Ces changements ont été mesurés à partir d'enregistrements d'une tâche d'imitation de mots et d'un échantillon de parole continue. Ces résultats concordaient avec les observations des parents. D'après les changements observés et l'expérience des orthophonistes, l'agence a conclu que ce modèle de prestation de services était réalisable, répondait mieux aux besoins de ce sous-groupe d'enfants et l'a par conséquent ajouté à ses programmes cliniques. Ce projet était une série de cas avec des mesures pré- et post-traitements. Il manquait de contrôle pour déterminer si l'intervention était responsable des changements observés chez les enfants et les parents, ou si d'autres facteurs en étaient responsables. Des études mieux conçues, avec un contrôle approprié et suffisant ainsi qu'un processus à l'aveugle afin d'éliminer les biais dus aux cliniciens et aux chercheurs, sont essentielles pour répondre à ces questions.

Introduction

Children who are close to 3 years of age who have age-appropriate receptive language and very limited speech production (low frequency use of a small number of 'words' with simple syllable shapes containing vowels and a few simple consonants) present a challenge for agencies providing services to young children with speech delay because of the severity and unknown origin of the delay, and limited research to guide decisions about treatment. In contrast to their chronological age, these children's speech behaviours are at an emerging stage, resembling those described for children aged 12 – 18 months (Kent, 1992; 1999; Netsell, 1981). They present with an apparent difficulty learning how to talk, that is, difficulties abstracting phonological information from the sensory input of the ambient spoken language and transforming this into actions to produce the sound patterns of the language.

While this difficulty could arise from impairments affecting one or more brain networks hypothesized to be involved in speech acquisition, processing, and production (e.g., Guenther, 2006; Guenther & Vladusich, 2012; Terband, Maassen, Guenther, & Brumberg, 2014), a common clinical practice has been to 'suspect' that these children's limited speech production reflects an impairment in higher mental functions involved in learning, storing, organizing, and sequencing movements to produce the sound patterns of speech, that is, an impairment in speech praxis (Davis & Velleman, 2000; World Health Organization, 2001). Despite this practice, use of the term 'suspected' childhood apraxia of speech (CAS) to classify these children is questionable because it is, at best, one of several hypotheses until a child has sufficient speech and requisite 'test-taking' behaviours (e.g., see assessment protocol described by Murray, McCabe, Heard, & Ballard, 2015) to make a more informed diagnosis and intervention plan. Furthermore, as observed by Murray et al., while most researchers agree that the core deficit for children with CAS is a reduced ability to convert abstract phonological codes to motor speech commands, referred to as motor planning and/or programming, there is longstanding disagreement regarding the criteria to classify children with this diagnostic label. It is generally agreed that the treatment priorities for preschool children with very severe speech delays, regardless of hypothesized underlying impairment, are to provide them with a functional means of communicating to meet their current needs while at the same time building their repertoire and functional use of target speech behaviours, that is, helping them to learn to produce the sound patterns of language. The focus of this article is on the latter.

In 2003, there was only one model of service offered to young children with severe speech delay and their families within the First Words Preschool Speech and Language Program in Ottawa, Ontario (Gaines & Gaboury, 2004; Gaines, 2006). This was a parent-focused group intervention program for young children identified with speech and language delays. It used a focused stimulation intervention approach described by Girolametto, Pearce, and Weitzman (1997), to develop receptive and expressive language, with some support for phonological development. The program was offered once weekly over an 8-week period, with two additional parent-only workshops. However, S-LPs offering this program were concerned that this service delivery model was not adequate for young preschool children who presented with severe speech and expressive language delays because of the limited progress these children demonstrated, compared to other children in the program.

The S-LPs' observations were supported by the findings of Girolametto et al. (1997) who studied the same parent training approach for intervention with 23 to 33 month-old children who had age-appropriate receptive language and severe speech and expressive language delay. Parents were trained to use frequent, highly concentrated presentations of target words without requiring responses from the child. The authors reported significant increases in the children's consonant and early word structure inventories but not in intelligibility or production accuracy as measured by percentage of consonants correct. Girolametto et al. (1997) observed that these findings were consistent with previous studies of the indirect effects of language intervention on consonant accuracy and speech intelligibility.

As part of their commitment to ongoing quality evaluation and improvement of services, the S-LPs in the First Words Preschool Speech and Language Program wanted to implement an additional type of intervention based on the current literature for young children with severe speech production difficulties and very limited expressive language. At the time the project described in this article commenced (2004), the authors had located only one data-based treatment study that specifically targeted speech production for children with severe delays in speech development. Miccio and Elbert (1996) reported increases in number of consonant types and syllable structure accuracy for a 3 year-old child with a severe speech disorder, limited phonetic inventory, and age-appropriate receptive and expressive language development, who received stimulability intervention. This approach includes the pairing of consonants with alliterative characters and hand/body movements for all consonants (both stimulable and nonstimulable) within turn-taking activities. These activities are designed to maintain joint focus between the clinician and child to encourage early communicative success and vocal practice.

Increasing a child's phonetic inventory is one strategy to build speech skills in a child with age appropriate expressive language. However, for preschool children who have very limited phonetic inventories, few words and severely delayed expressive language, relative to expectations for their age and receptive language level, it is hypothesized that a more developmentally and functionally appropriate treatment approach is needed, that is, one that focuses on helping children to learn to produce intelligible one- and two-syllable words with simple word shapes, using their existing phonetic inventory, in addition to systematically building their inventory (including vowels).

This is the focus of the integral stimulation treatment approach for children described by Strand and Skinder (1999). In general, integral stimulation approaches 1) require a client to imitate speech modeled by the clinician with attention focused on both the clinician's face and the auditory model (i.e., client watches and listens) and 2) may incorporate tactile, gestural, and prosodic methods. Strand and Skinder observed that integral stimulation is a common approach to treating children with speech disorders and provided a rationale for using it with children with very delayed speech production, including those for whom impaired motor processing may be a contributing factor.

Strand and Skinder (1999) posited that an approach that provides carefully selected, hierarchically organized sets of stimuli (speech learning targets), with supported practice in making the movements to produce these targets, provides the child with opportunities to experience sensorimotor speech processing. The child is producing speech while watching and listening and all responses are movements that result in a target acoustic output (sound, word, or phrase). The level of support provided is based on the child's needs. Techniques such as phonetic placement and gestural, tactile, and prosodic cueing are incorporated as needed to help the child attain articulatory configurations and transitions between these for target words and phrases. Hierarchical variation of the temporal relationship between the stimulus and response (i.e., simultaneous production, immediate repetition, repetition after a delay, etc.), along with multimodal cues, provides maximum cueing for movement performance, which is faded with repeated practice and as soon as possible so that the child's volitional control in accurately producing the desired speech behaviour increases. This allows for high levels of success and practice. Strand and Skinder reiterated that to benefit from this approach, children must 1) be able to maintain selective attention and establish eye contact to watch the face of the person providing the model and 2) have the ability to imitate and can be motivated to do this.

Strand and Skinder (1999) also observed that integral stimulation incorporates principles that have been identified as important in learning skilled motor behaviours. That is, 1) speech learning tasks are goal directed, 2) repeated opportunities are provided to practice the target speech behaviour, using a slower rate of production to establish accuracy initially and then move this to a normal rate of production while maintaining accuracy, and 3) clinicians can manipulate conditions of practice (e.g., massed, distributed) and amount and nature of feedback to the child about his or her production. Readers are referred to Maas, Gildersleeve-Neumann, Jakielski, and Stoekel (2014) and Strand (1995) for further discussion of motor learning principles applied to treatment.

Strand and Debertine (2000) and Strand, Stoekel, and Baas (2006) reported the results of multiple baseline studies investigating the efficacy of this integral stimulation approach (renamed the dynamic temporal-tactile cueing hierarchy) for children with very severe speech delay. In their systematic review of the literature on treatment outcomes for CAS, Murray, McCabe, and Ballard (2014) reported that the integral stimulation approach of Strand and colleagues was a treatment method judged to have sufficient evidence for interim clinical practice.

Description of *Let's Start Talking*

Hodge, Lopushinsky, and Wellman (2000) described a model of service delivery for young children with severe speech delay that incorporates Strand and Skinder's (1999) integral stimulation approach (*Let's Start Talking*™ or *LST*). *LST* targets children of approximately 3 to 3.5 years of age who exhibit a severe delay in speech production and a significant gap between receptive and expressive language development (higher receptive language development), and their parents. It is based on a synthesis of a comprehensive review of scholarly and commercially available publications published between 1980 and 2000 that targeted children with a history of severe speech delay and/or suspected speech motor learning difficulties, supplemented by a survey and follow-up focus group of experienced speech-language pathologists (Esau & Martin, 1998; Helme & Viray, 1999). In addition to the integral stimulation treatment approach of Strand and Skinder (1999), *LST* incorporates perspectives on early phonetic and communication development in young preschool children (e.g., Girolametto, Weitzman, & Greenberg, 2003; Kent, 1992; 1999; McDonald & Carroll, 1992), and an adaptation of a hierarchical model of how speech motor control develops in young children, proposed by Hayden and Square (1994), and requires that parents be active participants.

Approach to Teaching Speech Targets

The integral stimulation approach used in *LST* to teach children speech targets is a slight modification of that described by Strand and Skinder (1999). It is illustrated in Figure 1 along an axis of decreasing cue support and increasing time between model and response to increase the child's volitional control over production of the target. Each new target is introduced at the level of direct imitation. If the child is not able to imitate the target accurately at a normal rate over several trials, support is increased by moving to simultaneous production at a slowed rate. If the child is still unsuccessful, then visual and gestural placement and transition cues are added to help the child achieve the initial articulatory configuration and subsequent movements for the target. This is continued, using tactile cues only as necessary (and if tolerated by the child) until the child can produce the target accurately at a slow rate. Then cue support is decreased as the clinician moves to direct imitation practice.

For sound (consonant and vowel) targets, when the child can produce the target accurately in direct imitation, it is considered ready to be used in word targets. For word and phrase targets, when the child can produce the target accurately in direct imitation at a normal rate, cue support is decreased by adding in a delay time (1 -3 seconds) between the model and response. A visual cue (e.g., hand up) to signal 'wait' before responding is effective for some children. Other strategies to achieve a delayed response include having the child produce two responses or having the clinician make a comment between the model and the child's response. Strand and Skinder (1999) also suggested introducing variations in production style at this point (e.g., altering loudness and intonation of the model), to encourage flexibility in the child's productions.

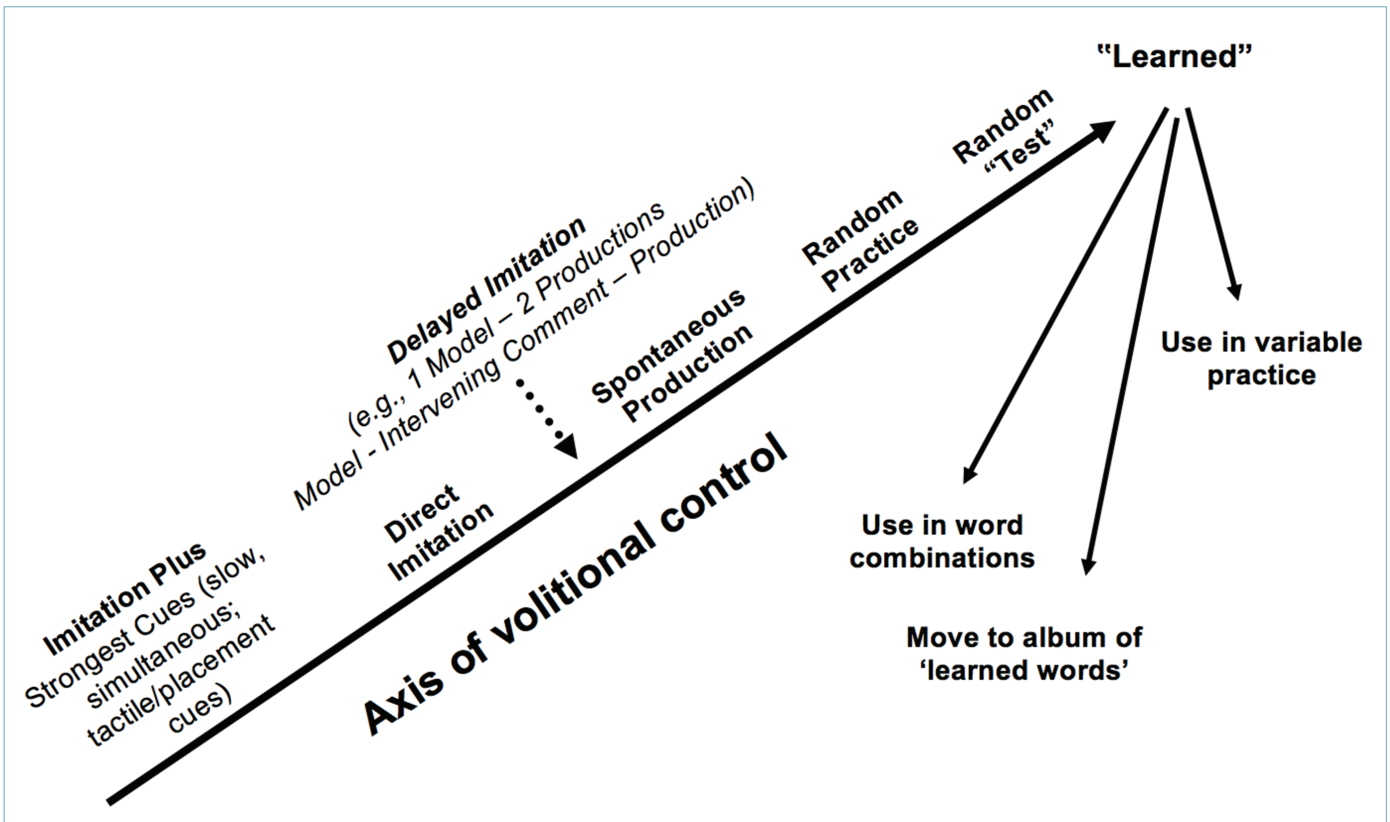

Figure 1. Levels of the integral stimulation approach used in *LST* presented along an axis of decreasing cue support and increasing time between model and response to increase the child's volitional control over production of the target (modified from Strand & Skinder, 1999).

Once the child can produce the target accurately in delayed imitation, then productions are elicited without a model in an interactive activity designed to provide contextually relevant opportunities to use the speech target. These include activities where the child names pictures or objects, gives commands to perform actions, or completes a sentence by filling in the missing word(s) (cloze technique). When the child can produce a word target accurately with no models provided, the word is then elicited with no models in random order with 1 to 2 words that are already in the child's repertoire. If the child can produce the target word accurately in three out of three trials in random practice with these other words, the word is considered 'learned'. When the child can produce a phrase target accurately with no models on at least six of eight trials, it is considered 'learned'. A new word or phrase target is then introduced into the treatment session. Targets that have met the criteria for 'learning' continue to be practiced in other ways. These include adding a picture stimulus to an album of 'learned' speech targets for additional home practice and creating new phrase targets with words already in the child's repertoire.

Selecting Speech Targets

Four suggestions for selecting speech targets that were proposed by Strand and Skinder (1999) are followed in *LST* when using their integral stimulation method with children: 1) use a small set of training targets (5 – 6) to allow for massed practice, 2) base the phonetic content of targets (sounds and word shapes) on what the child already has in their repertoire, what the child is stimulable for, and what is appropriate for the child's developmental stage of phonologic acquisition (e.g., Kent, 1999), with attention to development of motor control for speech muscle groups, 3) use real words (as opposed to nonsense syllables) with which children can experience communicative success, and 4) target accurate production of a variety of early developing word structures in one- and two-syllable words and in combinations of these.

Strand and Skinder (1999) emphasized the importance of carefully controlling the phonetic complexity (sounds, syllable, and word shape) of speech targets in early stages of treatment and using meaning as a motivational factor. Embedding multiple opportunities for practice on a speech target that is made meaningful within a motivating interaction between the child and clinician is a key learning strategy used in *LST*. For example, an activity using a whiteboard and multiple coloured pens could be used to motivate a child to produce "O" at the appropriate level of the integral stimulation hierarchy, if the child liked using the pens. The child is offered a choice between two different coloured pens and then the clinician uses the desired pen to draw the letter "O" on the whiteboard. Then the clinician holds this pen by his or her face while saying the model "O". After the child's attempt, the clinician takes the cap off the pen and gives it to the child to make an "O" (mark) on the whiteboard. This is repeated at least 6 - 8 times, providing multiple opportunities for the child to practice the response.

Strand and Skinder (1999) recommended that development over control of movements used in speech by various muscle groups also be considered in selecting speech targets. Hayden and Square (1994) proposed a framework organized by stages for the development of motor control for speech that was supported by their evaluation of the *Verbal Motor Production Assessment for Children* (Hayden & Square, 1999). The framework is based on the supposition that this process is hierarchical and nonlinear over various speech subsystems. From earlier to later in development these include: 1) postural support and muscle tone adjustments specifically for breathing when speaking, 2) control over phonation for at least short speech units (minimum of 2 to 3 seconds), 3) control over mandibular (jaw) lowering and raising actions within the range of movement for speech, 4) control over lip and facial muscles for bilabial closure and for lip rounding and retraction within the range of movements for speech, and integration of these with vertical jaw movements, 5) control of tongue movements in the anterior-posterior and superior-inferior directions within the range for speech and ability to integrate independent tongue movements with lip and jaw movements, 6) ability to sequence jaw, lip, and tongue movements used in speech with symmetry and precision, and 7) control over temporal aspects of connected speech (e.g., rate, rhythm, intonation contours).

The framework is nonlinear in that it posits that complete control at each lower level does not occur before emergence of control at higher levels. However the model presumes that the young child who is developing normal speech motor abilities generally gains control of speech subsystems in a hierarchical manner and must integrate movements at each successive level with control established at preceding levels. This model does not address the velopharyngeal subsystem. Based on phonetic studies of infant vocalizations, Kent (1999) hypothesized that control of oral-nasal resonance emerged between 6 to 12 months, in conjunction with jaw lowering and raising and lip closure for bilabial stops and nasal sounds.

Support for the ordering of stages 1 and 2 of the hierarchy proposed by Hayden and Square (1994) (respiratory and phonatory adjustments for phonation and early vocalizations) was provided by the findings of Boliek, Hixon, Watson, and Morgan (1996; 1997). Green, Moore, and Reilly (2002) provided support that the earliest stages of speech motor development are constrained by the nonuniform development of articulatory control, with the jaw preceding the lips. These authors used kinematic methods to record vertical displacements of the upper lip, lower lip, and jaw during speech for groups of 1-, 2-, and 6-year-olds and adults to examine if control over these articulators develops sequentially. The experimental findings revealed that 1- and 2-year-old children's jaw movements were significantly more adult-like than their upper and lower lip movements, which were more variable. Upper and lower lip movement patterns became more adult-like with maturation.

LST uses an adapted version of the lower levels of Hayden and Square's (1994) motor speech treatment hierarchy as one of several factors considered in selecting the phonetic content of speech training targets for a given child. Prior to *LST*, a child needs to have volitional control to start, stop, and sustain phonation for greater than two seconds (stages 1 and 2). Stages 3 (jaw movements) and 4 (lip movements) have been modified into several levels, and movement of the velopharyngeal muscles (opening and closing) has been added as a level in stage 3. Vowels and consonants have been mapped to movements of muscle groups of this adapted hierarchy, based on their phonetic characteristics, as follows. At stage 2, controlled closing movements of the larynx, coordinated with respiration for speech and no surpraglottal articulation, are represented by phonation for the central vowel /ʌ/ and aspiration for /h/. Stage 3 is divided into several levels. Jaw lowering movements are represented by low vowels with minimal rounding and spreading (tongue linked to jaw) (/ɑ/, /ae/). Jaw raising, with the lower lips moving with the jaw to achieve closure of the lips, is represented by labial consonants, with the nasal /m/ requiring less compression, the oral stops (/b/, /p/) requiring more compression, and the labiodental /f/ requiring coordination of lower lip inversion in contact with the upper teeth. Stage 4 is also divided into several levels. Lip rounding is represented by the vowels /u/ and /o/ and spreading by the vowels /i/ and /e/. Sequencing and integrating movements of jaw raising with lip spreading is represented by the diphthong /aɪ/, of jaw raising with lip rounding by the diphthong /aʊ/, and lip rounding and spreading by the diphthong /ɔɪ/. More rapid transitions in these movements are represented by the glides /w/ (lip rounding with lower lip/lower jaw opening) and /j/ (lip spreading with lower lip/lower jaw opening).

LST primarily targets intelligible production of one- and two-syllable words of varied, early developing word shapes, and phrases using combinations of these words. Different syllable and word structures become speech targets as soon as children have a few sounds in their repertoire and meaningful word combinations become targets as soon as children have accurate production of candidate words that they are using spontaneously. The phonetic content of target words is based on sounds in the child's repertoire. If a child does not have the sounds represented at levels 2 through 4 in the adapted motor speech hierarchy, these sounds also become speech targets in the sound building section of a session, with sounds selected from stages 2 and 3 before those from stage 4. When the child is able to imitate these accurately, the sounds are incorporated into target words to build an intelligible word and phrase repertoire. Example word possibilities with varying shapes that include only the sounds mapped on to stages 3 and 4 include "up, hop, Baa (sheep), Bubba, Ma, Pa, Bawffa (characters in story), off", which then can be combined into phrases such as "hop up", "Bubba off", etc. when the child is ready. Given the developmental observations that voiced stops tend to appear first in syllable initial position and voiceless stops and fricatives tend to appear first in syllable final position (Kent, 1999), it is recommended that early word targets with /b/, /p/, and /f/ follow these patterns.

Delivery of LST

LST represents a translation of these components into a service delivery model with a manualized treatment program. Delivery of *LST* is based on collaboration between the S-LP and caregiver (most typically a parent). This recognizes the central role that the family plays in the child's development, the assumption that parents prefer direct involvement in addressing their child's developmental needs (Eiserman, Weber & McCoun, 1995) and the important role of parents in contributing to their child's progress by providing additional structured opportunities to practice assigned targets between treatment sessions (ASHA 2012a; Günther & Hautvast, 2010).

LST has explicit goals for the child and for the participating caregiver. The overall goal for the child is to increase functional communication by increasing his or her speech intelligibility in communicative acts occurring within social contexts. The overall goal for caregivers is to provide them with knowledge, skills, and confidence to foster their child's communication development.

LST is not prescriptive; rather, it promotes increased effectiveness of S-LPs by providing procedures to apply a framework of guiding principles to determine treatment goals, select target sounds, words and word combinations, select treatment strategies and activities, design and implement therapy sessions and home practice assignments, measure changes in the child's phonetic and speech skills and in parents' skills and perception of their child's progress, and to reflect on their practice. S-LPs are supported to design and deliver treatment that is tailored for each child and parent.

The recommended frequency (twice weekly) and duration (10 weeks) of treatment sessions for *LST* is based on Jacoby, Lee, Kummer, Levin, and Creaghead's (2002) findings regarding the amount of treatment time needed to realize functional improvements in young children's speech and language abilities. They reported that the majority of participants improved by at least one or more levels on a functional communication measure (FCM) following 20 or more hours of therapy. ASHA's Pre-Kindergarten National Outcome Measurement System Fact Sheet (2012b) reported that, on average, 14.8 hours of articulation treatment was required for a child to demonstrate one level of progress on the articulation functional outcome measure (FCM); children who achieved multiple level gains on the FCM received 21.4 hours of treatment on average. In addition, the proportion of children demonstrating progress in articulation treatment increased with amount of treatment time; 91% of children who received at least 20 hours of individual articulation treatment demonstrated at least one level of progress on the FCM. These data indicate that more treatment time is associated with more progress and with a higher proportion of children demonstrating functional gains in their speech skills.

Purpose: Pilot Implementation of LST

As a result of their search for an alternative service delivery model for young children with severe speech delay, the First Words S-LPs invited the first author to collaborate with them on a first, real-world implementation of *LST*. The purpose of this article is to describe a pilot implementation of the *LST* service delivery model by First Words clinicians to 1) determine its feasibility in their work setting, 2) report measures of the children's speech behaviours obtained before and following treatment, and 3) report parents' feedback about their experiences and their perceptions of their children's experiences with the program. The project lacked sufficient controls to determine if this implementation of *LST* was responsible for any changes observed in the children and the parents and what other factors might account for these changes.

Method

A case series pre-post design without a control group is reported for 10 child-parent dyads who were on the caseloads of First Words S-LPs, met the criteria for *LST*, and consented to participate. Ethical approval to conduct the project was obtained from the Health Research Ethics Boards of the Children's Hospital of Eastern Ontario and the University of Alberta. The families of all children who met the inclusion criteria were invited to participate. Two of these 12 families declined to participate because their schedules could not accommodate two treatment sessions per week. By consenting to participate, a parent agreed to attend all assessment and treatment sessions with the child, carry out home practice between sessions, participate in one meeting with the S-LP (parent education/goal-setting session) without the child present, and complete several questionnaires. The child-parent dyads were recruited over a 20-month period. The low frequency of occurrence of children with the severity of speech delay targeted by the project necessitated this extended timeframe. Families were enrolled on a staggered basis as they were identified.

Training

Six S-LPs and one communication disorders assistant (CDA) who were experienced and highly motivated to participate in the pilot project received training to implement *LST*. They attended an initial full-day workshop presented by the first author (Hodge, 2003) that provided information about 1) current research and consensus of clinical experts regarding the nature, etiology, identification, and management of children with a history of severe speech delay and suspected speech motor learning difficulties, 2) the key components and target population for *LST*, 3) sample pre-post treatment measures for children and parents, 4) selecting treatment goals for children, 5) building parents' knowledge and skills to support their child's progress, 6) designing and implementing treatment sessions, and 7) reflecting on the child and parent's performance to plan for subsequent sessions. Prior to the start of the project, these same clinicians attended two additional training workshops to review and practice procedures for: 1) making video recordings of speech samples to be analyzed to obtain pre- and post-treatment measures for the child, 2) summarizing assessment information about the child's speech behaviours pre-*LST* treatment and using this information to select initial speech goals, 3) planning sample treatment sessions that followed the *LST* lesson plan protocol and were individualized to the child's current phonetic abilities and word inventory, and 4) establishing procedures for tracking data collection for each child-parent dyad. The CDA had time designated specifically by the agency's administration to monitor and manage data collection for each clinician and child-parent dyad. This followed a step-by-step protocol to maintain up-to-date records as the project progressed. These tasks required a significant amount of time and were essential to completion of the project. The agency also provided additional time for the participating S-LPs and CDA to engage in the planning that is necessary to deliver *LST* treatment (individualized to the child and parent) and to collect the pre- and post-measures.

The S-LPs and the CDA were also provided with copies of the contents of what is now the *LST Clinician Manual* (Hodge, 2007). This contains descriptions, summaries, references, and resources for the key components of *LST*, sample materials, and written procedures and forms to support each aspect of *LST* implementation. The first author also provided ongoing mentoring by telephone conference calls and email correspondence with the S-LPs and CDA. This provided support through discussion of questions and concerns regarding training targets, designing motivating and meaningful learning activities to engage the child in multiple opportunities to produce the targets, applying the levels of the integral stimulation hierarchy in a systematic way to support the child's learning of selected targets, responding to unexpected patterns in the children's speech, and allowed opportunities to monitor some aspects of fidelity of *LST* implementation. The S-LPs and CDA also engaged in peer-to-peer mentoring throughout the project, and developed their own "community of practice" for *LST*, under the leadership of the second author. The skill sets of the S-LPs and CDA improved as they gained experience delivering *LST* treatment sessions throughout the project. It is expected that later treatment sessions for a given child, and children recruited later in the project, would reflect the S-LPs' and CDA's changing experience.

Participants

All children had receptive language skills within normal limits based on their performance on the *Preschool Language Scale–4* (PLS-4) (standard score greater than 85) (Zimmerman, Steiner & Pond, 2002). Severe delays in expressive language were evident as measured by the *MacArthur-Bates Child Development Inventories (CDI): Words and Sentences* (Fenson et al., 1994). A norm-referenced parent report measure was used because of the severity of the children's speech and expressive language delays. Eight of nine children for whom CDI data were available had a score below the 10th percentile for 30 months of age on the expressive vocabulary section (30 months is the highest age for which norms are reported for this measure). Each of the 10 children had significantly reduced speech sound and word shape inventories compared to age expectations (e.g., restricted to stops, nasals, glides; vowel [V], consonant-vowel [CV], VC, CVCV word shapes), as determined by an experienced speech-language pathologist, and a score below the 2nd percentile on Part 2 of the *Kaufman Speech Praxis Test for Children (KSPT)* (Kaufman, 1995), reflecting the severity of the presenting speech production delay. Part 2 of the *KPST* assesses the child's performance in imitating vowels and early developing consonants (/p, b, t, d, m, n, h/) in isolation and in simple one and two-syllable word shapes (CV, VC, CVC, CVCV, VCV). Part 1 of the *KPST*, which assesses non-speech imitation of oral gestures and provides a measure of oral nonverbal praxis, was also administered. The results are reported to provide additional descriptive information for the children. Table 1 reports the children's scores on the *PLS-4* (receptive language), CDI (expressive vocabulary), and KSPT (Parts 1 and 2). The mean age of the children at the start of treatment was 37.3 months (Range 34-43 months). Percentile scores on the *PLS-4* receptive language subtest ranged from 23 to 99, with six of the children having relatively high scores (at or above the 50th percentile). Percentile scores on Part 1 of the *KPST* ranged from 2 to 50.

Children met the following additional criteria: English was the first language spoken in the home and hearing was within normal limits on audiometric screening. No structural abnormalities of the lips, tongue, or palate were evident as judged by an experienced S-LP and no diagnosis of autism spectrum disorder, cognitive impairment, or neuromuscular condition (e.g. cerebral palsy, muscular dystrophy) had been given. All children were observed to be making attempts to imitate speech and appeared ready for a 'listen and watch' approach to intervention. The majority of children (9) were boys. Participating parents included nine mothers and one father. Table 1 provides descriptive information about the participants.

Treatment

Prior to initiating treatment sessions with the child, the S-LP met with the caregiver on two occasions. The first session (60 minutes) was a pre-evaluation with the child present. The parent attended the second session (45-60 minutes) to learn more about *LST*, his or her

Table 1. Child participant characteristics.

Child	Sex	CA[a]	PLS-4[b]	CDI[c]	KPST[d] (Part 1)	KPST (Part 2)
1	M	2:10	114 (82nd)	65 (<5th)	4th	<2nd
2	M	2:10	116 (86th)	81 (<5th)	49th	<2nd
3	M	2:11	133 (99th)	103 (<5th)	28th	<2nd
4	M	2:11	89 (23rd)	197 (<10th)	5th	<2nd
5	F	2:11	104 (61st)	230 (<10th)	28th	<2nd
6	M	3:00	98 (45th)	230 (<10th)	28th	<2nd
7	M	3:04	94 (34th)	156 (<5th)	<2nd	<2nd
8	M	3:06	No ceiling (>99th)	431 (<30th)	<2nd	<2nd
9	M	3:06	100 (50th)	19 (<5th)	26th	<2nd
10	M	3:07	98 (45th)	Not done	50th	<2nd

Notes: [a]CA= Chronological age is reported in years: months, [b]Receptive portion of the *Preschool Language Scale-4 (PLS-4)*: scores reported are Standard Scores and (Percentile scores), [c]*MacArthur Bates Communicative Disorders Inventories Words and Sentences (CDI)*: scores reported are: Number of expressive vocabulary words and (Percentile scores), [d]*Kaufman Speech Praxis Test for Children:* scores reported are Percentile scores.

role in the treatment program and to participate in goal setting. Parents were provided with information about: the basics of speech development, disordered speech development, a hierarchy for introducing early vowel and consonant targets (adapted motor speech treatment hierarchy), the cueing hierarchy described by Strand and Skinder (1999), and other treatment strategies used in *LST* (cloze elicitation techniques, and visual place and manner cues). This information was discussed with parents and was also included in the *Let's Start Talking Parent Guide* (Hodge, Gaines, & Tachereau-Park, 2004), which was provided to each parent to keep for reference. Parents worked collaboratively with the S-LP to set speech goals that included sounds (vowels and consonants), words, and word combinations. Specific goals were individualized for a given child to build on the child's current speech behaviours and depended on: 1) the child's speech sound, syllable, and word shape repertoires and ability to produce combinations of two or more words with accurate consonant and vowel production, and 2) sound and word targets that the parent had identified as goals. If needed, these latter targets were simplified in sound content and word shape to fit the phonetic repertoire of the child in a manner that was acceptable to the parent. This was an effective strategy to provide the child with an intelligible and consistent means of labeling important referents within his or her current level of capability (for example, the desired name "Grammy" for a child's grandmother was simplified to /mæmi/). Specific goals for parents were provided in the *LST Parent Skills Checklist* that was reviewed periodically by the S-LP and parent.

Forty-five minute treatment sessions with the child and parent were scheduled twice weekly for 8 weeks to fit the mandated "real-world" treatment delivery constraints of First Words, which provided treatment in blocks of 8 weeks. Each session was organized using an individualized lesson plan that followed the *LST* lesson template. This starts with a "hello" time (approximately 5 minutes) when the caregiver provides the S-LP with information about how the home practice sessions went and any new words that the child has used. This is followed by about a 30-minute period where the caregiver actively observes the S-LP and child practicing the session's speech targets and may participate with guidance from the S-LP. During this practice time the S-LP records the accuracy of the child's performance for each attempt at a given target over multiple trials, noting the associated cueing level of the integral stimulation hierarchy used to elicit the child's responses. The session concludes with about a 10-minute period where the S-LP reviews and demonstrates the speech targets and corresponding activities to be assigned for home practice and coaches the caregiver and child as they try these out. At the conclusion of the session, the S-LP is prompted by several questions on the lesson plan to reflect on the session and plan for the next one.

Pre- and post-treatment measures were used to evaluate changes in the child's phonetic skills and spoken language. These included phonetic analysis of the *TOCS-30* (a 30-item imitative word sample) (Davis & Hodge, 2017), and measures of speech productivity and intelligibility from a video recording of a 12-minute connected speech sample where the child interacted with the parent during play. Ongoing review of the *LST Parent Skills Checklist* and responses to parent questionnaires over the treatment period provided information about parents' skill development and perceptions of their child's progress.

LST treatment was delivered to three of the child-parent dyads by one S-LP for all sessions. For the other seven families, two clinicians shared the therapy sessions for a given child-parent dyad so that a team of two S-LPs or a team of a S-LP and CDA carried out alternate sessions within a week. This sharing of client intervention was done to accommodate clinical schedules to provide twice weekly sessions. Communication between clinical team members occurred through the use and sharing of lesson plans, telephone discussion, and email correspondence. Over the course of treatment the first author also monitored fidelity to the *LST* treatment model by reviewing a minimum of four completed lesson plans for each child-parent dyad to check for documented adherence to *LST* guidelines for target selection, speech learning activities, progression using the integral stimulation cueing hierarchy, assignment of home practice activities, and post-session reflections by the clinician. All sections of the lesson plan were completed for all the lesson plans reviewed. Follow-up occurred through email or telephone in the few instances when clarification of the appropriateness of content was needed. Use of a detailed protocol to check against video recordings of treatment sessions was beyond the scope of the pilot project but is recommended as a future component of training and fidelity checking.

All parents attended the pre- and post-treatment assessment sessions, the educational and goal-setting session, and all of their child's treatment sessions. Seven children attended all 16 treatment sessions; Child 10 attended 15 sessions, Child 5 attended 14 sessions and Child 3 attended 13 sessions. The missed sessions were due to illness of the child or treating clinician. Due to limitations on the clinicians' schedules, these missed sessions could not be rescheduled.

Child Pre- and Post-Treatment Measures

Word Imitation Sample

The child's productions of the *TOCS-30* items were elicited and video recorded by the clinician. The clinician encouraged the child to watch her mouth; thus, if the child complied, he or she received additional visual cues for speech production. Six randomizations of the *TOCS-30* items were used to reduce the child's familiarity with the task. Pre-treatment measures of phonetic accuracy were based on the mean of three separate administrations of the *TOCS-30* on separate days during a two-week period before treatment sessions commenced. Pre-treatment measures of phonetic inventory were based on the syllable, vowel, and consonant types that occurred in at least one of the three pre-treatment *TOCS-30* samples. *TOCS-30* stimuli sample 53 consonant targets (19 consonant types; [h, p, b, m, w, j, f, t, d, n, s, z, k, g, l, ɹ, ʃ, ʤ, ʧ], 33 vowel targets (10 vowel types; [ə, i, æ, o, u, ɑ, ʊ, ʌ, ɛ, ɔɪ]) and 33 syllable targets (6 syllable types; [V, CV, VC, CVC, CCV, CCVC]).

In two instances (Child 2 and Child 7), the child did not attempt to produce at least 27 (90%) of the 30 items on one of the three administrations. In these cases, measures were based on the mean of the two administrations for which the child attempted at least 27 items. Child 1 attempted 11 or fewer items on each of the three administrations of the *TOCS-30* before the start of treatment. His responses provided information about what sounds and syllable shapes he would try to imitate but were too limited to include in a group analysis.

One administration of the *TOCS-30* was conducted post-treatment. All children attempted at least 27 of the 30 items. For instances where the child attempted between 27-29 of the items on the *TOCS-30* in the pre- and post-treatment samples, the denominators for calculating measures of phonetic accuracy obtained from the sample were adjusted to reflect the number of items attempted.

Connected Speech Sample

A 12-minute connected speech sample was video recorded from a parent-child play interaction using a standard set of toys and instructions adapted from Wetherby and Prizant (2002). The same materials were provided for each sample and consisted of toys such as play-dough, plastic fruit and vegetables, toy trucks, and magnetic puzzles. A blanket was placed over the table to reduce toy noise during the recording. The parent was instructed and encouraged to use communication strategies such as labeling, commenting, expanding, following the child's lead, and limiting the number of questions during the play session. The pre-treatment measure was based on the third of three connected speech samples recorded during the two-week period before treatment sessions commenced to provide some assurance that the child and parent were familiar with the task. One 12-minute connected speech sample was recorded for analysis post-treatment and followed the same procedures as the pre-treatment samples.

Transcription and Analysis of the Speech Samples

Copies of the video tape recordings of the *TOCS-30* and connected speech samples for each child were deidentified and sent to the first author at the University of Alberta. The original recordings were kept at CHEO. Data reduction was carried out by trained graduate student research assistants, under the supervision of the first author. Each child's *TOCS-30* video recorded sample was transcribed phonetically. The *Programs to Examine Phonetic and Phonologic Evaluation Records (P.E.P.P.E.R.)* procedures for using X, Y, and Z lines were followed (Shriberg, 1986). The target word was transcribed orthographically on the "X" line, a phonetic transcription of the adult form of the target word was transcribed below this on the "Y" line, and the child's production of the target word was transcribed phonetically below this on the "Z" line, so that the two phonetic transcriptions lined up, with the adult form above the child's production. This facilitates identification of matches in phonetic segments between the Y and Z lines to determine measures of phonetic accuracy such as percentage consonants correct. Broad phonetic transcription was used with the addition of generic diacritics to indicate a sound distortion (dentalized, lateralized, nasalized, glottalized, frictionalized, derhoticized, devoiced). The underscore symbol was used to indicate omission of a phoneme. Shriberg's (1986) conventions for phonetic transcription were followed for intelligible and questionable syllables and segments. These are elaborated in Davis and Hodge (2017).

Research assistants underwent training prior to transcribing the children's samples. Chapter 3 "How to Transcribe and Format a Speech Sample" in the manual *Programs to Examine Phonetic and Phonologic Evaluation Records (P.E.P.P.E.R.)* (Shriberg, 1986) served as the reference for transcription conventions. Each transcriber read this reference and then practiced using the conventions by completing a phonetic transcription of a set of *TOCS-30* recordings from a preschool child who was not part of the project. This was followed by a meeting with the supervisor to review the transcriptions, discuss questions, and clarify procedures as necessary. A set of video recordings from preschool children with speech sound disorders who were not part of the project was used to train and establish reliability between the research assistants. The transcriber completed a phonetic transcription for another set of recordings of the *TOCS-30* stimuli and this was compared with a transcription for the same set of recordings to determine segment-by-segment agreement between raters. If 85% agreement was not attained, the instances of disagreement were reviewed and discussed. Then the process was repeated with another set of *TOCS-30* recordings until a level of at least 85% agreement was obtained. For the pre-treatment recordings, the same transcriber completed all the *TOCS-30* transcriptions for one child; a different transcriber completed the child's post-treatment transcriptions. There were eight transcribers in total, necessitated by the extended period of recruitment.

The completed transcriptions were used to calculate two kinds of phonetic variables according to the procedures described by Davis and Hodge (2017): five measures of phonetic accuracy and three measures of phonetic inventory. The measures of phonetic accuracy were: 1) percentage syllable shapes correct or PSSC, 2) percentage vowels correct or PVC, 3) percentage consonants correct or PCC, 4) percentage whole word accuracy or PWWA, and 5) percentage recognizable [non-questionable] segments or PRS. The measures of phonetic inventory were number of 1) syllable types, 2) vowel types, and 3) consonant types.

Two or three *TOCS-30* recordings were selected randomly from each of the three pre-treatment recordings and the post-treatment recordings available for each child to provide a set of 10 of 35 possible recordings for independent transcription by a second transcriber to estimate inter-rater agreement. A third transcriber compared the two transcripts for the same *TOCS-30* recording to determine segment-by-segment agreement (includes agreement on distorted segments as indicated by diacritics). Mean inter-rater agreement was 79.9% for consonants and 80.5% for vowels, across the 10 pairs of transcriptions. Measurement error estimates for the phonetic variables are as follows: percentage syllable shapes correct (5.6%), percentage vowels correct (8.5%), percentage consonants correct (4.3%), percentage whole word accuracy (6.8%), percentage recognizable segments (4.5%), syllable types (0.25), vowel types (0.83), and consonant types (1.58) (Davis & Hodge, 2017).

Shriberg's X, Y, and Z line procedure was also used to transcribe each child's utterances from the videotape recordings of the connected speech samples. Orthographic and phonetic transcriptions were made but only the orthographic transcriptions were used for the variables reported here. An utterance was defined as a vocalization or group of vocalizations (including intelligible and unintelligible) where the child came to a complete stop, produced a falling tone in the voice, had inflection for exclamations or questions, or where it was clear that the child did not intend to finish the sentence (Shriberg, 1986). Multiple productions of the same word that the child produced within an utterance were included in the transcription (e.g., 'No, no Mommy!'). The child's intended utterances were often unknown because of poor intelligibility. Unintelligible utterances or portions of utterances that were not intelligible were indicated on the "X" line using the "*" symbol for each unintelligible syllable. The parent's utterances were also glossed for reference.

The same transcriber completed the connected speech sample transcriptions for a given child. There was a minimum of at least one month between transcription of the pre- and post-samples. Five variables were obtained from the connected speech samples: 1) number of child utterances, 2) total syllables produced, 3) mean length of utterance in syllables (calculated by summing the number of intelligible and unintelligible syllables produced in all of the child's utterances and dividing this by the number of utterances); 4) number of intelligible words, and 5) number of intelligible word types (i.e., number of different intelligible words). These variables were based on the first 12 minutes of the connected speech sample recordings (matched to within 10 seconds), with the exception of child 1. For this child, the first 10.7 minutes of each recording were used, as this was the length of the shorter recorded sample. All counts for the variables were re-checked by the first author. Three connected speech samples were selected randomly from the pre- and post-samples for independent transcription by two transcribers. The first author compared these on an utterance-by-utterance basis for agreement on occurrence of the utterance, number of syllables in the utterance, and the words transcribed in the utterance (intelligible words). The total number of utterances compared across the three samples was 372. Mean inter-rater agreement was 95.8% for number of utterances, 82.6% for number of syllables, and 78.1% for the words identified.

Parent Measures

The *LST Parent Skills Checklist* and *LST mid-program questionnaire* were completed during the 8th treatment session (treatment mid-point) and the *LST end-of-program questionnaire* was completed after the final treatment session. These measures were developed during the pilot project so they were not available for the first few parents who participated. At the mid- treatment session, the S-LP reviewed the 12 items on the *Parent Skills Checklist* with the parent. Example skills include how to segment words into syllables, how to simplify words for the child's current repertoire of sounds, and how to identify words that contain target sounds at the lower levels of the adapted motor speech treatment hierarchy. The S-LP used a combination of an interview and observation of the parent during the treatment sessions to classify each skill on the checklist as either "parent can perform the skill independently" or "parent requires clinician support to demonstrate success with the skill". The results of the checklist review guided goal-setting and coaching for the parent for the remainder of the program, with the objective of supporting the parent to become independent in as many skills as possible.

The *mid-program questionnaire* was used to obtain parents' written feedback about perceptions of their child's progress and to identify any concerns to be addressed in the remainder of the treatment program. It had the following three items: 1) What changes have you seen in your child's communication since we've started the treatment block?, 2) What goals do you think your child has attained?, and 3) Comment on changes (if any) to your child's use of sounds since beginning the program. The *end-of-program questionnaire* was used to obtain parents' written feedback about their experiences and their perceptions of their child's experience relative to the overarching goals of *LST*. The items are listed in Appendix 1 and took the form of responses to a Likert-type scale, yes-no questions, invitations to provide comments to support their choices, and open-ended questions.

The *mid-program* and *end-of-program* questionnaires were analysed separately using a conventional content analysis approach to provide a subjective interpretation (Hsieh & Shannon, 2005). Written responses were transcribed and numbered for each item that invited comments or was an open-ended question. Following transcription, the second author reviewed the responses to each question and completed an independent initial analysis to sort the responses into categories such that responses judged to have similar content were grouped together. She created a descriptive label to capture the content of each category. The first author compared and contrasted the content of the categories in light of their descriptive labels. She revised the initial categorization of responses by combining the content of some categories into a single larger category and identifying several new categories. She created revised descriptive statements for each category based on this resorting of responses. Both authors reviewed the revised content and descriptive labels of these categories for the relevant items and reached consensus on a final version. As the parents had completed their involvement with First Words at the time of the analysis, the S-LPs who implemented the *LST* program reviewed these categories for the *mid-* and *end-of-program questionnaires* and agreed that they were consistent with the ideas shared by the parents.

Results

Word Imitation Sample

Table 2 reports the pre- and post-treatment scores for each child for the measures of phonetic accuracy for syllable shapes, vowels, consonants, words, and recognizable segments obtained from the *TOCS-30* samples. As can be seen in Table 2, group means were higher for the post-treatment scores for all five measures. The greatest mean pre-post difference was for PSSC (28%) and the smallest was for PVC (10%). All data analyses were performed using SPSS version 21. The nonparametric Wilcoxon Signed Ranks Test was used to compare the pre- and post-treatment scores for each measure for the nine children with adequate data for the pre-treatment samples. The results for each measure, including effect size calculated using Cohen's *d* (Cohen, 1988) follow: PSSC Z = -2.67 (p = .004) (*d* = 1.79), PVC Z = -2.31 (p = .02) (d= 0.90), PCC Z = -2.67 (p = .004) (d =1.37), PWWA Z= - 2.43 (p = .007) (*d* = 0.86), and PRS Z = -2.67 (p = .004) (*d* = 0.84). One-tailed significance

Table 2. Children's pre- and post-treatment scores on measures of phonetic accuracy obtained from the *TOCS-30*.

	PSSC[a]		PVC[b]		PCC[c]		PWWA[d]		PRS[e]	
Child	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1[f]	NA	52	NA	90	NA	56	NA	0	NA	80
2	12	30	67	76	19	30	14	10	56	64
3	23	82	74	94	55	74	29	67	91	92
4	41	52	88	85	35	43	14	30	74	80
5	37	45	80	85	39	45	17	20	75	76
6	43	73	72	79	30	53	13	37	72	88
7	21	59	87	90	38	57	16	44	67	81
8	41	55	87	100	27	55	25	38	77	80
9	2	42	46	82	10	40	2	17	29	63
10	12	42	93	91	16	36	7	17	54	76
Mean	25.8	53.2	76.9	87.2	29.9	48.9	15.2	28.0	66.1	78.0
(SD)	(15.5)	(15.1)	(14.5)	(7.2)	(13.8)	(12.7)	(8.2)	(19.4)	(17.8)	(9.1)

Notes: [a]PSSC = percentage syllables shapes correct, [b]PVC = percentage vowels correct, [c]PCC = percentage consonants correct, [d]PWWA = percentage whole word accuracy, [e]PRS = percentage recognizable segments, [f]Child 1 = too few responses to calculate score for pre-treatment samples.

levels are reported because it was predicted that scores would be higher following treatment. Using a family-wise error rate of p < .006 (0.05/8) to account for the eight analyses performed on the *TOCS-30* transcriptions (five for phonetic accuracy and three for phonetic inventory), significant increases were observed for PSSC, PCC, and PRS but not for PWWA or PVC.

Table 3 reports the pre- and post-treatment scores for each child for the phonetic inventory measures (number of syllable types, vowel types, and consonant types) obtained from the *TOCS-30* samples. As shown in Table 3, group means were higher for the post-treatment scores for all measures. The Wilcoxon Signed Ranks Test was used to compare the pre- and post-treatment scores for each measure for the nine children with adequate data for the pre-treatment samples, with the following results: syllable types; Z = -1.63 (p = .05) (*d* = 0.91), vowel types; Z = -1.26 (p = .11) (*d* = 0.29), and consonant types; Z= -2.69 (p= .004) (d=1.12). Based on the family-wise error rate of p < .006, only the pre-post-treatment difference in consonant type was significant.

Connected Speech Sample

Table 4 reports the pre- and post-treatment scores for each child for the measures obtained from the connected speech samples. As shown in Table 4, group means for all variables were higher in the post-treatment samples. A large degree of variability is evident in scores across children at each sampling time and in the patterns of scores between the pre- and post-treatment samples. With respect to the variables MLU in syllables (derived from total utterances and syllables), total intelligible words, and total intelligible word types, five children (3, 4, 5, 7, and 8) had higher scores on all three variables in the post-treatment sample. Child 6 showed negligible change in all three variables. Child 10 had lower MLU and total intelligible word scores in the post-treatment sample and negligible change in intelligible word types. Child 2 and Child 9 had

Table 3. Children's pre- and post-treatment scores on measures of phonetic inventory obtained from the *TOCS-30*.

	Syllable Types		Vowel Types		Consonant Types	
Child	Pre	Post	Pre	Post	Pre	Post
1[a]	NA	4	NA	6	NA	10
2	3	2	10	10	7	10
3	4	4	7	8	9	13
4	3	4	8	9	11	15
5	3	4	8	7	10	7
6	4	4	8	9	12	14
7	4	4	7	7	9	12
8	3	4	9	10	9	13
9	3	4	6	10	6	7
10	3	4	10	9	9	9
Mean	3.3	3.8	8.1	8.5	8.8	11.4
(SD)	(0.5)	(0.6)	(1.4)	(1.4)	(2.1)	(2.5)

Notes: [a]Child 1 = too few responses to calculate score for pre-treatment samples.

lower MLU scores and higher total intelligible words and intelligible word types in the post treatment sample, while Child 1 showed the opposite pattern. The Wilcoxon Signed Ranks Test was used to compare the pre- and post-treatment scores with the following results: MLU (syllables) Z = -1.27 (p = .10) (d = 0.35), total intelligible words Z = - 2.19 (p = .01) (d = 0.52), and total intelligible word types Z = -2.70 (p = .003) (d = 0.64). One-tailed significance levels are reported because it was predicted that scores would increase following treatment. Using a family-wise error rate of $p < .016$ (0.05/3) to account for the number of comparisons made, only total intelligible words and number of intelligible word types were significantly higher in the post-treatment samples.

Parent Measures

Eight of ten parents completed the *Parent Skills Checklist* at the midpoint of their child's treatment sessions. All parents were judged as performing the following skills independently: breaking down words into syllables, consonants, and vowels and describing shapes of single syllable words. All parents were keeping records of their child's home practice and performance and were able to identify which syllable shapes were easier or harder for their child, without assistance. Seven of eight parents could describe how he/she might practice a new word in a fun family routine; the parent who needed support indicated that she was not very creative and appreciated the S-LP's suggestion of ideas. Seven of eight parents were also keeping notes of the new words their child was trying to say; for the other parent, the S-LP noted the child was speaking a lot more and the parent was not able to determine if new words were present because she could not understand what the child was saying. S-LPs noted that they had observed parents using the integral stimulation hierarchy to teach their child a new word; two families required ongoing support from the S-LP with this skill at the mid-point. Most parents could take a highly desired word such as the name of a family member, pet, or favourite toy or activity and simplify their child's production to a word that used a word shape and sounds in the child's repertoire. Half

Table 4. Children's pre- and post-treatment scores on measures obtained from the connected speech sample.

	Total Utterances		Total Syllables		Mean Length of Utterance (Syllables)		Total Intelligible Words		Total Intelligible Word Types	
Child	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	32	26	37	36	1.16	1.38	27	19	13	12
2	94	134	180	211	1.91	1.57	50	91	12	24
3	135	124	285	353	2.11	2.85	186	243	51	82
4	94	162	142	543	1.51	3.35	67	235	34	66
5	82	101	189	299	2.30	2.96	130	202	39	67
6	89	71	146	116	1.64	1.63	54	52	22	26
7	107	131	199	262	1.86	2.00	77	171	28	45
8	130	122	472	489	3.63	4.01	272	283	73	110
9	103	122	212	224	2.06	1.84	16	45	7	15
10	94	64	381	244	4.05	3.81	143	136	49	52
Mean	96.0	105.7	224.3	277.7	2.22	2.54	102.2	147.7	32.8	49.9
(SD)	(28.3)	(40.5)	(125.4)	(154.3)	(.92)	(.98)	(80.5)	(93.2)	(20.8)	(31.8)

of the parents needed assistance from the S-LP when asked to provide examples of how the adapted motor speech treatment hierarchy could help them identify words containing target sounds at their child's level and how to use these sounds to build their child's vocabulary. Similarly, half of the parents did not know the term "cloze" procedure, although several of these parents were employing the strategy.

Seven of ten parents completed the *mid-program questionnaire*. The authors applied the content analysis procedures described previously to the three open-ended items, which solicited parents' perceptions of their child's progress. The authors agreed upon the following seven categories, which captured 58 of the 69 responses: 1) Increased confidence in talking and communicating (seven parents), 2) New sounds produced and accurate use of these in words with different syllables shapes (i.e., CV, VC, CVC) (seven parents), 3) Increase in vocabulary (six parents), 4) Increase in utterance length (six parents), 5) Improved clarity in communicating (six parents), 6) Increased willingness to imitate sounds and words (three parents), and 7) Self-correction emerging (one parent).

Six of ten parents completed the *end-of-program questionnaire*. Three of the parents did not complete the questionnaire because it was developed after their participation in the *LST* program ended and one parent failed to return it. The 11 items of the questionnaire are listed in Appendix 1. A summary of the responses to the items follows. A few illustrative quotes from the questionnaires are given in parentheses. Readers interested in a more detailed report of the information provided by the parents are invited to contact the authors.

Item 1. All six parents agreed that their child made at least "quite a bit" of progress in the program.

Item 2. Comments about the kinds of changes that parents had observed in their child's communication and speech behaviour were similar to those reported on the *mid-program questionnaire*.

Item 3. All six parents agreed that they had learned new strategies for helping their child learn and use new words. Their comments were sorted into four categories: 1) Using learning activities that motivate and engage the child to elicit target productions ("using lots of varied games and stories to keep his attention"), 2) Selecting speech targets that build on what the child can do ("mostly [I learned] to use small easy sentences that she can copy. It's not because she can't understand, but because she won't even try to say something too difficult"), 3) Using integral stimulation techniques ("having him watch my mouth first [and use] some hand cues"), and 4) Using general strategies to promote spoken language learning ("label everything and [give)] choices…to [help] her to tell me which thing she wants").

Item 4. Parents' descriptions of the kinds of words that their children found easiest to say included one-syllable words with simple shapes ("one-syllable words like Mom, no, me, ba"), two-syllable words with simple syllable shapes ("CVCV words like 'Bubba' [name of frog character]; "two-syllable words and combinations of two syllable words". "The easiest for him are words with identical syllables such as 'papa', although he has been getting better at saying more complicated words and words with sounds in his repertoire".

Item 5. All six parents agreed that the "right amount" of home practice activities was provided after each session ("After a few sessions, I had an understanding of what kind of additional activities to incorporate at home"; " [We] would have preferred to do more because we saw how it helped but it was not always possible.")

Item 6. Parents' comments regarding what would have made the experience better for their child and family were sorted into four categories. 1) One family indicated that they were satisfied with their experience, 2) Family and agency service delivery logistics ("I perhaps would have wanted the rest of my family to participate"; "I'd rather have one therapist instead of two"; "I don't feel the program is long enough at 8 weeks"; "I'd prefer a better time slot"), 3) Rate of progress (concern for one family) ("we are still hoping to see a sudden explosion of words which hasn't happened yet, just a steady increase (which is still good); we're a bit impatient"), and 4) Perception of how S-LP viewed child ("{child's name} is difficult to engage and we feel the assessment coloured the therapist's understanding of when he was mispronouncing due to motor/speech issues versus when he is not engaged in an activity".)

Item 7. Four categories were identified in parents' responses to what they liked best about the program: 1) Service delivery model ("The frequency. Coming twice a week to work with professionals made me more confident about my child's progress. Having completed a parent-focused group therapy program previously, I feel that the intensity of this program is much more suited for children like {child's name} who needs lots of one on one"), 2) Positive relationship between clinician, child, and parent. ("{Child's name} liked it; it was like fun, not work;

he improved, the therapists were able to understand him, which was a rare thing and they were able to form a good relationship with my child right away"; "Communication between therapist and parent is excellent; goals are clear; both {clinicians} were sensitive and responsive to my concerns"), 3) Gained new insights about child's speech and language ("Discovering that there's actually things we can do to help {child's name} speech; seeing the number of words/ideas etc. he can communicate increase....we understand him much better; discovering his level of understanding was ahead of his age was both a relief and a source of some pride ....we relate to him on a slightly different level [now]", and 4) Program focus ("I like the focus on particular sounds. Breaking it down in this way made the task of helping him seem less overwhelming".)

Item 8. All six parents responded "yes" when asked if they thought that their input was valued and incorporated into the treatment sessions. Their comments were sorted into three categories: 1) Clinicians used the strategies suggested by the parent to gain child's cooperation, 2) Clinicians selected target words identified by the parent as important for child ("[The clinicians] taught him words that we wanted him to learn"), and 3) Clinicians incorporated parent's comments about home practice and progress between sessions into session goals and activities ("At the beginning of each session, [clinicians' names] always inquired about changes since the last session. I always felt that my input was incorporated in the exercise or in the home activities assigned based on any progress {child's name} had made").

Item 9. All six parents responded that their child liked to attend the treatment sessions. Sample comments included: "She got excited when I asked her to get ready to come"; " "He would ask to go 'practice talking'; "I think that as {child's name} became more confident/familiar with the exercises or 'work' he enjoyed them more. More importantly the 'work aspect' of the program was very well balanced with the play, so that {child's name} associated the sessions with having a great time"; "I believe he enjoyed a sense of accomplishment; he knew when he had done well; on the other hand, I don't think he liked the focus on him and what he knows he lacks or the hard work (required)".

Item 10. Five of six parents responded affirmatively when asked if they would recommend the program to another parent who had a child with a severe speech delay. The sixth parent responded that "Because I am not an S-LP, I do not feel qualified to recognize if it would benefit (another) child".

Item 11. Additional comments from parents did not add new categories to those identified from the previous items.

S-LP Feedback

After the post-treatment measures had been collected for the final child-parent dyad, the project S-LPs met as a group with the authors. During this meeting the S-LPs were asked to provide their opinions (in written form) about the advantages and disadvantages of the *LST* service delivery model, as they experienced it in the pilot project. The first author sorted their responses into groups with similar content and distilled these into several points. The second author reviewed and revised these to the following, mutually agreed upon, set of summary statements. 1) The practice of obtaining information to determine a child's eligibility for *LST*, including measures of receptive and expressive language skills, leads to better decision-making for treatment. The pre- and post-treatment measures provide meaningful information for selecting goals and to share with parents before and following treatment. The pre-treatment connected speech sample also provides an opportunity to observe child-parent interactions. S-LPs recommended that that the *CDI* be added as a pre- and post- measure. 2) Explicit inclusion of parents through: a) selecting goals for parents, b) including parents in selecting goals for the child, c) home practice forms for which parents were made accountable, and d) the *Parent Guide, Parent Skills Checklist*, and *mid-questionnaire* helped parents to build their skills and working relationship with the clinician. Parents need more than one opportunity for education; *LST* provides multiple opportunities for parents to 'hear it', 'see 'it', and 'do it'. 3) The frameworks for selecting speech goals and teaching speech targets are helpful to structure clinical thinking and treatment planning for young children with severe speech delay. 4) The structured lesson plan protocol helps to guide lesson design and cue post-session reflection to organize and keep clinicians 'on track'.

Discussion

This article reports the results of a pilot implementation of the *LST* model to determine its feasibility as a clinical service for 3 year-old children with severe speech and expressive language delay. Six S-LPs and one CDA received training and support to provide this service to 10 child-parent dyads who met the criteria and consented to participate. While all children met the criteria for severe speech delay and scored below the 2nd percentile on the *KSPT* (Part 2), they demonstrated a wide range of scores on the pre-treatment imitated word task (*TOCS-30*) and connected speech sample measures. The amount of pre- to post-treatment change in these scores also varied widely across the children. Pre-post treatment measures of the children's speech behaviour and parent responses to *mid-* and *end-of-treatment questionnaires* provided support that children's performance increased on some measures of phonetic inventory and accuracy, and that parents responded positively to their roles and their child's experiences during treatment. Responses from the parents who completed the *end-of-program questionnaire*s suggested that at least some parents reported increased skills and confidence in fostering their child's speech development.

Most measures from the word imitation task (*TOCS-30*) showed change for most children (significant increases were found for number of consonant types, inclusion of recognizable speech sounds, and accurate production of syllable shapes and consonants). Two measures from the connected speech sample also showed change for the majority of children (significant increases were found for number of intelligible words and number of intelligible word types). Parental reports supported these findings. All parents who completed the *mid-program questionnaire* noted that their children were producing new vowels and consonants and using them accurately with different syllable shapes both within and outside of the treatment sessions; all parents who completed the *end-of-program questionnaire* indicated that their child made at least "quite a bit" of progress in learning new sounds and words.

Few comparable data have been published that report pre- and post-treatment measures for young children with severe speech and expressive language delay. Girolametto et al. (1997) reported significant changes in number of consonant types and syllable types for a group of younger children with severe speech delay who received a group-based parent intervention to increase children's vocabulary that did not require the children to produce the target words. In contrast to the results of this pilot implementation of *LST*, which provided a child with multiple opportunities to produce target words and phrases individualized to the child's sound and word structure repertoire, Girolametto et al. did not find significant increases in the children's accuracy of sound production or intelligibility as measured by percentage consonants correct.

Major and Bernhardt (1998) reported pre- and post- treatment measures that included the variables percentage consonants correct, percentage vowels correct, and percentage word shapes correct for 19 children between 36 and 59 months with moderate to severe phonological disorders following two treatment blocks of 18 sessions each of phonological intervention. Three of the children with severe phonological disorder and delayed expressive language were of comparable age (36-43 months) to the children in the *LST* pilot project. The intervention used a nonlinear approach to selecting speech sound and word structure targets and therapy techniques described as awareness activities, perceptual contrast training, and production activities (oral motor facilitation techniques, imitation, and spontaneous production). Significant increases in percentage consonants correct, percentage vowels correct, and percentage word shapes correct were reported post-treatment. Amount of pre-post treatment change in these variables observed in the pilot implementation of *LST* compares favourably with those reported by Major and Bernhardt. Estimates of effect size cannot be determined from their results but group mean pre-to-post treatment differences following 36 treatment sessions estimated from Figure 1 in their 1998 publication appear to be approximately 10% for percentage consonants correct (compared to a difference of 19% for the children in the *LST* pilot), 12% for percentage vowels correct (compared to a difference of 10% in the *LST* pilot), and 15% for percentage word shapes correct (compared to a difference of 28% for percentage syllable shapes correct in the *LST* pilot). The results are not directly comparable because the pre-post-treatment variables obtained by Major and Bernhardt were based on elicited, non-imitative productions of a larger sample of words than the *TOCS-30* imitative word task.

Use of the *Parent Skills Checklist* at mid-program provided valuable information about which skills that parents had learned and direction for which skills to target in the latter half of the program. The checklist also revealed information about those skills that appear easier for parents to acquire and those that are more difficult, which may be helpful to guide future selection of parent goals. Parents varied in their level of engagement in treatment sessions, skill levels, and ability to learn to use the strategies targeted in *LST*. Experience with the pilot project demonstrated that S-LPs need to adapt expectations for parent learning and coaching based upon the parent's incoming skill set (e.g., one parent may be ready for coaching on more advanced skills while a parent who is not understanding concepts of imitation and levels of support using integral stimulation should have additional coaching before moving to more challenging skills). Questionnaire responses reflected parental buy-in for *LST*. Qualitative comments on the parent questionnaires indicated that they collaborated with their clinicians as partners in the treatment process. The *end-of-program questionnaire* also provided information about the fidelity of the S-LPs and CDA in demonstrating key principles of *LST*. All parents who completed the questionnaire agreed that their input was valued and incorporated into the treatment sessions and that their child liked to attend the treatment sessions.

The structure of the implementation project enabled participating clinicians to provide services in a manner that could be replicated across S-LPs and evaluated across children and parents. S-LPs participating in the project observed that they learned how to do "*LST*" treatment by practicing it, supported by ongoing mentoring from the first author and their peers. S-LPs agreed that the additional time and effort required to learn and implement an alternative service delivery was worthwhile because of the knowledge, skills, and confidence that they gained and the changes that they observed in the children and parents. Essentially the S-LPs liked the program, found the materials useful, and benefitted from the community of practice. This resulted in an administrative decision to add *LST* as a service delivery option for children who fit the criteria. It was judged to be a more appropriate service delivery model for these children than the agency's continuing parent-focused group intervention program. S-LPs at the agency also used knowledge and skills from their experiences implementing *LST* to develop an additional program for small groups of younger children with severe speech delay, and their parents, which provides explicit speech production practice (see Kiesewalter, Vincent, & Lefebvre, 2017). This program provides the opportunity for S-LPs to better determine those children who need the more intensive speech production practice afforded by *LST*.

In this pilot implementation, the structure of *LST* service delivery was modified to meet the block scheduling limitations of the clinical setting such that only one parent-only session and 16 child-parent treatment sessions were provided. The effect of this modification has not been examined to date. However, our experience suggests that parents vary in their abilities to learn new knowledge and share information about their child's speech behavior. Given this, providing two parent sessions has the advantage of giving the parent time to think about the information provided in the *LST* Parent Guide, relate it to their child, and identify questions for clarification in the second session. The additional session also provides the S-LP with time to reflect on and incorporate information provided by the parent at the first session into the discussion of goals, which is intended to be a focus for the second session. A question for future investigation is the cost-benefit of adding four more child-parent treatment sessions (i.e., twice weekly over a 10-weeks) per the findings of Jacoby et al. (2002).

Clinical Implications

Ten 3 year-old children identified with severe speech and expressive language delay of unknown origin and age appropriate receptive language showed positive changes in at least some measures of phonetic accuracy and intelligibility following 16 sessions of individual treatment, provided twice weekly, that focused on speech production and incorporated structured, regular home practice. Key components of the treatment included careful selection of speech targets (sounds, one- and two-syllable words, and word combinations) that build systematically on the child's existing sound and syllable shape repertoire, and use of teaching strategies that are based on learning principles (Hodge, 2006), (i.e., importance of child's active attention to models of the speech targets and multiple opportunities to practice these in interactions with an adult that engage, motivate, and are meaningful for the child). This pilot project highlighted the heterogeneity of 3-year-old children who present with a severe speech and expressive language delay and age appropriate receptive language for the participating agency and demonstrated that 'suspected CAS' is not warranted as a default diagnostic label for all such children.

Limitations

Although the agency's experience participating in the pilot project led to a change in practice, at most, the results of this pilot implementation of the *LST* model suggest that it is feasible in at least one clinical setting with some S-LPs, some children, and with some parents. The project lacked sufficient rigour to endorse the effectiveness of *LST* based on scientific evidence. The case series approach, using pre-post treatment measures without any further controls, can only suggest that children progressed on a few measures (mostly in the context of single word repetition) over the course of the intervention. The sample of parents who were involved may not reflect the diversity of families who seek services. The effects of factors such as parent education level, SES, and bilingualism on child outcome and responses to parent questionnaires were not controlled in this pilot project. It is unknown if participation in the intervention was the reason for the changes observed in several pre- and post-treatment measures of the children's speech behaviour (beyond what would have happened without the intervention), or if similar changes would have been observed with a different intervention identified as being appropriate for young children at an emerging level of speech development (e.g., Parent and Children Together Intervention, the Nuffield Centre Dyspraxia Programme, PROMPT; Williams, McLeod & McCauley, 2010) or nonlinear phonological intervention. A necessity before undertaking a research study to investigate the efficacy of *LST* is to have a procedure to determine the adequacy of training of S-LPs to provide the treatment to children and parents. In this pilot implementation, the S-LPs continued to develop their skills as they worked with the participating families. A formal procedure for training S-LPs to provide *LST*, that includes supervised practice with an appropriate child-caregiver dyad, has since been completed by the first author.

The inter-rater agreement of 80% for the phonetic transcription of the children's productions of the *TOCS-30* items is less than the 85% or greater target suggested by Shriberg and Lof (1991). Measurement error rather than real change may be reflected in the pre-post treatment comparisons. However, the variables identified as showing significant change had larger changes than what would be expected by measurement error alone (Davis & Hodge, 2017). With respect to the phonetic variables reported, a consideration for future studies would be to combine vowel and consonant types into a single 'phoneme type' category to capture changes in the child's sound repertoire in a single measure. Similarly, word shape may be a more sensitive dependent variable than syllable shape for the level of severity of speech delay.

There is also a potential for bias in many aspects of this clinical project. In this first agency level implementation of the *LST* model, the clinicians who treated the children also recorded the pre- and post-speech samples and administered the parent questionnaires, which pose threats to the validity of the results. The transcribers were graduate students who varied in their knowledge of the timing of the sample recordings and potential investment in the *LST* model. Characteristics of the parents were not controlled other than they agreed to participate and reported that English was the first language of the home. Furthermore, no information is reported to speak to longer term maintenance of gains observed post-treatment. A systematic program of research to address these questions has not been undertaken to date. Judicious use of more controlled small N designs that could be implemented in the clinical context (Graham, Karmarkar & Ottenbacher, 2012) by the participating agency (e.g., multiple baseline) by S-LPs who now have considerable experience with the *LST* model would provide a feasible next step for this process.

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Appendix 1: Questions on the *End-of-program Parent Questionnaire* (child's name is inserted into blanks)

1. How would you rate ________________'s progress in learning new sounds and words over the treatment sessions?

   Not at all Very Little Some Quite a bit A lot

2. What kinds of changes have you seen in ________________'s communication behaviour over the past 3 months?

3. From watching the sessions and working at home with ________________ on the practice activities have you learned new strategies for helping ________________ learn new words?

   Yes No

   If yes:
   Please describe some of these:
   Which one(s) seem to work best with ________________?

4. Do you think that you have a better idea of whether a word might be easy or difficult for ________________ to say after participating in the treatment program?

   Yes No

   What kinds of words are easiest for ________________ to say?

5. In general, how would you rate the number of home practice activities provided after each session?

   Not enough Right Amount Too many

   Comments:

6. Tell us one thing that would have made this a better experience for your child and your family:

7. What did you like best about the treatment program?

8. Do you think that your input was valued and incorporated into the treatment sessions?

   Yes No

   Ideas for ways that we could have done more of this?

9. Do you think that your child liked to attend the treatment sessions?

   Yes No

   Please give some reasons for your response:

10. Would you recommend this program to another parent who had a child with a severe speech delay?

    Yes No

    Why or why not?

11. Please tell us anything else that you would like us to know about your experience with the treatment program:

Wee Words: A Parent-Focused Group Program for Young Children with Suspected Motor Speech Difficulties

Wee Words : un programme de groupe qui s'adresse aux parents de jeunes enfants chez qui l'on soupçonne des difficultés motrices de la parole

KEY WORDS

SPEECH-SOUND DISORDER

GROUP INTERVENTION

PARENT TRAINING

THERAPY

MOTOR-LEARNING

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Abstract

This paper describes *Wee Words* and pre-post treatment measures for this parent-child group-based program for children under 3 and a half years of age with suspected speech motor planning difficulties. A post-hoc review of measures obtained pre- and post-participation in the *Wee Words* program was undertaken to determine if positive changes in speech and expressive vocabulary skills were evident. Data are reported, covering a period of 2 years, for 32 children and their parents who participated in this 10-week program and for whom pre- and post-treatment measures were available for analysis. *Wee Words* included two evaluation sessions, two parent-education sessions, and six 1-hour parent-child group sessions. Parents were taught and coached to implement motor and sensory-based intervention strategies, as well as strategies to encourage imitation skills. Taken as a group, post-treatment, positive changes were apparent in measures of the children's imitation skills, speech sound repertoires, intelligibility, and expressive vocabulary development.

Abrégé

Cet article décrit le programme *Wee Words* et fournit les mesures pré- et post-traitements obtenues lors de l'application de ce programme de groupe s'adressant à des parents d'enfants de moins de trois ans et demi chez qui l'on soupçonne des difficultés de planification motrice de la parole. Une analyse post-hoc a été effectuée sur les mesures obtenues avant et après une participation au programme *Wee Words* afin de déterminer si des changements positifs étaient observés sur le plan de la parole et du vocabulaire expressif. L'article présente les données de 32 enfants et leurs parents ayant participés à ce programme de 10 semaines et pour qui les mesures pré- et post-traitements étaient disponibles pour les analyses. Les données ont été recueillies sur une période de deux ans. Le programme *Wee Words* comprend deux rencontres d'évaluation, deux rencontres d'information destinées aux parents et six rencontres de groupe d'une heure réunissant les parents et les enfants. Les parents ont reçu un enseignement et un encadrement afin qu'ils intègrent des stratégies d'intervention basées sur les principes moteurs et sur l'utilisation des informations sensorielles, en plus de stratégies pour encourager les habiletés d'imitation. Dans l'ensemble, des changements positifs ont été observés post-traitement sur les mesures des enfants, soit les habiletés d'imitation, le répertoire des sons de la parole, l'intelligibilité et le développement du vocabulaire expressif.

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Introduction

The importance of early intervention has been well documented for children with communication impairments (Awcock & Habgood, 1998; Young et al., 2002) and family involvement can improve the success of early intervention (Eiserman, Weber & McCoun, 1995; Roberts & Kaiser, 2011). For example, children with expressive language delays who participated in *It Takes Two to Talk* (The Hanen Program; Pepper & Weitzman, 2004), a parent training program that provides an indirect model of service delivery, showed growth in expressive language skills (Girolametto, Pearce, & Weitzman, 1996). However, there is some question whether children with suspected motor speech difficulties make adequate speech and language changes in parent-based group programs. Gaines and Gaboury (2004) noted that children with signs of severe motor speech difficulty showed no growth in expressive vocabulary in their parent-focused group program when a focused stimulation approach to language stimulation was used (i.e., Toddler Talk).

Let's Start Talking (LST) (Hodge, 2007; Hodge & Gaines, 2017) is a treatment program for young children with severe speech delay (target age is around 36 months) and suspected speech motor learning difficulties, and their parents. *LST* applies motor learning-based principles to practice and has been offered by the First Words Program in Ottawa since 2004. The program includes parent education sessions and active parent involvement in individual speech therapy sessions with the child twice weekly for 8 to 10 consecutive weeks, with assigned home practice sessions in between. While many children have responded positively to the *LST* service delivery model, some of the younger (or developmentally younger) children who participated in *LST* struggled with the behaviour demands needed to participate in individual therapy twice a week. To be eligible for *LST*, children were required to participate in therapist-led activities for short amounts of time, intentionally vocalize, listen to the clinician's model, and attempt to imitate the clinician. Strand, Stoekel, and Bass (2006) commented that children must have the motivation to try and be willing to participate in numerous practice trials to see progress in therapy. Despite an initial classification of 'severe speech delay' with suspected childhood apraxia of speech, some children made rapid progress in *LST*, suggesting that they did not need twice weekly treatment to make significant gains. The positive responses of families to *LST* and a desire to provide developmentally appropriate therapy that incorporated motor learning principles to children younger than age 3 years with suspected motor speech difficulties provided the motivation to develop *Wee Words*. *Wee Words* is a parent-focused group program targeting speech and expressive vocabulary development for young children with suspected motor speech difficulties. It was expected that some of the children participating in *Wee Words* would later participate in the *Let's Start Talking* program. As such, *Wee Words* was designed to provide parents with information that aligns with the principles of *LST*.

The purpose of this article is to describe *Wee Words* and report the results of an analysis of pre-post treatment measures obtained as part of the program. Specifically, the pre-post measures were examined to determine if they reflected growth in the children's 1) expressive vocabulary skills and 2) speech sound skills (e.g., consonant repertoire, number of one and two-syllable word shapes, intelligibility).

Identification of Children with Motor Speech Difficulties

Childhood Apraxia of Speech (CAS) has been defined by the American Speech-Language Hearing Association (2007) as a neurologically based speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits. This includes significant impairment in the planning and/or programming of movement sequences in speech sound production and prosody (ASHA, 2007). Characteristics commonly used to identify children with CAS include: inconsistent errors of consonants and vowels on repeated trials, limited consonant and vowel repertoires, vowel errors, difficulty with smooth movements towards articulatory configurations, increased errors in longer units of speech output, predominant use of simple syllable shapes, difficulty/articulatory groping when imitating words and phrases, inappropriate prosody, and reduced expressive skills compared to receptive language skills (ASHA, 2007; Davis & Velleman, 2000; Thoonen, Maassen, Gabreels, Schreuder, & DeSwart, 1997).

Despite this list of characteristics, it is well recognized that CAS is difficult to define and speech-language pathologists do not all use a consistent set of criteria to identify children with CAS (Forrest, 2003; Martikainen & Korpilahti, 2011). Prosodic disturbances, a common characteristic used in the identification of CAS, cannot be used with young children, as young children who are later diagnosed with CAS often present with limited speech output (Highman, Hennessey, Sherwood & Leitao, 2008). Children diagnosed with CAS have been reported by Highman et al. (2008) to combine words later (average = 33.3 months) when compared with both typically developing children (average = 14 months) and children with Specific Language Impairment (average = 27 months).

Identifying CAS in young children is additionally challenging as the profile of children with CAS may change with time and currently little is known about this. Davis and Velleman (2000) recommended 6 to 12 months of diagnostic therapy with infants and toddlers before using the label '*childhood apraxia of speech*'

Early Intervention for Children with Suspected CAS

Given the challenges in identifying children with CAS, especially in younger children, it is not surprising that relatively few studies have looked at the efficacy of intervention for this group of children (Strand et al., 2006). Studies that have been published frequently involve a small number of children, almost always over 3 years of age. Strand et al. (2006) investigated the efficacy of Dynamic Temporal and Tactile Cueing (DTTC) treatment on four children with severe CAS from 5:1 to 6:1 years old. Iuzzini and Forrest (2010) investigated the impact of Stimulability Training and Modified Core Vocabulary treatment on four children with CAS from 3:7 to 6:10 years old. Murray, McCabe, and Ballard (2012) investigated the efficacy of two treatment approaches on 20 children aged 4 to 16 years of age. It is commonly agreed that children with CAS need intensive speech therapy (McCauley & Strand, 2008). Edeal and Gildersleeve-Neumann (2011) found that frequent and intense practice of speech resulted in more rapid response to treatment in two children with CAS. Treatment approaches for children with CAS typically involved therapy at least twice a week, often more. Strand et al. (2006) provided sessions two times a day, five days a week. Iuzzini and Forrest (2010) provided 20 therapy sessions over 10 weeks. Martikainen and Korpilahti (2011) provided therapy three times a week for six weeks.

McCauley and Strand (2008) commented that there is widespread agreement that effective intervention for CAS needs to include motor-based therapy principles to optimize motor learning. Motor learning principles have been shown to be effective in the acquisition of motor skills (Magill, 2010). These principles include: (a) frequent training sessions; (b) repetition of the same targets to improve movement accuracy (i.e., mass practice); (c) variety of stimuli to facilitate greater learning and retention; (d) awareness of feedback (i.e., initial feedback should be specific to the movement, immediate, and frequent), and (e) use of cues (i.e., tactile, melodic, rhythmic, gestural). Magill (2010) reported that motor learning is most effective in contexts similar to real-life situations. As well as motor-based therapy principles, sensory-based strategies have frequently been used to treat children with suspected CAS. Integral Stimulation, a sensory-based therapy, involves practicing movements using multiple sensory models including listening to the auditory model, visual attention to the clinician's face, and tactile cues (McCauley & Strand, 2008). Research does support the combination of more than one therapy approach for children with CAS. Iuzzini and Forrest (2010) found that a combination of a modified Core Vocabulary treatment (i.e., linguistic based) and Stimulability training (i.e., motor-based) provided greater benefits than either therapy approach used independently.

DeThorne, Johnson, Walder, and Mahurin-Smith (2009) provided a review of evidence-based strategies to facilitate imitation skills in young children who do not easily imitate sounds and words, which includes children with CAS. DeThorne et al. (2009) found support for six treatment approaches including: a) access Augmentative and/or Alternative Communication (e.g., Picture Communication symbols), b) minimize pressure to speak as high pressure situations can negatively impact motor performance, c) imitate the child to encourage the child to imitate, d) use exaggerated and slow tempo, e) use auditory, visual, tactile, and proprioceptive cues and feedback, and f) avoid emphasis on non-speech movements.

Research supporting frequent therapy sessions for children with CAS is based on an older group of children. Children developmentally younger than 3 years may lack the motivation or attention for multiple therapy sessions in a week. It is unknown whether more intensive intervention is needed for this age group. However, parent-focused interventions have been shown to be an effective and efficient intervention approach for toddlers with delayed speech and language development (Girolametto et al., 1996). Girolametto (1988) found that familiar interaction and naturalistic settings may reduce pressure to speak. Gaines and Gaboury (2004) demonstrated expressive vocabulary growth following participation in *Toddler Talk*, a parent-focused group program where therapists demonstrated intervention techniques and coached parents in order to help them model speech and language skills more effectively.

In summary, parent-training programs that have been developed for late talkers have questionable effectiveness for young children with suspected motor speech difficulty, when a general language stimulation approach is the focus of therapy. At the Children's Hospital of Eastern Ontario (CHEO), children under 3 and a half years of age typically participate in group parent-training programs. A small number of 3 year-old children with suspected motor speech difficulty receive *LST* if the child and parent meet the program criteria. However, from clinical observation it became evident that some younger children and some families struggled with the individual therapy sessions twice a week that are part of *LST*. As well, some children made rapid progress in *LST* and may not have required intensive individual therapy sessions. Further, there is currently limited published information regarding the speech and expressive language outcomes of intervention programs for this group of children. In particular, parent-based training intervention that is designed specifically for small groups of parent-child dyads where the child presents with suspected motor speech difficulties has not been reported to date.

Wee Words Program

Wee Words was developed at the Children's Hospital of Eastern Ontario (CHEO) to meet the needs of children under 3 and a half years of age with suspected motor speech difficulties. In addition, the speech and language changes and parent commitment observed during participation in *Wee Words* provided further information regarding which children would benefit from later participation in *LST*. *Wee Words* was designed by Jennifer Kiesewalter, speech-language pathologist, and Mary Lynn Taschereau-Park, communicative disorders assistant. *Wee Words* is a parent-child group based program that provides demonstration and coaching to parents. *Wee Words* combines motor-based therapy principles, sensory-based strategies, and strategies to facilitate imitation skills for young children with suspected motor speech difficulties. The goals of children participating in *Wee Words* include: 1) build imitation skills, 2) increase consonant repertoires to include /p, b, m, h, t/, 3) increase range of one and two-syllable word shapes to include consonant-vowel (i.e., CV), vowel-consonant (i.e., VC), and CVCV shapes, and 4) increase expressive vocabulary. These speech targets are similar to those of the *LST* program to help create consistency for parents from one program to the next. A more detailed description of the content of *Wee Words* is provided in the Methods section. Like *LST*, measures of parents' perceptions and children's speech behaviours were developed to collect information pre- and post-participation in *Wee Words*. An advantage of using the same measures for all participants is that the results can be aggregated for analysis.

Methods

A post-hoc analysis of pre- and post-treatment measures obtained from families participating in *Wee Words* was approved by the Research Ethics Board at the Research Institute of the Children's Hospital of Eastern Ontario. The same assessment measures were obtained at the pre- and post-treatment sessions for all participants whose measures were analyzed. These are described in the following section.

Participants

Speech-language pathologists from the First Words Speech and Language program were invited to refer children to *Wee Words* if motor speech difficulties were suspected at an evaluation or a re-evaluation appointment. Clinicians were provided with a list of eligibility criteria for *Wee Words* and a list of common characteristics to help identify children with suspected CAS (Thoonen et al., 1997). Eligible children were 24 to 40 months of age at the start of *Wee Words*, with receptive language subjectively judged to be at or near normal limits. The referred children presented with appropriate behaviour and social skills as subjectively judged by the clinician (i.e., sit for short periods of time, positive intent to communicate, age-appropriate play skills). As well, parents reported no concerns with hearing and exposure to English at home, although English did not have to be the first language. Clinicians referred children with a limited consonant and vowel repertoire, including limited use of early developing consonants /p, b, m/, and limited word shape repertoire (e.g., limited use of 2-syllable words, omission of final consonants). Children may also have presented with other characteristics of motor speech difficulty (e.g., vowel distortions, inconsistent productions on repeated attempts, articulatory groping behaviours) and poor imitation skills that may have included the inability to imitate or inaccurate attempts.

The files of referred children were then reviewed by the *Wee Words* clinician to counter-verify that the children met eligibility criteria. Children that met all eligibility requirements were offered a pre-therapy evaluation session to obtain further information on motor speech skills and to choose therapy goals. If children's goals matched those of *Wee Words*, they were admitted. Forty children were offered a therapy spot in *Wee Words* from the fall of 2007 to the winter of 2009. Thirty-eight families completed the program (one child discontinued participation after achieving age-appropriate speech and language skills shortly after the start of the program and a second child discontinued participation due to personal reasons). The data from three children who completed the program were later excluded from analysis due to unidentified hearing loss, illness, and atypical social skills. Three children did not attend the post-treatment evaluation session and were also excluded from the study. The data from 32 children were included in this study. At the start of the program, the children ranged in age from 24 to 37 months and the mean age of the 32 children was 29.7 months (*SD* = 3.44).

Procedures and Materials

Pre-treatment measures.

Children attended the pre-therapy evaluation session with their parent(s) and the speech-language pathologist and communicative disorders assistant facilitating *Wee Words*. At the pre-therapy evaluation session, the parents were given the MacArthur-Bates Communicative Development Inventory (Fenson et al., 1993; MCDI) and a pre-program parent questionnaire, to be returned at the first parent education session. The MCDI was used as a parent-report measure of expressive vocabulary (included both gestures and words). The parent questionnaire was adapted from the parent questionnaire used in the *Let's Start Talking* program (Hodge, 2007) and was used to gain a better understanding of the parents' perception of changes in their children's speech and language skills. The questionnaire includes two sections; questions about speech and language development (i.e., questions 1-5) and questions about the *Wee Words* program (i.e., questions 6-16). The questionnaire includes eight Likert scale questions using a 5-point rating scale (i.e., 1 = strongly disagree; 5 = strongly agree) and eight open-ended questions (e.g., In the past two months, what changes have you seen in ____'s communication development.). Only the first three questions, which relate to parents' perception of changes in their child's speech and language skills, were analysed in the current study. These appear in Appendix A.

Each child participated in a speech probe measure with the speech-language pathologist, videotaped by the communicative disorders assistant. The speech probe consisted of a list of 14 real words (i.e., up, moo, baa, hi, bye bye, mmm, farmer, hat, dirty, eat, fall, off, puppy, boom). The words were selected to sample early consonant sounds (i.e., /p, b, m, t, d, h/) in a variety of one and two syllable word shapes (i.e., vowel, consonant-vowel, vowel-consonant, consonant-vowel-consonant-vowel). Each word was presented three times in a book reading activity and/or free play with a farm set. The target word was presented with a slight emphasis following a pause. For example, the speech-language pathologist said "the dog hops....**up**!", then waited a few seconds for the child to attempt the target word. Children were encouraged to imitate by the clinician waiting expectantly. Some verbal encouragements were provided (e.g., "you try").

Three different speech-language pathologists facilitated this program. The speech probe was consistently administered by the same clinician at the beginning and end of the program with each child. Measures obtained from the speech sound probe included: (a) number of imitation attempts, (b) number of correct attempts, (c) number of different consonants, (d) number of different vowels, and (e) number of different one and two syllable word shapes.

As well, each child and caregiver dyad participated in a video-taped 10-minute spontaneous speech/language sample. Again the videotaping was done by the communicative disorders assistant co-facilitating the program. Parents were instructed to play naturally with their child, limiting questions and requests to imitate. Each parent-child dyad was provided the same set of toys, including play-doh, baby set, trucks, and puzzles. Measures obtained from the speech/language sample included: (a) number of utterances, (b) number of intelligible utterances, (c) number of imitated utterances, (d) number of different vocabulary words (i.e., words that convey a different meaning), and (e) and number of different consonants. The quality of the videotape did not allow for analysis of vowel sounds from the speech/language sample.

Intervention Program.

Each *Wee Words* included up to five parent-child dyads. The intervention was co-facilitated by a speech-language pathologist and communicative disorders assistant. Parents attended two education sessions and participated in six 1-hour parent-child group therapy sessions. Each parent-child session targeted a specific word shape (e.g., consonant-vowel) or speech sound (e.g., /h/) as part of a vocabulary theme (e.g., bugs and outdoor play).

Parents attended the first education session following participation in the pre-therapy evaluation. The goal of this session was to provide parents with an understanding of typical speech sound development (e.g., how sounds are produced) and provide information on strategies to support speech at home. Parents were introduced to motor learning principles (i.e., initial use of immediate, specific feedback; importance of frequent practice sessions; how to elicit repetition of a target word; types of cues and why they are used) to facilitate speech. As well, strategies were provided to encourage imitation skills (e.g., imitate child; use picture symbols at snack time). Parents were provided with an overview of a typical *Wee Words* parent-child group session. Expectations of both parents and children were discussed (e.g., homework, parent participation, cancellation policy).

The second parent education session was scheduled following the third parent-child group session. In this session, parents were given an opportunity to discuss successes and challenges. A review of motor learning principles was completed. At this point, parents were encouraged to select target words from the word shape and sound goals the speech-language pathologist had identified for each child. Parents were encouraged to think of the rationale behind a target word, considering their children's needs and speech sound skills. As well, parents were encouraged to think about future speech goals for their child. For example, a child who had successfully mastered 'up' could begin to practice this word in a two-word combination or could choose another target word with similar movement patterns.

The word shape or speech sounds targeted within a vocabulary theme with respective suggested words and activities for each of the six *Wee Words* parent-child sessions are shown in Table 1. It should be noted that a child was not expected to be able to use each new sound pattern proficiently at the end of the week. Rather, it was expected that parents would learn strategies to work on a variety of speech targets, which they could continue to practice at home. Although a general sound pattern was targeted each week, clinicians used the coaching time to individualize this to each child/family. The speech movements required were considered when selecting individualized target sounds and words.

The therapy sessions followed a 60-minute routine that included: (a) instrument parade to therapy room, (b) *hello* circle, (c) three to four parent-child activities, (d) story/song, and (e) snack. The *hello* song was used to encourage imitation of motor actions (e.g., waving, clapping) at the beginning of each session. Children then participated in an activity with their caregiver. The clinician introduced each activity explaining the target word shape and a strategy to practice in that activity (e.g., holding objects to face to encourage children to watch model, use of visual cues, providing specific feedback). The speech-language pathologist and communicative disorders assistant visited each family and provided teaching and/or coaching on the use of strategies to facilitate speech sound skills and how to apply these principles through play. At the end of an activity, children returned the toys to a bin and another activity was introduced. In the first few weeks, one activity targeted imitation of motor actions. A storybook was read by the speech-language pathologist and related to the vocabulary theme. At snack, each child was provided with pictures. Pictures were provided to introduce parents to Augmentative and/or Alternative Communication systems and to reduce communicative pressure on children.

Weekly homework suggestions were provided for each vocabulary theme. Parents were encouraged to do mass practice in the session and homework activities were provided for variety to encourage generalization and retention.

Table 1. Sample Schedule of Weekly Themes and Goals from the *Wee Words* program

Week	Word shape/ speech sound	Vocabulary Theme	Target Words	Activities
1	V	Body awareness and feelings	Ow, ah, aa	Doctor kit and baby set
2	CV	Farm animals	Moo, baa, bah	Find farm animals
3	CVCV	Family and pets	Puppy, muddy, momma, dada	Wash puppies and pretend houses
4	VC	Mealtime and bedtime	Eat, umm, out	Feed puppets and make soup
5	Airflow (/h, f/)	Bugs and outdoor play	Off, fall, high	Bug slide and bubbles
6	Sound review	Around the town	Out, hi, bye, boat, up, fall	School bus, boats in water

Note. V = vowel; C = consonant.

Post-treatment measures.

The week after the end of the program, children attended the post-therapy evaluation session with their parents and the speech language pathologist who facilitated *Wee Words*. Parents returned an updated MCDI and a post-program parent questionnaire. The parent questionnaire was used to evaluate parents' satisfaction following participation in *Wee Words*. As in the pre-therapy evaluation, the speech probe and speech/language sample were videotaped by the communicative disorders assistant who co-facilitated the program.

Calculation of Pre- and Post-Treatment Measures from the Speech Probe and Speech/Language Sample

Videos of the children's pre- and post intervention speech probes were coded by two speech language pathology students from the University of Ottawa. Training was provided by the first author on how to code each measurement. After each target word was presented, a checkmark was used to mark whether the child attempted to imitate or not. Each child response was coded as correct (i.e., +) or incorrect (i.e., -). Incorrect responses were transcribed phonetically. The consonant or vowel needed to be imitated accurately in the correct word position to be counted. Thirty of the videos coded by each of the two students were also coded by a speech language pathologist (the first author). The videos were randomly selected from all the possible pre- and post intervention speech probes. An inter-rater reliability analysis was performed to assess the degree of consistency with the speech language pathologist that each student provided in their coding (Hallgren, 2012). Inter-rater reliability was calculated using a two-way, single-measure Intra Class Coefficient (ICC) (McGraw & Wong, 1996) for each of the following measures: number of attempts (Student 1: ICC_2 = 0.98; Student 2: ICC_2 = 0.98), number of correct attempts (Student 1: ICC_2 = 0.96; Student 2: ICC_2 = 0.96), number of different consonants (Student 1: ICC_2 = 0.93; Student 2: ICC_2 = 0.89), number of different vowels (Student 1: ICC_2 = 0.94; Student 2: ICC_2 = 0.92) and number of different syllable shapes (Student 1: ICC_2 = 0.85; Student 2 ICC_2 = 0.93). The resulting ICCs were all within the excellent range (Cicchetti, 1994).

A third student from the University of Ottawa coded the videos of the speech/language samples. Again, training was provided on how to code each measurement. Each utterance in a sample was given a number. The utterance was coded as intelligible if completely understood with available context. Each utterance was also coded as spontaneous or directly imitated. The consonants in each utterance were transcribed phonetically. A speech language pathologist (the first author) also coded 35 of the speech/language samples. These were randomly selected from the total pool of pre- and post intervention speech/language samples. An inter-rated reliability analysis was performed to assess the degree of consistency between the student and speech language pathologist. Inter-rater reliability was calculated using a two-way, single measure ICC for each of the following measures: number of utterances (ICC_2 = 0.99), number of imitated words (ICC_2 = 0.99), number of intelligible utterances (ICC_2 = 0.98), number of different consonants (ICC_2 = 0.92), and number of different vocabulary words (ICC_2= 0.98). The resulting ICCs were all within the excellent range (Cicchetti, 1994).

Analyses

Paired-samples *t*-tests were used to determine if there was a significant difference between the pre-program and post-program measures of the speech probe, the speech/language sample, and expressive vocabulary as reported by parents on the MCDI. Of the 32 children included in this paper, 30 children's pre- and post-treatment speech probes and MCDI were available for analysis. The quality of the sound recording did not allow for the analysis of a speech sound probe for two children. Thirty-one children's pre- and post-treatment speech/language samples were available for analysis as one video recording could not be analysed for a different child's speech/language sample.

Parents' answers on the questionnaire's 5-point rating scales about children's changes in speech sound skills, vocabulary, and communication frequency were converted into ranked numbers (1 = strongly disagree and 5 = strongly agree). The Wilcoxon signed rank Test was used to determine if responses on the parent questionnaires changed after the completion of the program. The pre- and post-program questionnaires for 26 children were available for comparison.

Results

Speech Probes and Speech/Language Samples

Table 2 displays the participant's results on the speech probe measures and the paired t-tests values comparing those measures before and after the program.

There was a statistically significant difference on all speech probe measures between pre-treatment and post-treatment evaluations. The eta squared statistic indicated large effect sizes for all measures according to the guidelines proposed by Cohen (1988, pp. 284-287; .01 = small, .06 = moderate, and .14 = large). On average, after the program, the children added 6.7 imitation attempts,

Table 2. Results on the Speech Probe Measures and Paired t-Tests Values Comparing Pre- and Post-treatment scores

	Pre-treatment		Post-treatment				95% CI		
Measures	*M*	*SD* (*Range*)	*M*	*SD* (*Range*)	*t*(29)	*p*	*LL*	*UL*	*eta squared*
n. of imitation attempts	6.4	9.1 (0-30)	13.1	10.9 (0-37)	4.09	< .01*	3.4	10.1	.37
n.. of correct attempts	1.3	2.8 (0-12)	6.1	6.8 (0-21)	4.47	< .01*	2.6	7.0	.41
n. of different consonants	1.9	2.2 (0-7)	3.3	2.3 (0-7)	3.26	< .01*	0.5	2.2	.27
n. of different vowels	1.6	2.1 (0-7)	3.4	2.4 (0-7)	4.83	< .01*	1.3	3.1	.45
n. of different word shapes	1.2	1.6 (0-5)	2.7	2.0 (0-6)	4.84	< .01*	0.9	2.2	.45

Note. *M* = mean score; *SD* = standard deviation; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit, ( ) = range.
* p< .05.

4.8 correct attempts, 1.4 consonants, 2.2 vowels, and 1.5 word shapes in their productions during the speech probes. Seven children did not make any imitation attempts on the pre-treatment speech probe. Only one of those children had no imitation attempts on the post-treatment speech probe. The Intra Class Coefficients for the measures of the speech probes were within the excellent range indicating the coders had a high degree of agreement and suggested similar transcriptions across the two students and the speech language pathologist.

Table 3 shows the participant's results on the speech/language sample measures and the paired t-test values comparing those measures before and after the program.

There was a significant increase in all measures, except for the mean number of utterances children produced. The eta squared statistic indicated large effect sizes for all measures that increased significantly. On average, after the program, the children added 3.5 imitated utterances, 16.5 intelligible utterances, 3.3 different consonants, and 9.7 different vocabulary words in their productions during the speech/language sample. The Intra Class Coefficients for the measures of the speech/language samples were also within the excellent range, suggesting consistent transcriptions across the student and the speech language pathologist.

Parents' Report of Expressive Vocabulary on the MCDI

There was a statistically significant increase in the number of vocabulary words parents reported on the MCDI. At the beginning of the program, parents reported an average of 82.8 (*SD* = 88.8) words. At the end of the program, parents reported an average of 151.5 (*SD* = 125.2) words. This represented a significant increase, $t(29) = 2.40$, $p < .02$ (two-tailed). The mean increase in vocabulary was 68.7 words with a 95% confidence interval ranging from 11.4 to 126.1 words.

Parents' Perceptions of Children's Speech and Language Skills from the Parent Questionnaire

Table 4 shows the medians of the parents' ratings of their child's speech and language skills on the three items

Table 3. Results on the Speech/Language Sample Measures and Paired t-Tests Values Comparing Pre- and Post-treatment Scores

Measures	Pre-treatment *M*	Pre-treatment *SD* *(Range)*	Post-treatment *M*	Post-treatment *SD* *(Range)*	*t(30)*	*p*	95% CI *LL*	95% CI *UL*	*eta squared*
n. of utterances	82.7	37.6	97.8	38.3	-1.93	.06	-	-	-
		(11-155)		(26-155)					
n. of imitated utterances	3.3	5.3	6.8	9.2	-2.17	.04*	0.2	6.9	.14
		(0-31)		(0-44)					
n. of intelligible utterances	22.5	18.3	39.0	19.9	-4.49	< .01*	9.0	24.0	.40
		(0-66)		(6-88)					
n. of different consonants	4.6	2.7	7.9	3.2	-6.27	< .01*	2.3	4.5	.57
		(0-12)		(2-15)					
n. of different words	8.4	7.1	18.1	12.7	-5.36	< .01*	6.0	13.4	.49
		(0-30)		(2-42)					

Note. *M* = mean score; *SD* = standard deviation; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit, ( ) = range.
* p< .05.

Table 4. Results on the Parent Questionnaire and Wilcoxon Signed Rank Test values Comparing Pre- and Post-treatment Scores

Questions	Pre-test	Post-test *Md*[a] *(Range)*	*z* *Md*[a]	*p* *(Range)*	*r*
1) In the past 2 months, my child's speech sound skills have improved	4.0	4.0	-2.56	.01*	.33
	(1-5)	(2-5)			
2) In the past 2 months, my child has learned to say new words	4.0	4.5	-1.85	.06	-
	(1-5)	(2-5)			
3) In the past 2 months, my child's frequency of communication has increased	4.0	4.0	-2.72	< .01*	.35
	(1-5)	(2-5)			

Note. *Md* = median score.
[a]1 = strongly disagree; 5 = strongly agree.
* p< .05.

on the parent questionnaire and the Wilcoxon signed rank test values comparing those measures before and after the program.

The Wilcoxon signed rank test revealed a statistically significant difference in the first question and the third question, but not on the second one. According to Cohen (1988) criteria of .1 = small effect, .3 = medium affect, and .5 = large effect, medium effect sizes were found regarding the perception of speech sound improvement (question 1) and of children's frequency of communication (question 3).

Discussion

Measures taken pre- and post-participation in *Wee Words* were compared for a relatively large group of children (i.e., 32) under 3 and a half years of age with suspected motor speech difficulties. Improvements were expected given that the strategies taught to the parents were evidence-based and teaching parents of young children has been shown to be an effective therapy approach. As a group, the children in *Wee Words* showed significant positive changes in expressive vocabulary and all of the targeted speech goals, including improvements in imitation skills, consonant sound repertoire, and a variety of word shapes, as measured by speech probes, speech/language samples, and the MCDI. However, on the speech/language sample, no significant difference were observed in the mean number of utterances children produced from the pre- to post-treatment evaluation. The high standard deviations indicate that children varied considerably in the number of utterances produced in the sample. On an individual basis, some children did show marked increases in frequency of utterances in the post-treatment sample but this was not the case for a majority of children. Clarity of word production and use of a greater variety of speech sounds and vocabulary words appeared to be the areas of significant change for the group of children following participation in *Wee Words*.

Parents' perception of vocabulary growth, as measured by the parent questionnaire, did not reflect the significant growth children made in their expressive vocabulary as measured by the MCDI. This was not surprising given that on the pre-treatment questionnaire many parents scored a 4 on the 5-point rating scale question "In the past two months, my child has learned to say new words". The 5-point rating scale used by the questionnaire did not allow for changes in expressive vocabulary to be captured. However, the pre-treatment results for this item suggest that children were gaining words prior to attending *Wee Words*. As expected, the children demonstrated growth in expressive vocabulary development. Gaines and Gaboury (2004) also observed expressive vocabulary growth following parent coaching in a parent-child group program. A significant increase in use of new words was also reported for a group of 34 preschool children identified as late talkers following participation in Target Word™ (The Hanen Program), a treatment program based on a parent coaching model (Annibale, 2015). The design of the current project does not allow determination if the rate of new word acquisition over a comparable period before attendance in *Wee Words* was similar to the rate of new word acquisition over the period of *Wee Words*.

Previous studies have shown improvements in speech sound repertoires following participation in therapy for older children diagnosed with CAS (Iuzzini & Forrest, 2010; Powell, 1996). Strand et al. (2006) reported that children with CAS demonstrated improvements in articulatory accuracy and Martikainen and Korpilahti (2011) observed a decrease in speech sound errors following therapy three times a week. Similarly, following participation in *Wee Words*, as a group, children produced a greater number of correct attempts on the speech probe and an increase in intelligible utterances. Improvement in consonant repertoires was also observed. The results do provide support "from the field" for a parent-focused group program as a first intervention for very young children with suspected motor speech difficulties.

Limitations

This article is presented as a clinical report. It lacks the rigour of a research study, and so it is not possible to conclude that the observed gains were the result of *Wee Words*. In addition, some of the measures were likely influenced by the realities of clinical practice. The speech probe was developed primarily as a clinical tool to help identify which children would benefit from participation in *Wee Words* and it was administered by the clinician facilitating the program. As data collection took place over several years, three different speech language pathologists administered the speech probe measure. Although training was provided to increase consistency, inconsistent administration of the speech probe may have affected the measures obtained. For example, although both play with a farm set and a story reading task were used to elicit imitation, the number of targets produced with the story reading task varied across each administration of the probe. Children may have been less likely to imitate in the story reading task as it may be a new experience for them. As well, the number of direct requests to imitate varied depending on the clinician and child. These factors may have had an effect on the number of words a child attempted to imitate. A standardized assessment would improve the consistency of administration both across clinicians and from the pre-to post-treatment assessment. However, no known assessment tool would have been appropriate for evaluating the speech sound skills of children as young as 24 months of age or children with poor imitation skills. Some flexibility was needed due to the young age of children and their readiness to participate in assessment tasks. In addition, some of the improvements from the pre- to post-treatment administration could have been attributed to comfort level with the clinician.

The level of analysis possible was another limitation of the pre-post measures. The lack of sensitive recording equipment limited the analysis of a child's speech sound repertoire to consonants. Vowels were too difficult to transcribe reliably in the speech/language sample. Both the speech probe and speech/language sample measures examined changes at the sound level, including changes in the phonetic repertoire, or at the word level. However, it is known that prosodic disturbances are a common characteristic of CAS. Adding measures beyond the sound and word level would address this.

Parent participation was an integral component of *Wee Words*. However, it is unknown how much time each parent spent participating in home activities. This may have had a significant impact on the results. Examining a parent's ability to implement the strategies and the amount of time each child spent practicing with a parent at home would address this issue. *Wee Words* combines strategies of a motor-based approach (Magill, 2010) with sensory-based strategies (McCauley & Strand, 2008) and strategies to facilitate imitation skills. Therefore, no inference can be made about the relative benefit of each approach.

Implications and Conclusions

The results of the analysis of the pre-post treatment measures reported for *Wee Words* demonstrate that, following a parent-focused group based intervention, children under 3 and a half years of age with suspected motor speech difficulties can show positive changes in imitation skills, intelligibility, speech sound repertoire, and expressive vocabulary development that agree with parent reports of observed positive changes in the children's speech sound skills and frequency of communication. Research has suggested that children with suspected CAS benefit from frequent therapy sessions. However, given the increasing demands of identifying children at a younger age, it was necessary to find an efficient yet effective way of providing therapy for a group of children that may not be ready to participate in an individual therapy approach that requires a child to watch a clinician model and imitate. The pre-post treatment changes reported in this article support the use of parent-focused intervention for young children with suspected motor speech difficulties. Providing parents with strategies to support their child's communication development at a young age may encourage long-term participation in therapy. Twelve of the 35 children (34.3%) that participated in *Wee Words* later participated in the *Let's Start Talking* program (Hodge, 2007). *Wee Words* greatly increased the efficiency of service delivery to children under 3 and a half years of age with suspected motor speech difficulty by identifying those children who appeared to need the intensity of the *LST* service delivery model and those who did not.

The lack of a control group, rigorous inclusion criteria, and standardized assessment measures limit the validity of the results. However, the *Wee Words* program is a clinical success story and continues to be part of 'standard clinical practice' in CHEO's care pathway to serve this population of children.

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Appendix A
WeeWords Parent Questionnaire
(adapted from Hodge, 2007)

Date: ______________________________ Pre – Post
(circle one)

Parent and Child: ______________________________

Parents: We would like to understand and measure the experiences of parents who participate in the *Wee Words* Program. We hope you will share your observations about your child at the beginning and end of the therapy program. Completion of this questionnaire is optional and will not effect your child's involvement in the *Wee Words* program. However, your feedback is very valuable to us.

For each question, please circle one number from 1 (strongly disagree) to 5 (strongly agree) to indicate how the information applies to you and your child.

Questions About ______________________________'s Speech and Language Development

1) In the past 2 months, my child's speech sound skills have improved (i.e., able to pronounce new sounds, able to use a known sound more frequently).

Strongly Disagree		Disagree	Neutral	Strongly Agree
1	2	3	4	5

2) In the past 2 months, my child has learned to say new words.

Strongly Disagree		Disagree	Neutral	Strongly Agree
1	2	3	4	5

3) In the past 2 months, my child's frequency of communication has increased.

Strongly Disagree		Disagree	Neutral	Strongly Agree
1	2	3	4	5

Shared Storybook Reading to Enhance Early Literacy Skills of Children with Speech Sound Disorders: A Feasibility Study

Étude de faisabilité sur l'utilisation de la lecture interactive de livres d'histoires dans le but d'améliorer les habiletés d'éveil à l'écrit chez les enfants ayant un trouble du développement des sons de la parole

KEY WORDS

SPEECH SOUND DISORDERS

SCHOOL-AGED CHILDREN

SHARED STORYBOOK READING

EARLY LITERACY

INTERVENTION

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Abstract

Many children with speech sound disorders (SSD), including those with childhood apraxia of speech, also experience early literacy difficulties; however most of the available literature focuses on intervention related to their speech sound production errors. This study explored the feasibility of using an intensive individual shared storybook reading (SSR) intervention with two English-speaking school-aged children with SSD in order to foster the development of their early literacy skills. This intensive SSR intervention took place over the course of two weeks and consisted of two 30-minute sessions per day for a total of 20 sessions. Explicit phonological awareness, letter knowledge, handwriting, and vocabulary instructions were embedded within the SSR context. The results demonstrated that this type of intervention was feasible for these two participants despite their reduced intelligibility. Furthermore, improvements in the participants' early literacy skills were observed. Findings suggest that an SSR intervention employing an embedded-explicit model is appropriate and promising for school-aged children with SSD in order to target the development of their early literacy skills.

Abrégé

Plusieurs enfants ayant un trouble du développement des sons de la parole (TDSP), incluant ceux qui présentent une dyspraxie verbale, connaissent également des difficultés d'apprentissage de la lecture et de l'écriture. Cependant, la plupart des écrits scientifiques mettent l'accent sur l'intervention visant leurs erreurs de production des sons de la parole. La présente étude a exploré la faisabilité d'utiliser une intervention individuelle et intensive de lecture interactive de livres d'histoires auprès de deux enfants anglophones d'âge scolaire présentant un TDSP, dans le but de favoriser le développement de leurs habiletés d'éveil à l'écrit. Cette intervention s'est déroulée sur une période de deux semaines à raison de deux séances de 30 minutes par jour, pour un total de 20 séances. L'enseignement explicite de la conscience phonologique, de la connaissance des lettres, de la calligraphie et du vocabulaire était intégré au contexte de lecture interactive. Les résultats ont démontré que ce type d'intervention était faisable avec les deux participants, et ce, malgré leur intelligibilité réduite. De plus, des améliorations dans les habiletés d'éveil à l'écrit des participants ont été observées. Ces résultats suggèrent qu'une intervention de lecture interactive intégrant l'enseignement explicite est appropriée et prometteuse pour les enfants d'âge scolaire qui ont un TDSP, afin de cibler le développement de leurs habiletés d'éveil à l'écrit.

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A set of early literacy skills has been identified as a critical predictor of reading and writing achievement in school (National Early Literacy Panel [NELP], 2008). Speech sound disorders (SSD), including childhood apraxia of speech (CAS), can have a negative impact on the development of these skills (Anthony et al., 2011; Gillon & Moriarty, 2007; Peterson, Pennington, Shriberg, & Boada, 2009). Studies have shown that interventions that target the improvement of speech sound production and intelligibility do not necessarily influence the development of early literacy skills in these children (Tambyraja & McCauley, 2012). One type of intervention that has proven effective in improving early literacy skills for typical developing children, children at risk for literacy difficulties, and children with language disorders is shared storybook reading (SSR) (Lefebvre, Trudeau, & Sutton , 2011; Lovelace & Stewart, 2007; NELP, 2008). When embedded in a SSR context, explicit speech sound intervention has been proven to facilitate speech sound development in children with SSD (Bellon-Harn & Credeur-Pampolina, 2016; Hart & Gonzalez, 2010; Lawrence, 2014); however this approach has not been used to target early literary skills in children with SSD. The current study explores the feasibility and effectiveness of an SSR intervention in order to improve the development of early literacy skills of English-speaking, school-age children with SSD using a repeated single case pre-experimental design.

Early Literacy Skills Related to Later Reading and Writing Achievement

Multiple early literacy skills are the foundation for learning to read and write (Scarborough, 2001). According to the research synthesis conducted by the National Early Literacy Panel (NELP, 2008) on early literacy development, five skills in preschool and kindergarten children clearly predict later reading and writing development when variables such as socioeconomic status or intellectual potential are controlled: alphabet knowledge, phonological awareness, rapid automatic naming, writing, and phonological memory. Other skills also have a predictive relationship with later literacy achievement; however certain contextual variables could confound their effect: concepts about print, print knowledge, reading readiness, oral language, and visual processing. Table 1 provides the definitions used in the NELP report for each of these skills.

Table 1. Definition of Early Literacy Skills Used in the Nation Early Literacy Panel Report (2008)

Skill	Definition
Alphabet knowledge	knowledge of the names and sounds associated with printed letters
Phonological awareness	the ability to detect, manipulate, or analyze the auditory aspects of spoken language (including the ability to distinguish or segment words, syllables, or phonemes), independent of meaning
Rapid automatic naming	the ability to rapidly name a sequence of random letters and digits. The ability of repeating random sets of pictures of objects (e.g., "car," "tree," "house," "man") or colors
Wrtiting	the ability to write letters in isolation on request or to write one's own name
Phonological memory	the ability to remember spoken information for a short period of time
Concepts about print	knowledge of print conventions (e.g., left–right, front–back) and concepts (book cover, author, text)
Print knowledge	a combination of elements of alphabet knowledge, concepts about print, and early decoding
Reading readiness	usually a combination of alphabet knowledge, concepts of print, vocabulary, memory, and phonological awareness
Oral language	the ability to produce or comprehend spoken language, including vocabulary and grammar
Visual processing	the ability to match or discriminate visually presented symbols

These skills can be grouped into four categories. The first category, *phonological processing skills*, includes phonological awareness, rapid automatic naming (or lexical retrieval), and phonological memory (or phonological working memory) (Wagner & Torgesen, 1987). These skills enable children to perceive, discriminate, identify, encode, store, access, and manipulate phonemes of words (Lonigan, 2006) and are required when learning to decode and spell words (Melby-Lervåg, Lyster, & Hulme, 2012). *Print awareness* (or print knowledge), includes knowledge and skills related to the forms, functions, and conventions of the written language (Ezell & Justice, 2005). Print awareness includes alphabet knowledge, handwriting, and concepts about print. *Language skills* refer to the ability to produce or comprehend spoken language (NELP, 2008). *Vocabulary*, in particular, has been identified as a key predictor of reading success for both word identification and text comprehension (Nation, 2005). Finally, *visual processing* is the ability to match or discriminate visually presented symbols (NELP, 2008).

Different types of skills are predictive of word-level (decoding and spelling) versus text-level (comprehension and composition) skills. Phonological processing, print awareness, and visual processing form a larger set of abilities predictive of word level reading and writing skills, whereas language is more predictive of text level skills (NELP, 2008; Storch & Whitehurst, 2002). Comprehensive, evidence-based approaches for the prevention of literacy difficulties should target both larger sets of skills (Justice & Pullen, 2003); however not all of these skills can be easily taught. Unconscious information processing abilities such as rapid automatic naming, phonological memory, or visual processing are implicit in nature (Melby-Lervåg et al., 2012), and are thus difficult to teach explicitly. On the other hand, phonological awareness, print awareness (concept of print, alphabet knowledge, and handwriting), and certain oral language competencies can be explicitly taught and are therefore excellent skills to target in early literacy intervention activities. Moreover, these early literacy skills are of particular importance for children with SSD who often exhibit weaknesses in these areas, which in turn, may hinder later reading and writing achievement (Gillon & Moriarty, 2007; Peterson et al., 2009).

Deficits Associated With SSD

SSD often have a negative impact on the development of various early literacy skills (Anthony et al., 2011; McNeill & Gillon, 2013; Teverovsky, Bickel, & Feldman, 2009). It is widely recognized that children with SSD are at a higher risk of displaying poor phonological awareness skills (Anthony et al., 2011; McNeill, Gillon, & Dodd, 2009a). Handwriting, which requires fine hand motor coordination and attention, also seems to be an area of difficulty for children with CAS, a specific type of SSD characterized by speech motor planning deficits (Teverovsky et al., 2009). In a recent study, Lefebvre, Gaines, Staniforth, and Chiasson, 2017) found that kindergarteners with SSD who were suspected to have characteristics of CAS performed significantly worse than their typically developing peers on phonological awareness skills and on a large set of print awareness skills (including print conventions, print functions, print forms, letter knowledge, and handwriting readiness). Taken together, these studies demonstrate that some young children with SSD show deficits in phonological processing and print awareness skills, putting them at high risk of word identification and spelling difficulties in school.

Children with SSD are not only at risk of displaying poor early literacy skills; they also often present with larger language difficulties that could also hinder their literacy development (Nathan, Stackhouse, Goulandris, & Snowling, 2004). Shriberg, Tomblin, and McSweeny (1999) in their study found that approximately one third of the children with SSD also displayed language impairments. For children with CAS, weak language skills may be observed as early as 24 months old (Highman, Hennessey, Leitão, & Piek, 2013). McNeill and Gillon (2013) demonstrated that children with CAS show deficits not only in expressive vocabulary, but also in expressive morphosyntax that cannot be explained solely by their speech errors. Given that language skills, especially vocabulary, are highly correlated with reading comprehension, the various language deficits observed in children with SSD add another layer of risk for higher-level skills (in contrast to word identification and spelling problems), potentially leading to reading comprehension deficits later in school (Lewis, Freebairn, Hansen, Iyengar, & Taylor, 2004). In summary, the scientific literature on the development of early literacy skills in children with SSD suggests that these children often have deficits in all of the explicit early literacy skills that are predictive of eventual literacy success.

Current Interventions Used With Children With SSD

Most interventions designed for children with SSD focus on improving speech sound production, even though children with SSD may present with other difficulties as well (Pena-Brooks & Hedge, 2007). The evidence of effectiveness of these interventions on early literacy development is limited (Strand & Skinder, 1999);

these interventions do not directly address reading and writing skills even though instruction targeting early literacy skills is needed in order to better prepare children with SSD to read and write (Gillon & Moriarty, 2007; Tambyraja & McCauley, 2012).

In their review, Baker and McLeod (2011) found 134 intervention studies for children with SSD. A total of nine of these studies addressed phonological awareness explicitly using three distinct approaches: the Metaphonological intervention (e.g. Adams, Nightingale, Hesketh, & Hall, 2000), Metaphon (e.g. Dodd & Bradford, 2000), and generic phonological awareness intervention (e.g. Denne, Langdown, Pring, & Roy, 2005). Murray, McCabe, and Ballard (2014) reviewed treatment approaches designed specifically for children with CAS and found that the Integrated Phonological Awareness approach demonstrated an improvement in skills such as phonological awareness, letter knowledge, word decoding, and spelling in children with CAS (McNeil, Gillon, & Dodd, 2009b). It is important to note that this approach includes explicit focus on those skills.

Although phonological awareness interventions are effective for children with SSD, integrating phonological awareness instructions into a more naturalistic and meaningful context has been shown to promote generalization in children who do not have SSD (Richgels, Poremba, & McGee; 1996). Therefore, the NELP (2008) suggested that phonological awareness be integrated into the child's everyday literary environment in order to promote generalization to the child's daily activities. Furthermore, as reviewed earlier, some children with SSD present with deficits in early literacy skills other than phonological awareness and these areas also need to be addressed.

Shared Storybook Reading (SSR)

The use of storybooks provides an ideal naturalistic and meaningful context in which to teach phonological awareness (Raisor, 2006) and has been shown to be effective for developing other early literacy skills as well (NELP, 2008). Shared storybook reading (SSR), also referred to as interactive reading, reading aloud book sharing, book reading, storybook reading, adult-child storybook reading, and book reading interaction, is the interaction that takes place between an adult (or a more competent reader) and a child while reading or looking at a book together (Ezell & Justice, 2005). The context of an SSR intervention allows for the use of an embedded-explicit approach (Justice & Kaderavek, 2004), integrating explicit teaching within the natural context of reading a story, which is essential in the prevention of reading and writing difficulties (Kaderavek & Justice, 2004) and for acquiring the necessary skills for literacy development (Justice & Pullen, 2003). To further enhance children's literacy development, individuals can modify their reading behaviours through SSR interactions using a technique called dialogic reading (Whitehurst et al., 1988), which involves gradually shifting the storytelling role from the adult reader to the child through various techniques such as open-ended questions, repetition, and/or modelling (Ezell & Justice, 2005).

According to a synthesis of research by Swanson et al. (2011), SSR has been shown to have a positive impact on children's phonological awareness, print awareness, and language outcomes. Integration of explicit phonological awareness activities led by adults during or after SSR sessions has a positive effect on phonological awareness skills in typically developing children, in children from low-income families, and in children with language impairments who speak different languages (Lefebvre et al., 2011; Pullen & Justice, 2003; Ukrainetz, Cooney, Dyer, Kysar, & Harris, 2000). During these activities, the adults used the "sound talk" strategy as suggested by Ukrainetz-McFadden (1998). This strategy consists of explicitly discussing and asking questions about phonemes, rhymes, and syllables during shared reading and writing activities.

SSR also provides a rich context for children to interact with print and is an effective method for targeting print awareness, including alphabet knowledge, for all children, including those with language impairments (Justice, Kaderavek, Fan, Sofka, & Hunt, 2009; Mol, Bus, & de Jong, 2009). In order to promote print awareness development, the adult should use print-referencing strategies (Justice & Ezell, 2000), such as drawing the child's attention to print and talking about it explicitly (e.g., pointing to the letter in the book while naming it, following the text with a finger while reading, discussing the functions of print). Handwriting, however, has not been targeted in the context of an SSR intervention.

Research supports the benefits of SSR for language development, especially when the SSR sessions involve verbal interaction between the adult and the child (Arnold, Lonigan, Whitehurst, & Epstein, 1994; Whitehurst et al., 1988). Multiple readings of the same book, coupled with an explicit focus on vocabulary (elaboration of word meaning through the use of definitions, synonyms, gestures, etc.), leads to a more pronounced growth in the child's vocabulary (Penno, Wilkinson, & Moore, 2002; Sénéchal, 1997). The language used in books is more decontextualized than oral language, making the vocabulary used in books more complex and abstract (Justice & Pullen, 2003). Vocabulary words can be grouped into three different tiers (Beck, McKeown, & Kucan, 2013): (a) tier one words are high-frequency, basic words that children are likely to learn on their own through exposure in their everyday environments and therefore they do not require explicit instruction; (b) tier two words are less commonly used in conversations and are more specific to books and written text, making them optimal words for vocabulary instruction; and (c) tier three words are highly specialized words targeting specific domains and hence are rarely used (Beck et al., 2013).

In summary, SSR interventions offer a wide range of early literacy targets to support children's reading and writing development, and provide a context in which several of these targets can be addressed simultaneously (Lefebvre et al., 2011; Milburn et al., 2015; Shamir, Korat, & Fellah, 2012). Currently there are no SSR studies which target early literacy skills with children with SSD including those with CAS, despite the children's high risk for literacy difficulties. The SSR studies that were carried out with children with SSD focused on speech sound production (Bellon-Harn & Credeur-Pampolina, 2016; Hart & Gonzalez, 2010; Lawrence, 2014). There are strong reasons to believe that SSR interventions targeting several early literacy skills could be beneficial for this population given that these interventions have been successful with other at-risk populations. SSR provides a context for specifically targeting early literacy skills that seem to be challenging for children with SSD (i.e. phonological awareness, alphabet knowledge, handwriting, and tier-two vocabulary). Whether this type of intervention, involving extended speech interactions, could be effective for children with SSD due to their reduced speech intelligibility, has yet to be explored.

Goals of the Study

The primary goal of the current study was to investigate whether SSR intervention is an appropriate approach to target early literacy skills in children with SSD. A secondary goal was to explore whether SSR interventions show promise in improving phonological awareness, alphabet knowledge, handwriting, and vocabulary in English-speaking school age children with SSD. A repeated single-case pre-experimental design was used with two children with SSD.

Methods

Participants

The participants were recruited through an association for parents of children with CAS in a Canadian metropolitan region. The inclusion criteria were: being between 5 and 9 years of age, speaking English at home, attending an English school, having SSD, having hearing and corrected vision within normal limits, showing good contextualized language comprehension, and not having significant medical history or other major developmental impairments as reported by the parents during a face-to-face interview.

The following tests were administered prior to the intervention in order to verify eligibility and to provide a description of the participants' overall speech and language skills: the Sounds in Words subtest of the Goldman-Fristoe Test of Articulation 2 (GFTA-2; Goldman & Fristoe, 2000), the Peabody Picture Vocabulary Test-Fourth Edition, Form A (PPVT-4; Dunn & Dunn, 2007), the Expressive One-Word Picture Vocabulary Test-Fourth Edition (EOWPVT-4; Martin & Brownell, 2011), and the Clinical Evaluation of Language Fundamentals-Fifth Edition (CELF-5; Semel, Wiig, & Secord, 2013).

The profiles of the two participants were consistent with the initial speech and language evaluation reports that had been provided by the treating speech-language pathologists, in which the nature of their communication difficulty included SSD. They also both presented with suspected speech motor planning deficits.

Tom. Tom (pseudonym), a right-handed boy aged 5:3 (years:months), had just completed junior kindergarten at the time of the study. He was adopted at 8 months of age from Asia. He attended a daycare where English and French were spoken. Tom was being followed by a speech-language pathologist at the time of the intervention, but did not have any therapy during the two-week period of the study.

Tom presented with a severe speech sound disorder with no associated language deficits. As shown in Table 2, he performed very poorly on the speech sound production measure (GFTA-2) but his receptive (PPVT-4) and expressive (EOWPVT-4) vocabulary were within normal limits as was his performance on receptive and expressive language measures of the CELF-5.

Sam. Sam (pseudonym), right-handed and aged 7:2, had just completed Grade 1 at the time of the study. He was not being followed by a speech-language pathologist at the time of the intervention, but participated in a summer day-program targeting academic and social skills to prepare for his transition into a Grade 2 classroom.

Sam presented with a mild speech sound disorder associated with a severe expressive language disorder.

His score on the GFTA-2 fell within the lower range of average speech production abilities, but at the borderline of mild difficulties. His receptive (PPVT-4) and expressive (EOWPVT-4) vocabulary scores were within normal limits.

His global performance on the CELF-5 fell within the range of a language disorder of moderate severity, characterized by receptive language skills within the normal range and expressive language skills that were significantly delayed.

Table 2. Participant's Performance on Speech and Language Tests

Test	Tom		Sam	
	SS[a]	PR	SS[a]	PR
GFTA-2 (speech sound production)	55	1	88	15
PPVT-4 (receptive vocabulary)	115	84	98	54
EOWPVT-4 (expressive vocabulary)	110	75	104	61
CELF-5				
Sentence Comprehension	9	37	10	50
Word Classes	9	37	10	50
Following Directions	9	37	11	63
Receptive Language Index	94	34	101	53
Word Structure	7	16	4	2
Formulated Sentences	10	15	4	2
Recalling Sentences	9	37	2	0.4
Expressive Language Index	92	30	62	1
Core Language Index	92	30	73	4

Note. SS = standard score or scaled score (for subtests of the CELF-5 only); PR = Percentile rank
[a] For standard scores: mean = 100 and 1 *SD* = 15, for scaled scores: mean = 10 and 1 *SD* = 3.

Materials and Procedures

General procedures. All assessment and intervention sessions were conducted with each child individually in a quiet room at the researchers' university. There were two pairs of examiners, each one assigned to a specific child. The examiners were graduate students in speech-language pathology who had received training by the first author for the assessments as well as for the intervention procedures. Assessment measures were taken before and after the intervention. In addition, progress measures were taken during the intervention. For each child, both examiners noted the responses during the assessment sessions. All sessions were video recorded (Canon HD VIXIA HF10) for verification. In each assessment and intervention session, one examiner led the activities and interacted with the child while the other examiner videotaped the session. The examiners alternated roles across intervention sessions.

SSR intervention

Books. Five books were selected for the intervention: *The Great Sheep Shenanigans* (Bently & Matsuoka, 2011), *Spaghetti with the Yeti* (Guillain, Guillain, & Wildish, 2013), *The Gruffalo* (Donaldson & Scheffler, 2001), *The Wonderful Pigs of Jillian Jiggs* (Gilman, 1988), and *Here Comes the Crocodile* (White & Terry, 2012). These books included interesting themes, fewer than 30 pages, tier-two vocabulary words, large fonts in the title, two to five sentences per page, variable font size and location of print on the pages, a durable cover, and appealing illustrations. The same books, following the same reading order, were used in both Tom's and Sam's SSR intervention programs.

Procedures. This intervention program closely followed the procedures outlined in Lefebvre et al. (2011). The program consisted of two readings per day, five days a week, for two weeks, for a total of 20 readings. Each reading lasted approximately 30 minutes. Each of the five different books was read four times in a row. The parents did not read the books with their children at home during the intervention period.

During each reading, the adult interrupted the story to incorporate explicit instructions or probes specific to each of the three following areas: phonological awareness, letter knowledge combined with handwriting, and vocabulary. Each area was targeted three times per session, for a total of nine interruptions, except for the first session. Since the story was unfamiliar to the children during the first reading, no phonological awareness interruption occurred in order to avoid interference with comprehension of the story.

Within a single book, all four readings focused on the same phonological awareness task, the same three letters, and the same three vocabulary words. Other interruptions were made during the readings to encourage children's active participation, which is an essential component of a dialogic SSR intervention (Ezell & Justice, 2005).

During the first reading of each book, the examiner familiarized the children with the characters, the pictures, and the events of the story, with a focus on understanding the narrative. The examiner interrupted the story only to integrate explicit elaboration of targeted vocabulary words using varied strategies, and to provide explicit instruction regarding the name of target letters and how to trace them.

Before starting the second reading of the same storybook, the examiner explained that she was "confused today" and "might say some silly things or silly words." The examiner then made intentional errors while reading the story. The participants were encouraged to flag these errors or silly words. Intentional errors were made in explaining the same target vocabulary words and in naming the same target letters as in the previous reading. The examiner also inserted pseudowords between words of the storyline in order to introduce explicit phonological awareness instructions. Pseudowords rather than real words were chosen as targets because they sound like real words but they do not carry meaning, and thus, help the child to focus solely on the phonological form (Lefebvre et al., 2011; van Kleeck, 1995). These are described in greater detail in the Instructions section below.

During the third reading of the same book, it was expected that the children would know the story well, allowing them to take a more active role during the session. The examiner interrupted the story and asked the children to explain the same target vocabulary words and to name and write the same target letters as in the previous reading. In addition, the children were asked to flag pseudowords inserted in the story and to perform the same target phonological awareness task as in the previous reading. If the children did not respond correctly, the examiner provided corrective feedback and reviewed instructions for the particular target vocabulary word, letter, or phonological awareness task.

During the fourth reading of the same book, the children were encouraged to retell the story guided by the examiner; some of the story was read by the examiner, while the children told some of the story in their own words. The storybook itself served essentially as a support in the guided story retelling. When it was the children's turn to tell the story, the examiner provided questions or prompts to scaffold the children's narrative, for example, "What happens next?" or "What's going on here?" In addition, the examiner asked the children to explain the same target vocabulary words, and to name and write the same target letters as in previous readings of the same book. During the examiner's turn, she inserted pseudowords into the narrative for the children to flag the word and then asked the children to perform the same target phonological awareness task with those pseudowords.

Instructions. The examiners provided specific instructions for each of the targeted early literacy skills. A detailed script of each intervention session can be obtained by contacting the first author.

Phonological awareness. Forty-five monosyllabic pseudowords were created. They followed the phonotactic rules of the English language, including 30 with a simple syllable structure, consonant-vowel-consonant (CVC) (e.g. thid) and 15 with a more complex syllable structure, either consonant-consonant-vowel-consonant (CCVC) (e.g. fliss) or consonant-vowel-consonant-consonant (CVCC) (e.g. dasp). A Google search confirmed that all 45 proposed pseudowords did not exist in the English language.

The instructions for the phonological awareness tasks were introduced during the second reading of each book, using the pseudowords that were inserted throughout the reading of the storybook. The child was instructed to flag the presence of the pseudowords. If he did not do so, the examiner prompted him in order to elicit the pseudoword. If unsuccessful, the examiner identified the pseudoword herself. Once the pseudoword was identified, the examiner wrote it on a piece of paper in front of the child while pointing out the sounds and their corresponding letters. The examiner then hid the written pseudoword and gave explicit instructions regarding the target phonological awareness task.

A different phonological awareness task was used for each book: phoneme identification, partial phonemic blending, partial phonemic segmentation, complete phonemic blending, or complete phonemic segmentation. Phoneme identification consisted of identifying whether a given sound was present in the initial or final position of the pseudoword. Partial phonemic blending consisted of joining an onset (comprised of only one consonant) with a rime in order to create a pseudoword. Partial phonemic segmentation consisted of identifying the onset of the word by isolating it from the rest of the word. Complete phonemic blending consisted of combining each individual sound in a pseudoword. Complete phonemic segmentation consisted of separating the pseudoword into all of its individual sounds. Partial and complete phonemic blending tasks were performed at the end of the reading, where the phonemes and/or rimes of all the flagged pseudowords were mixed up to create new pseudowords or real words. Once the examiner gave explicit instructions orally, she showed the written pseudoword to the child again and performed the phonological awareness task a second time while manipulating the piece of paper (e.g. pointing to the first grapheme while identifying the first phoneme or cutting the pseudoword into graphemes while segmenting it into phonemes).

Letter knowledge and handwriting. Fifteen alphabet letters (uppercase or lowercase) were selected, including the letters that the children had not mastered in the letter or handwriting pre-test assessment which is presented below. Other letters were selected based on their availability (i.e. font size, presence in title, prominence, and standard calligraphy) in the books.

The examiner directed the child's attention to the target letter in the book and gave explicit instructions on the name of the letter and how to write it, using a traditional handwriting step-by-step approach. This consisted of breaking up each letter into its individual strokes with numbers corresponding to the appropriate order of the strokes. Afterwards, the examiner prompted the child to write the letter in the air using his finger, then to imagine writing the letter in his head with his eyes closed, and finally to write the letter on a piece of lined paper without a model.

Vocabulary. Three, tier-two vocabulary targets from each book were chosen from the words that the child did not know on the vocabulary pretest assessment presented below, for a total of 15 words. Specific words were selected for each child based on the distribution of the words in the text, their representation in the picture, and their word class membership (i.e. nouns, verbs, adjectives).

The examiner elaborated on the target vocabulary words using the following strategies: giving a definition, giving a synonym and an antonym, acting out a mime to represent the word, using the word in another context, as well as making a connection with the picture or a real-life situation. For example, for the word "bellowed", the definition was: "Bellow means to shout or yell in a deep voice"; the synonyms were: "shouted" or "yelled"; the antonym was "whispered"; the mime was: cupping hands around the mouth and yelling; the other context was: "If your friend were on the other side of the playground you would have to bellow his name for him to hear you"; and the real-life link was: "To bellow means to shout or yell in a deep voice just like I did when I said SCRAM!" Definitions, synonyms, and antonyms were found in the *Merriam Webster Children's Dictionary* (2008) and were adapted to be made more accessible to participants, when necessary.

Assessment. Assessment sessions were conducted during the week before and the week after the intervention program (one 90-minute session for Tom; two 90-minute sessions for Sam). During the last two readings of a same book, progress measures were taken in order to assess whether the participant learned what was taught in the first two readings. The child was prompted to respond to a question targeting the same concepts of interest that the examiner focused on during the previous readings of the storybook.

Phonological awareness. The Preschool and Primary Inventory of Phonological Awareness (PIPA; Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2000) was administered before and after the intervention. The children were asked to detect rhymes (rhyme awareness) and initial sounds (alliteration awareness), tap syllables in words (syllable segmentation), isolate the initial sound (sound isolation), segment a word into sounds (sound segmentation) and identify sounds corresponding to given letters (letter-sound knowledge).

After being explicitly taught a given phonological awareness task during the second reading of each book, the child was asked to perform it with new pseudowords without instruction during the third and the fourth reading. One point was given if the child correctly performed the task and zero points if any part of the task was not completed correctly. In the third reading, the pseudowords were similar to those seen in first and second reading; they included three sounds. In the fourth reading, the complexity of the task was increased by including more sounds (four instead of three), which also increased the syllable complexity (from CVC to CCVC or CVCC) in each pseudoword.

Letter knowledge. The Alphabet Knowledge subtest (Section II) of the Phonological Awareness Literacy Screening PreK (PALS PreK; Invernizzi, Sullivan, Meier, & Swank, 2004) was administered before and after the intervention. The child was asked to name the 26 letters of the alphabet presented on a single page in uppercase (Part A) and in lowercase (Part B).

During the third and the fourth reading of each book, the examiner asked the child to name each of the letters (including whether the letter was upper or lower case) explicitly taught in first and second readings. Two points were given for identifying the letter and case, and only one point for identifying the letter with the wrong case. The examiner prompted the child if he named the letter without specifying the case (e.g., "What kind of 'd' is it?"). If the child then provided the correct case, full points were given for that particular letter.

Handwriting. Four tasks were used to assess speed and accuracy of handwriting before and after the intervention. The examiner gave the child a wooden HB pencil without an eraser and lined paper appropriate to his respective grade levels to complete the tasks. See Appendix A for details regarding the scoring of these tasks. In the Alphabet Task (Berninger & Ruthberg, 1992), the participant was asked to write the entire alphabet in lowercase letters. In the Text Copy Task (Monroe & Sherman, 1966), the participant copied as many words as possible from a short text from "Captain Underpants and the Wrath of the Wicked Wedgie Women" (Pilkey, 2001) in a 90 second time frame. In the Quick Brown Fox Task (Berninger et al., 1997), the participant was asked to copy the sentence "The quick brown fox jumps over the lazy dog", which contains all the letters of the alphabet. In the Letter Quiz (Lefebvre et al., 2014, unpublished), the child was asked to write 20 letters (10 uppercase and 10 lowercase) that were read aloud at five-second intervals. The letters were selected based on the order in which children learn letters identified by Justice, Pence, Bowles, and Wiggins (2006). The instructions were to print each letter as quickly as possible and to move on to the next letter once it was spoken even if the previous letter was not yet completed. A trial of three letters was used to familiarize the child with the task.

During the third and the fourth readings of the same book, the child was then asked to write the target letter on a handwriting worksheet containing lines appropriate to his school level. The letter was judged as having been written correctly based on the final shape, regardless of the steps taken to write the letter. For letters that are written in the same way in uppercase and lowercase (e.g.: "O/o" or "S/s"), the case of the letter was judged to be correct if it was written using the three lines of the handwriting worksheet appropriately. Two points were given for writing the letter correctly with the correct case and one point for writing the correct letter with the wrong case.

Vocabulary. A customized asessement tool was used to assess vocabulary before and after the intervention. Five tier-two vocabulary words were selected in each of the five books used in the SSR intervention (see Appendix B). These words included verbs, nouns, and adjectives. The customized vocabulary assessment tool was created to test the knowledge of these 25 words. For each word, the examiner asked: "Do you know what [target word] means?" The response was considered correct if the child used one of the following strategies: definition, synonym, or gestures. All strategies were considered equally appropriate responses. A response such as "I don't know" or an erroneous use of a strategy was considered incorrect.

During the third and the fourth reading of the same book, the child was asked to explain the meaning of each target vocabulary word and was awarded one point per correct response. In order for a response to be deemed correct, the child needed to use at least one of the strategies provided in the first two sessions (i.e. giving a definition, a synonym, an antonym, acting out a mime, using the word in another context, making a real-life connection, or pointing to the corresponding image). All strategies were considered equally appropriate as responses demonstrating that the child had learned the meaning of the target vocabulary word.

Results

Tom

Phonological Awareness. On the subtests of the PIPA, according to the PIPA qualitative scoring protocol, Tom's performance before and after the intervention went from the emerging to the basic phase for rhyme awareness and sound segmentation, from the emerging to the proficient phase for sound isolation, and from the basic to the proficient phase for alliteration awareness. His performance remained in the basic phase for syllable segmentation and in the proficient phase for letter-sound knowledge (see Table 3).

On the progress measures of phonological awareness, Tom performed generally better on segmentation tasks than on blending tasks. However, regarding the complete segmentation task, although he was able to properly segment all of the pseudowords in third reading that only consisted of three sounds, he had difficulty with the more complex pseudowords that had four sounds in the fourth reading. No improvement was noted on any phonological awareness task between the third and the fourth reading of a same book (see Figure 1).

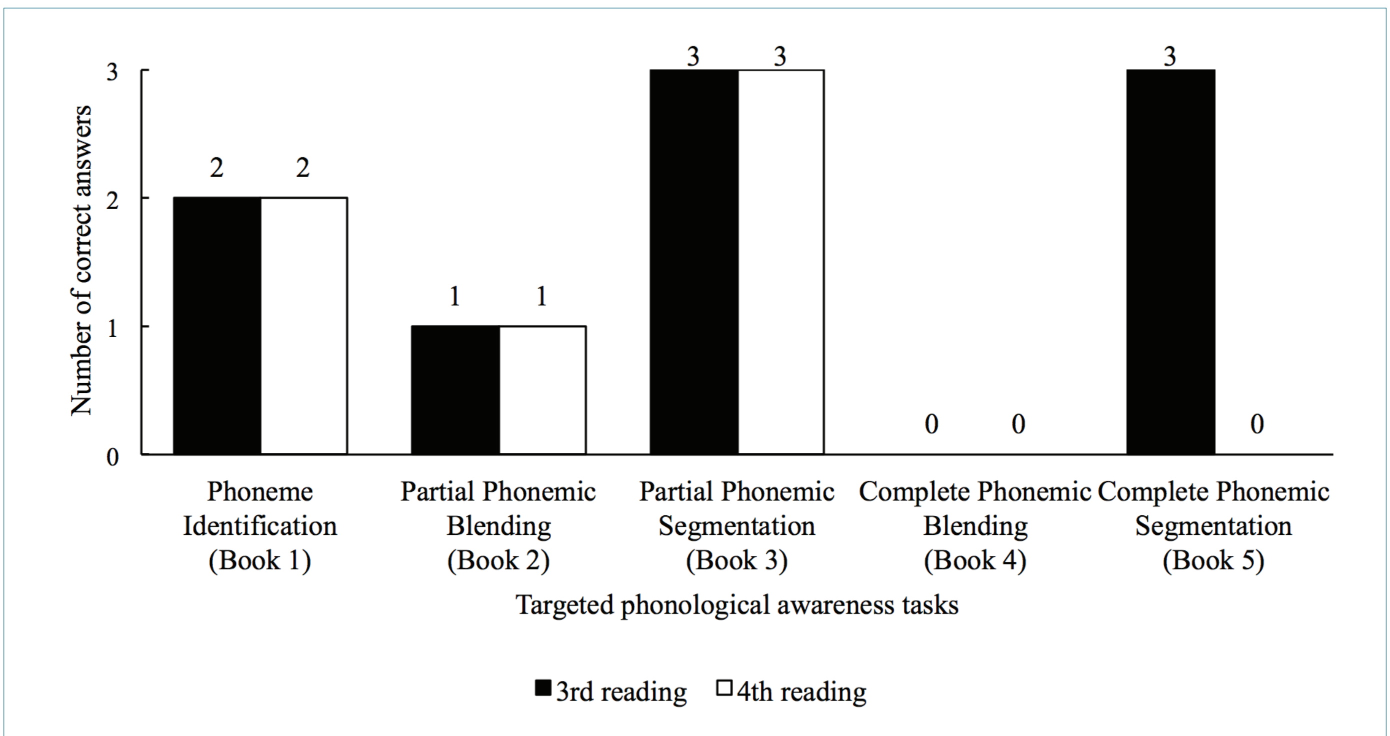

Figure 1. Tom's performance on phonological awareness progress measures

Letter Knowledge. On the Alphabet Knowledge subtest of the PALS, Tom's score was initially high, leaving little room for improvement between pre- and post-intervention measures. His letter identification performance went from 25 to 26 letters for uppercase, and from 24 to 25 letters in lowercase. Progress measures taken during the third and the fourth reading of each book revealed that Tom could identify all letter names. However, Tom made four letter case identification mistakes mainly in the third reading. It is noted that three of the four case mistakes were resolved by the fourth reading. The only letter case identification that remained incorrect was uppercase S, which he called lowercase (see Figure 2).

Handwriting. Tom's scores improved for all of the handwriting tasks except for the Text Copy Task (see Table 4). For the Alphabet Task, he was not able to complete the task before the intervention and of the five letters he did write, none were written as lowercase. After the intervention, he was able to complete this task in 7 minutes, but wrote only five letters in lowercase. For the Text Copy Task, Tom copied the same two words before and after the intervention; however, in the post-intervention assessment the letters conformed more to the conventions of written language. For the Quick Brown Fox Task, Tom wrote three more letters after the intervention than he did before the intervention. Before the intervention, he copied five letters, two of which were copied correctly; in contrast, after the intervention, he copied eight letters, five of which were copied correctly. As for the Letter Quiz, prior to the intervention Tom wrote four letters: two were the correct letter and case and one was the correct letter but the wrong case. After the intervention sessions, Tom wrote a total of 15 letters: 11 were the correct letter in the correct case, and two were the correct letter but in the wrong case. Tom's performance on handwriting progress measures reached the ceiling level for the test in the third and the fourth reading of each book, except on three occasions. The uppercase S was written backwards in the third reading of intervention block 1, but was written correctly in the fourth reading. On the other hand, lowercase d and q were correctly written during the third reading of the fifth book, but both were written backwards during the fourth reading.

Vocabulary. An increase in the number of correct responses was observed on the Vocabulary Quiz. Tom could not explain any of the 25 target vocabulary words prior to the intervention, however, after the intervention; he demonstrated knowledge of 10 of the 15 vocabulary words that were explicitly taught during the intervention by using a variety of strategies that were modelled. Regarding the vocabulary progress measures, Tom acquired all targeted vocabulary words by the third reading in all intervention blocks and maintained this knowledge in the fourth reading, except for two words: "trudged" and "wobble". These two words were not acquired until the fourth reading of the book.

Table 3. Participants' Performance on PIPA Pre- and Post-Intervention Subtests

	Tom				Sam			
	Pre		Post		Pre		Post	
Subtests (max. score)	RS	PR[a]	RS	PR[a]	RS	PR[a]	RS	PR[a]
Rhyme Awareness (12)	0	0-4	6	40-44	11	55-59	12	80-84
Syllable Segmentation (12)	9	65-69	8	55-59	9	35-39	12	80-84
Alliteration Awareness (12)	5	60-64	7	75-79	11	50-54	12	80-84
Sound Isolation (12)	1	20-24	10	70-74	11	30-34	12	65-69
Sound Segmentation (12)	0	20-24	1	50-54	0	0-4	0	0-4
Letter-Sound Knowledge (12)	16	80-84	16	80-84	21	10-14	23	15-19

Note. RS = raw score; PR = percentile ranks.
[a] 0-30 = emerging phase, 30-70 = basic phase, and 70 – 100 = proficient phase

Table 4. Participants' Performance on handwriting Pre- and Post-Intervention tasks

	Tom		Sam	
Task (max. score)	Pre	Post	Pre	Post
Alphabet Task				
n. correct letters (/26)	0	5	24	21
time	DNC	7 min 0 s	3 min 40 s	2 min 52 s
Text Copy Task[a]	2	2	4	5
Quick Brown Fox Task[b] (/35)	2	5	12	19
Letter Quiz[c] (/40)	5	26	32	28

Note. DNC = did not complete
[a]n. of words copied legibly in 90 s. [b]n. of letters copied correctly in 60 s. [c]for each letter written, 1 point for correct legible letter and 1 point for correct case

Sam

Phonological Awareness. Sam's performance on the subtests of the PIPA went from the basic to the proficient phase for rhyme awareness, syllable segmentation, and alliteration awareness. His performance remained in the emerging phase for sound segmentation and letter-sound knowledge, and in the basic phase for sound isolation (see Table 3).

In general, Sam performed better on the third than on fourth reading, except for the first book. The tasks with the lower performance were related to phonemic blending for more complex pseudowords.

Letter Knowledge. Sam initially identified 25 letters in both uppercase and lowercase. After the intervention sessions, he identified all letters correctly in both cases (see Table 4). Sam correctly identified the name of all

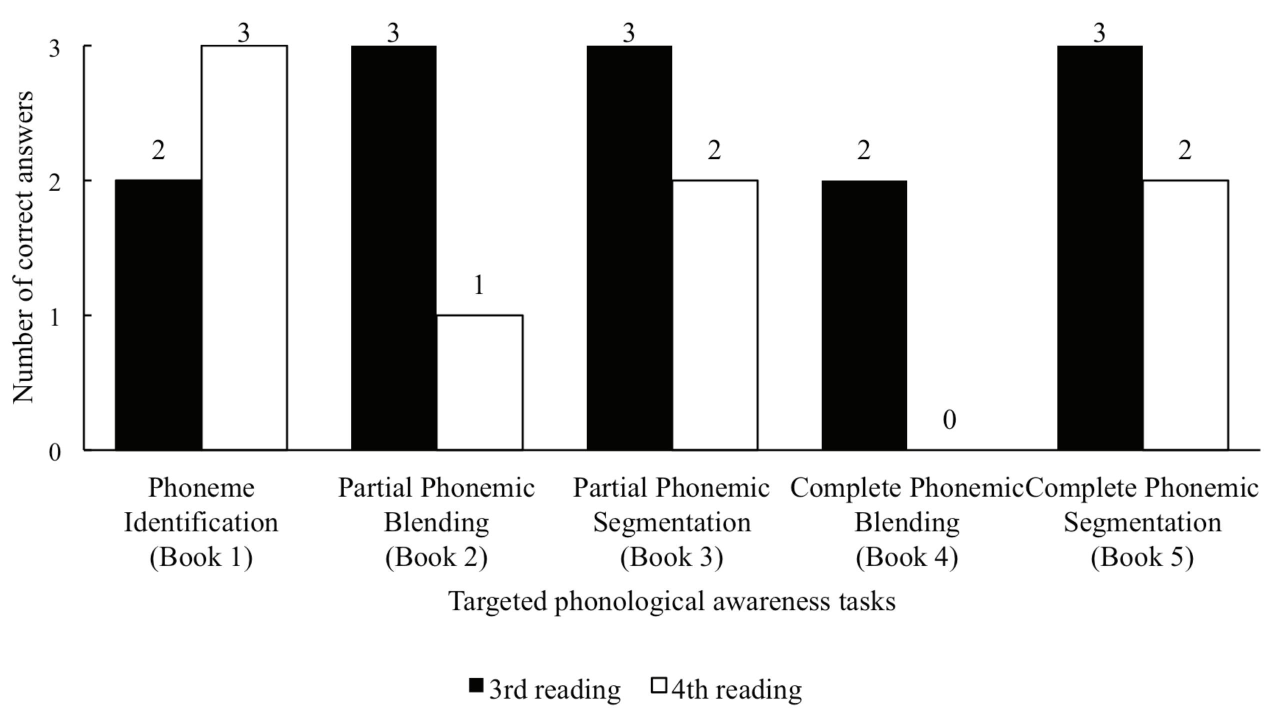

Figure 1. Tom's performance on phonological awareness progress measures

letters on the progress measures taken in the third and fourth reading.

Handwriting. Sam showed improvements across all handwriting tasks except for the Alphabet and Letter Quiz tasks (see Table 4). As for the Alphabet task, the number of letters written correctly decreased slightly from before to after the intervention; as did the time to complete the task. In the Text Copy task, Sam copied the same five words accurately both before and after the intervention; however, he miscopied one extra word prior to the intervention. In the Quick Brown Fox task, he copied seven more letters after the intervention compared to before the intervention. Finally, regarding the Letter Quiz, the difficulties observed before the intervention sessions were maintained once intervention sessions were completed; however, three additional letters were missed. As for Sam's performance on handwriting progress measures, only one targeted letter, lowercase a, was not produced correctly in the third reading of the second book.

Vocabulary. Before the intervention began, Sam explained 4 of the 25 words from the Vocabulary Quiz. Upon completion of the intervention sessions, he demonstrated knowledge of 19 of the words, by using various strategies. He demonstrated knowledge of the same four words that he knew before the intervention sessions; among the 15 other that he could explain, 13 were explicitly taught during the intervention program. The vocabulary progress measures showed that Sam mastered all 15 target words by the third reading of each book and maintained his performance in the fourth reading.

Discussion

The current study set out to investigate if an intensive individual SSR intervention involving considerable speech/language interactions would be a feasible intervention method for children with SSD, and secondly, if this intervention shows promise for improving critical early literacy skills in these children. It provided evidence that not only is this type of intervention feasible with two different children with SSD, but also that improvements could be measured in the participant's early literacy skills.

Feasibility and Efficacy

Several observations speak to the feasibility of this type of intervention for early literacy skills in children with SSD. First, both children were able to participate in the tasks presented during the SSR sessions, even though one child had an associated language disorder. Their reduced intelligibility did not prevent them from being able to effectively communicate with the adult examiner; this interaction may in fact have been facilitated by the contextualized nature of SSR. Intelligibility was an issue at times on the phonological awareness tasks, in which it was sometimes more difficult for the examiners to interpret whether incorrect responses were due to speech sound errors or phonological awareness skills. In addition, during the intervention, the participants had problems flagging the pseudowords by themselves. Prompts such as "Did I just say a silly word?" or "Did you hear my silly word?" were needed for most of the pseudowords inserted in the reading. In contrast, typically developing children as young as 4 years old have been shown to be able to pick up on the pseudowords inserted in a story without any prompting (Lefebvre et al., 2011). Therefore, the participants' inability to notice the intrusion of a pseudoword without prompting suggests that they may have weaker lexical awareness skills for their age. These findings are in accordance with the conclusions drawn by Stackhouse and Snowling (1992) who found that children with SSD had difficulty with lexical decisions required to differentiate real words from pseudowords.

Both participants maintained a high level of interest despite repetition with the same book. Parents reported that their children came willingly to the clinic to participate in the SSR intervention. Furthermore, the participants were very interactive during the activities. The individual format allowed the examiners to tailor the intervention to each child's needs in order to target skills relevant for each of them. The individual format also allowed for flexibility and control in the administration of the intervention. These results support the feasibility of SSR interventions for children with SSD and are in line with previous SSR intervention studies also conducted with children with SSD, but with a focus on improvement of speech sound production (Bellon-Harn & Credeur-Pampolina, 2016; Hart & Gonzalez, 2010; Lawrence, 2014).

The progress measures used during the third and fourth reading of each book also support the feasibility of the intervention. These measures were easy for the examiners to administer and judge, and provided relevant information concerning the children's learning.

Other observations provide preliminary evidence that the SSR intervention was effective. Comparison of participants' results on the pre- and post-intervention measures indicates improvements in early literacy skills, especially in phonological awareness and vocabulary. Furthermore, one participant, Tom, generalized the use of certain vocabulary words to everyday situations. For example, during snack time between SSR sessions, he correctly used one of the new vocabulary words and declared, "Look, I'm **scoffing** my goldfish!". His parents also reported that he even used the new words at home. Little change was noted in letter knowledge, since both participants already knew most letters before the intervention. Improvements in handwriting were more evident for Tom than for Sam; however, both participants' handwriting skills lacked speed and automaticity relative to their respective ages since most children can write an average of 10 lowercase letters in 60 seconds by the end of senior kindergarten (5 to 6 years old) (Puranik & Al Otaiba, 2012).

The progress measures also give some indication of the efficacy of the intervention. Slight improvements or ceiling effects were observed in the progress measures (third and fourth reading of each book) for all skills except phonological awareness. Thus, in general, most of the targeted skills were learned by the third reading, with a few being learned by the fourth reading. Phonological awareness skills showed no improvement or even a decrease in the performance from the third to the fourth reading of a book; this observation may be explained by the fact that more complex syllable structures were used as stimuli in the fourth reading without having provided explicit modelling with more complex pseudowords.

The study was not designed specifically to isolate the effect of the SSR intervention from other possible educational or environmental factors; thus, it would be premature to attribute changes during and following the intervention to the intervention alone. Nonetheless, both participants learned the targeted skills and showed improvements from pre- to post-testing in a very short period of time (two weeks). Given the rapid and substantial progress observed with respect to vocabulary for both participants, as well as the progress noted in Tom's handwriting skills, it is unlikely that this progress was attributable solely to factors outside of the intervention sessions. Taken together, the findings suggest that SSR is a promising intervention for the development of early literacy skills in children with CAS.

Suggested Modifications Within the Current Format of the Intervention

Within this context of generally positive evidence of the feasibility and efficacy of SSR intervention for children with SSD, the study findings and observations lead to proposed modifications or adjustments to some aspects of the intervention. First, the possible interference of speech intelligibility on performance on the phonological awareness tasks mentioned above could lead to an underestimation of the participants' phonological awareness skills (Sutherland & Gillon, 2005). One solution would be to propose a non-verbal response mode, similar to measures specifically developed for evaluating phonological awareness in children with speech sound disorders (Preston & Edwards, 2010; Stackhouse & Wells, 2001), in which a spoken response is not required.

It may be desirable to select target letters that are more closely aligned with the child's age level. The results on the Alphabet Knowledge subtest of the PALS PreK showed that both participants already knew most of the letters' names before the intervention. However, their results on the Letter-Sound Knowledge task of the PIPA suggest that instruction targeting the correspondence between the letter name and its sound could be more appropriate for their age level.

Use of different pre-and post-intervention tests could guide the identification and development of intervention targets and progress measures. For example, the PIPA, used in the current study, is intended for pre-readers (from 4:0 to 6:11 years) and does not test blending skills that are necessary for decoding words (Wagner & Torgesen, 1987). The Phonological Awareness Test 2 (*PAT-2;* Robertson & Salter, 2007) may be more appropriate for this purpose: it provides normative age range data from 5 to 9 years (the targeted age range) and includes a wider variety of tasks, including syllable and phoneme blending. However, this test can take up to 40 minutes to administer and requires spoken responses, which may be compromised by speech intelligibility issues of children with SSD, as noted above. Adaptations such as those proposed by Preston and Edwards (2010) may partially address this issue, but it would be necessary to establish equivalence for responses in a different mode than was used in the standardization of the test.

Furthermore, incorporating more explicit instructions earlier in the intervention (first and second reading) would be beneficial for the phonological awareness tasks. This increased instruction would facilitate participants' learning, especially for phonemic blending tasks and tasks involving stimuli with more complex syllable structures. In fact, blending phonemes in order to pronounce a word and dealing with complex syllable structures might be more difficult for children with SSD, especially if they present with difficulties in planning and programming movement sequences (American Speech-Language and Hearing Association, 2007).

In addition, as mentioned earlier, the participants had problems flagging the pseudowords without explicit verbal prompts. The use of real words taken from the story might be more appropriate for these children.

Finally, the limited improvement in some pre- and post-intervention measures and some of the progress measures could be addressed by modifying the instructions for handwriting and phonological awareness tasks and, particularly for handwriting, providing carryover activities to be done between the intervention sessions. For example, the child could be asked to write more than a letter at a time, in order to help them to generalize their learning to more demanding writing tasks, similar to those in the pre- and post-intervention measures.

Limitations and Future Directions

The preliminary nature of the study entails certain limitations. The study included only two children; stronger evidence of the feasibility and efficacy of the intervention will require additional replications. In addition, the participants were recruited through the local association for parents of children with CAS and were reported by a professional to have a diagnosis of SSD; they were not subjected to a detailed diagnostic evaluation of the exact nature of their SSD. In fact, Sam's profile showed larger deficits in expressive language than in speech sound production. Additional assessment measures to confirm the nature of the deficits in speech sound production would be useful in future replications of the study.

As noted above, the study design did not allow identification of the unique contribution of the intervention to the changes observed in the children's performance. Other replications would partially address this limitation; however, designs with greater experimental control are required to evaluate efficacy adequately. For example, a group design with participants randomly assigned to experimental and control groups or a multiple single-subject design using repeated measures during baseline and treatment for different children would be appropriate. Furthermore, it would be of interest to follow the participants longitudinally in order to measure the impact on literacy learning in school.

A group format for administering the intervention would also be more viable from an ecological point of view; given the overwhelming need for effective interventions for children with SSD (McNeill et al., 2009b), when maximizing resources is a priority. SSR interventions in a group setting have been proven effective in promoting early literacy skills in at-risk and language-impaired children (Lefebvre et al., 2011; Ziolkowski & Goldstein, 2008). Furthermore, SSR interventions administered by parents have also been shown to be effective (Justice et al., 2011). A group or parent-directed delivery model could allow for increased access to therapy by offering an alternative to a clinician-directed intervention.

The optimal age range for maximum benefit of SSR intervention is a question for future studies. Considering that emergent literacy skills typically develop during the preschool years (NELP, 2008), offering an intervention at the earliest age at which it can be beneficial is imperative for children at risk for difficulties, such as those with SSD. In the current study, the results suggest that the younger participant (Tom), benefited more than the older participant (Sam). SSR may be more beneficial within early intervention or even as a preventative framework for children with SSD. Once a child falls behind in the development of critical early literacy skills, they may require intensive intervention to bring them up to an age-appropriate level (Torgesen, 1998). Early intervention allows children who are at risk for literacy difficulties (such as children with SSD) to develop adequate emergent literacy skills before beginning school so that they may develop conventional reading and writing skills at the same rate as their normally developing peers (Good III, Simmons, & Smith, 1998).

Given the flexibility of the SSR intervention format, it may be possible for future studies to incorporate other language-related early literacy skills that are important for reading comprehension (Cain, Oakhill, Barnes, & Bryant, 2001; Cain, Oakhill, & Bryant, 2004; Nation, Clarke, Marshall, & Durand, 2004), such as inferential language, grammatical, narrative, and metalinguistic skills.

Conclusion

The current study provides preliminary evidence that SSR intervention is a promising approach to improve early literacy skills in children with SSD. The findings are encouraging and suggest several avenues for future research to determine the appropriate application of the approach, including more structured efficacy studies, consideration of alternate formats (e.g., group versus individual), and the possibility of addressing other literacy skills.

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Appendix A
Scoring Criteria for Handwriting Pre- and Post-Intervention Assessment Tasks

Task	2 points	1 point	0 points
Alphabet Task	N/A	Correct letter and correct case	Incorrectly formed letter, illegible letter, or wrong case
Text Copy Task	N/A	Word copied legibly	Incorrectly written word or incomplete word
Quick Brown Fox Task	N/A	Correct letter and correct case	Incorrectly formed letter, illegible letter, or incorrect case
Letter Quiz	Correct letter and correct case	Correct letter and incorrect case	Incorrectly formed letter or illegible letter

Appendix B
Target Vocabulary Words Chosen from Each Book for the Pre- and Post-Intervention Vocabulary Assessment

Book Titles	Words
The Great Sheep Shenanigans	bellowed, gunk*, thicket, scoffing*, and peered*
Spaghetti with the Yeti	sumptuous, gaze*, battered, trudged*, and glum*
The Gruffalo	stroll*, knobbly, prickles*, astounding, and rumble*
The Wonderful Pigs of Jillian Jiggs	zipped, drooping*, grin*, galore, and scattered*
Here Comes the Crocodile	snatched*, grimace, swift*, boulder, and wobble*

*words that were targeted in the intervention for both children.

Reliability and Validity of TOCS-30 for Young Children with Severe Speech and Expressive Language Delay

La fiabilité et la validité du TOCS-30 chez les enfants ayant un retard sévère de la parole et du langage expressif

KEY WORDS
ASSESSMENT
PHONETIC TRANSCRIPTION
EARLY SPEECH MEASURES
PRESCHOOL CHILDREN
SPEECH SOUND DISORDERS
SEVERE SPEECH DELAY

Erica Davis
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Abstract

ABSTRACT

TOCS-30 was developed to provide a standard speech sampling procedure to measure pre-post treatment change in speech behaviours for young children with severe speech and expressive language delay. Reliability and validity of eight phonetic variables (percentage recognizable segments, percentage consonants, vowels and syllable shapes correct, whole word accuracy, and number of vowel, consonant, and syllable types) obtained from phonetic transcriptions of children's imitated productions of *TOCS-30* stimuli were investigated. Ten 3-year-olds in each of three groups participated: age-typical speech and language, speech sound disorder and age-typical language, and severe speech and expressive language delay. Inter-rater agreement for phonetic transcription ranged from 82% to 96% across the three groups. Intraclass correlation coefficients for test-retest reliability ranged from $ICC_{(3,1)} = 0.71$ to $ICC_{(3,1)} = 0.98$. Scores for the phonetic variables were lowest for the group of children with severe speech and expressive language delay and highest for the group of children with age-typical speech and language, except for number of vowel types. These results suggest that *TOCS-30* provides a reliable, valid, and efficient procedure to measure phonetic behaviours of children with severe speech and expressive language delay based on the phonetic transcription conventions described.

Abrégé

Le *TOCS-30* a été développé avec l'objectif de fournir une procédure standardisée pour l'analyse des échantillons de parole, et ce, afin de mesurer les changements pré- et post-traitements touchant la production de la parole des enfants ayant un retard sévère de la parole et du langage expressif. Cette étude examine la fiabilité et la validité de 8 variables phonétiques (le pourcentage de segments reconnaissables, le pourcentage de consonnes, de voyelles et de structures syllabiques correctes, le pourcentage de mots produits de façon précise ainsi que le nombre de voyelles, de consonnes et de structures syllabiques différentes produites) à partir de la transcription phonétique des productions en répétition des enfants en réponse aux stimuli du *TOCS-30*. Trois groupes de 10 enfants âgés de 3 ans ont participé à l'étude : un groupe d'enfants ayant un développement normal de la parole et du langage, un groupe d'enfants ayant un trouble du développement des sons de la parole et un développement normal du langage et un groupe d'enfants ayant un retard sévère de la parole et du langage expressif. L'accord interjuge de la transcription phonétique variait entre les trois groupes de 82% à 96%. Les coefficients de corrélation intraclasse, calculés pour déterminer la fiabilité test-retest, se situaient entre $ICC_{(3,1)} = 0{,}71$ et $ICC_{(3,1)} = 0{,}98$. Les scores obtenus pour les variables phonétiques étaient plus faibles chez les enfants ayant un retard sévère de la parole et du langage expressif et plus élevés chez les enfants ayant un développement normal de la parole et du langage, sauf en ce qui concerne le nombre de voyelles différentes produites. Ces résultats suggèrent que le *TOCS-30* est une procédure fiable, valide et efficace pour mesurer les productions phonétiques des enfants ayant un retard sévère de la parole et du langage expressif, et ce, à partir des conventions de transcription phonétique décrites.

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Introduction

A significant challenge in evaluating change in the speech behaviours of young children with very limited spoken language and phonetic and word structure repertoires is the selection of appropriate measures for comparison. Published standardized articulation tests typically have norms with basal ages of 24 months or higher (e.g., Dawson & Tattersall, 2001; Goldman & Fristoe, 2000; McIntosh & Dodd, 2011). While the children of interest have chronological ages in this range, the severity of their speech delay may result in developmental spoken language age equivalents below 12 months. Standard articulation tests (e.g., *Goldman-Fristoe Test of Articulation 2nd ed.*, Goldman & Fristoe, 2000) use words with a phonetic structure that is too complex for these children's limited speech behaviours. Although the recently published *Goldman-Fristoe Test of Articulation 3rd ed.* (Goldman & Fristoe, 2015) includes two image sets, with one set of images noted as being appropriate for younger children, the test stimulus items are the same for the two sets of images and include words such as 'guitar' and 'spider'. Shriberg and Kwiatkowski (1980) argued that standardized articulation tests disadvantage children when the stimulus words are more complex than those typically found in their vocabulary. Such tests lack sensitivity to change because of the severity of the child's speech delay/disorder. Furthermore, children may not attempt items because they perceive them to be too difficult.

Phonological and phonetic measures such as percentage consonants correct (PCC) and percentage vowels correct (PVC), obtained from phonetic transcription of self-generated speech samples produced by children with speech disorders, have been shown to be a reliable alternative to articulation tests for describing children's phonological and phonetic abilities (Shriberg, Austin, Lewis, McSweeney, & Wilson, 1997). However, it is time consuming and sometimes impossible to elicit and transcribe an adequate spontaneous speech sample from young children with severe speech and expressive language delay. The frequency and variety of their spontaneous utterances is very low and, in many cases, their target words are unknown because their speech is so difficult to understand. An alternative is to elicit a standard set of word targets selected for consonant, vowel, and word shape content that can be administered, recorded, transcribed, and scored in a relatively short period. This is more time and labour efficient, a consistent sample is obtained across measurement times, and the child is provided with opportunities to attempt sounds that he or she may not use in self-generated speech. In addition, there is evidence to suggest that imitated word tasks are more sensitive to early changes in the speech behaviours of children (Wright, Shelton, & Arndt, 1969).

TOCS-30 (Hodge, 2003) is an imitative 30-item task developed to provide a standard speech sampling procedure to measure pre-post treatment change in speech behaviours for children participating in the *Let's Start Talking Program* or *LST* (Hodge & Gaines, 2017). It was designed to complement measures that could be obtained from a spontaneous speech sample and parent report. The target population for *LST* is young preschool children with severe speech and expressive language delay compared to their receptive language and social communication skills, who speech-language pathologists have identified as being at risk for speech motor learning difficulties.

This report describes the *TOCS-30* and provides detailed information about procedures for phonetic transcription of children's productions of the *TOCS-30* items. It also reports reliability (inter-rater and test-retest) and construct validity information for phonological and phonetic measures obtained from phonetic transcriptions of recordings of young children's productions of the *TOCS-30* items. Construct validity was assessed by comparing measures of phonetic ability obtained from the *TOCS-30* for three groups of children for whom scores would be expected to differ (Crocker & Algina, 1986): children with typical speech and language development, children with speech sound disorder of unknown origin and age-typical language, and children with severe speech and expressive language delay of unknown origin. It was hypothesized that the two groups of children with speech disorders/delay would score significantly lower than the group of children with typical speech development, and that the group of children with severe speech and expressive language delay would have the lowest scores.

Method

Participants

Recordings were collected from three groups of children who differed by speech and language diagnosis: (age-typical speech and language or TSL), speech sound disorder with age-typical language (SSD-TL), and severe speech and expressive language delay (SS-ELD). Children in the TSL and SSD-TL groups were recruited through convenience sampling in the Edmonton area. Children in the TSL group were recruited by posters in the community (e.g., health clinics and daycare centres) and word-of-mouth. Children in the SSD-TL group were recruited from speech-language pathologists serving preschool children. Children in these two groups were also part of a larger study evaluating the reliability and validity of the *Test of Children's Speech Plus (TOCS+)* (Hodge & Gotzke, 2014; also see www.tocs.plus.ualberta.ca). As part of this larger study, recordings were made of these children's imitative productions of the *TOCS+ Word Test 1* stimuli. The *TOCS-30* words are a subset of these stimuli and recordings of these words were available for ten 3-year-old children in each of the TSL and SSD-TL groups. A second set of recordings of these words was also available for two children in each of the TSL and SSD-TL groups. These children had been selected randomly to return for a second administration of form 1 of the *TOCS+* intelligibility measure within a two-week period of the first recording session. The 10 children in the SS-ELD group participated in a treatment project at the Children's Hospital of Eastern Ontario in Ottawa (Hodge & Gaines, 2017). Up to three recordings of the *TOCS-30* were obtained from these children over a two-week period prior to the treatment project and one recording was obtained post-treatment.

Children's chronological ages ranged from 38 to 46 months for the TSL group (M=41.8), 37 to 46 months for the SSD-TL group (M=42.2), and 34 to 43 months for the SS-ELD group (M =37.5). All 30 children had English as the first language of the home, passed a hearing screen (American Speech and Hearing Association, 1985), and were judged to have normal oral structures. No child had a diagnosis of autism spectrum disorder, pervasive developmental disorder, intellectual disability, or cerebral palsy. All children had age-appropriate understanding of spoken English as measured by standardized assessment. All children in the TSL and SSD-TL groups scored above the 16th percentile on the receptive language subtest of the *Fluharty Preschool Speech and Language Screening Test 2nd ed. (Fluharty-2)* (Fluharty, 2001). All children in the SS-ELD group had a receptive language score above the 16th percentile (range 23rd – 99th %ile) on the *Preschool Language Scale–4* (Zimmerman, Steiner, & Pond, 2002).

Groups differed in their expressive language abilities. All children in the TSL group and nine of 10 children in the SSD-TL group scored above the 16th percentile (TSL range 27th – 89th %ile; SSD-TL range 23rd – 89th %ile) on the expressive language subtest of the *Fluharty-2*. The 10th child in the SSD-TL group scored at the 12th percentile. Nine of 10 children in the *SS-ELD* group scored below the 10th percentile (range <5th – <10th %ile) for age 30 months (upper age limit of measure) for *Words Produced on the MacArthur-Bates Child Development Inventories (CDI): Words and Sentences* (Fenson et al., 1994). The 10th child in the SS-ELD group scored below the 30th percentile. A norm-referenced parent report measure was used because of the severity of the children's speech and expressive language delays.

The three groups also differed in their speech skills. All children in the TSL group scored above the 16th percentile on the articulation subtest of the Fluharty-2 (range 37th – 84th %ile) and all children in the SSD-TL group scored below the 16th percentile (range <1st – 9th %ile) on this measure. All children in the SS-ELD group scored below the 2nd percentile on Part 2: Simple Phonemes and Syllables of the *Kaufman Speech Praxis Test for Children (KPST),* (Kaufman, 1995). Individual language and *KPST* test scores are reported for the 10 children in the SS-ELD group in Hodge and Gaines (2017). In addition, all children in the SS-ELD group were described by their speech-language pathologists as having a restricted speech sound inventory (vowels, stops, nasals, glides), a reduced syllable shape inventory (V, CV, VC, CVC), and a reduced multiple-syllable word shape inventory (duplicated or varied VV, CVCV, VCV). In addition, their speech-language pathologists identified these children as being at risk for speech motor planning difficulties. The inclusion criteria for each group are summarized in Table 1.

The procedures followed in the study were in accordance with and approved by the Health Research Ethics Boards at the Children's Hospital of Eastern Ontario (CHEO) and the University of Alberta for the children's recordings collected at CHEO and analysed at the University of Alberta. Approval was granted from the Health Research Ethics Board at the University of Alberta for the children's recordings collected and analysed at the University of Alberta. Informed consent was obtained from the parents of the children. Parents of children in the TSL and SSD-TL groups were provided with payment to cover their parking expenses for attending the data collection sessions.

Data Collection

***TOCS-30* description.** *TOCS-30* consists of 30 items (31 English words; one item has two words), which are listed in Table 2. The stimuli sample 53 consonant targets (19 consonant types; [h, p, b, m, w, j, f, t, d, n, s, z, k, g, l, ɹ, ʃ, ʤ, ʧ], 33 vowel targets (10 vowel types; [ə, i, æ, o, u, ɑ, ʊ, ʌ, ɛ, ɔɪ]), and 33 syllable targets (6 syllable types; [V, CV, VC, CVC, CCV, CCVC]). According to information reported by Stemach and Williams (1988) regarding the first 2500 words of spoken English used by children, 19 of the 30 words are within the first 1000 acquired and 26 of the 30 words are within the first 1750 words acquired. Four of the

Table 1. Participant inclusion criteria by child group.

	Group		
Inclusion Criteria	TSL[a]	SSD-TL[b]	SS-ELD[c]
1st language of home	English	English	English
Hearing screening	Passed	Passed	Passed
Oral mechanism structures	Normal	Normal	Normal
Receptive language scores	>16th percentile (*Fluharty-2*[d])	>16th percentile (*Fluharty-2*)	>16th percentile (*PLS-4*[e])
Expressive language scores	>16th percentile (*Fluharty-2*)	>16th percentile (*Fluharty-2* for 9/10 children)	<10th percentile (*CDI*[f]: Words Produced for 9/10 children)
Articulation scores	>16th percentile (*Fluharty-2*)	<16th percentile (*Fluharty-2*)	<2nd percentile (*KPST Part 2*[g])
Diagnosis of ASD[h], PDD[i], cerebral palsy, or intellectual disability	No	No	No
Age range	36 – 46 months	36 – 47 months	34 – 43 months

[a]Typical speech and language, [b]Speech sound disorder and typical language, [c]Severe speech and expressive language delay, [d]*Fluharty Preschool Speech and Language Screening Test 2nd ed.* (Fluharty, 2001), [e]*Preschool Language Scale–4* (Zimmerman et al., 2002), [f]*MacArthur Communication Development Inventories Words and Sentences Form* (Words Produced) (Fenson et al., 1994), [g]*Kaufman Speech Praxis Test for Children* (Kaufman, 1995): scores reported are from Part 2: Simple Phonemes and Syllables, [h]Autism Spectrum Disorder, [i]Pervasive Developmental Disorder

30 words ("beanie" – type of hat; "hoot" – sound that owl makes; "D" – name of letter; and "yawn") did not occur in the first 2500 words. Experience to date suggests that 3 year-old children are familiar enough with these words to willingly attempt them.

A picture booklet of coloured photographs was created to elicit the word productions from children following a model spoken by the examiner. The child is shown the stimulus photograph and instructed to "Watch and listen. Say what I say." There are two practice items to familiarize the child with the task that are not scored. Items are not repeated unless the child produces a different word than the target item (e.g., named something else in the photograph). Administration is stopped if the child refuses to attempt six consecutive items. The examiner transcribes the child's responses on a form that lists the items and a corresponding phonetic transcription of the adult form of each item and its syllable shape(s).

TOCS-30 scores include eight phonetic variables that can be obtained from phonetic transcription of a child's imitative productions of the *TOCS-30* items. These variables were selected based on their potential to represent and show change in the speech behaviour of young preschool children with severe speech delay. These include five measures of phonetic accuracy (percentage recognizable segments, percentage syllable shapes correct, percentage vowels correct, percentage consonants correct, percentage whole word accuracy) that are based on relational analyses (i.e., compare child's production to adult models) and three measures of phonetic inventory (number of syllable, vowel, and consonant types) that are based on independent analyses (i.e., focus only on child's productions without comparison to the target words) (Stoel-Gammon & Dunn, 1985). The availability of several measures of phonetic ability from the same speech sample provides multiple opportunities to capture change in the speech production of children with speech delays in the "severe" range.

Table 2. *TOCS-30* items.

a dress	buddy	full	lock	sheet
bad	bus	gum	mud	snow
beanie	chew	hat	no	top
bee	come	hoot	pan	walk
bow	"D"	hot	rock	yawn
boy	eat	jar	seat	zoo

Recordings. The stimulus items in the *TOCS-30* sample were recorded using the *TOCS+* software (www.tocsplus.ualberta.ca) for the children in the TSL and SSD-TL groups. The auditory model and a picture of the stimulus were presented for each item and the child's productions were recorded directly to a computer using a 48 kHz sampling rate and 16 bit quantization, and were saved as digital audio files in .wav format. The software creates a unique order of the stimulus items for each administration. A Shure WH20 unidirectional dynamic headset microphone was connected to an Audio Buddy Dual Mic Preamplifier and then to the microphone input on the computer sound card to capture recordings of the children's productions. All recording sessions took place in a sound booth. One item was missing for one child's recordings in each of the TSL and SSD-TL groups due to examiner error.

The *TOCS-30* samples for the children in the SS-ELD group were elicited with photographs presented in a booklet (one per page) and modeled live by a speech-language pathologist. The child's productions were video-recorded using a microphone internal to the video camera in a clinical treatment room. Seven randomized sets of the *TOCS-30* items were available and a set was selected randomly for each administration. The videotapes were dubbed and copies were sent by courier to the University of Alberta. Original copies were kept at the participating agency. Pre-treatment *TOCS-30* recordings were analysed for nine of the 10 children. One child produced fewer than half of the items in his pre-treatment *TOCS-30* recordings so his post-treatment recording was used. Three of the 10 children's *TOCS-30* recordings that were analysed had fewer than the full 30 items (27, 28, or 29) due to refusal to attempt the item(s). At least two pre-treatment recordings of the *TOCS-30* (with a minimum of 27 items produced) were obtained within a two-week period for eight of the children. Examination of the time codes on the video recordings of administration of *TOCS-30* to the 10 children revealed the average length to be approximately five minutes.

Data Analyses

Transcription training. Two speech-language pathology graduate students generated phonetic transcriptions of the children's *TOCS-30* samples following a period of structured training. Chapter 3 "How to Transcribe and Format a Speech Sample" in the manual for *Programs to Examine Phonetic and Phonologic Evaluation Records (P.E.P.P.E.R.)* (Shriberg, 1986) served as the main reference for transcription conventions. After becoming familiar with this reference, together the graduate students completed phonetic transcriptions of two sets of *TOCS-30* recordings from children not used in this study to practice using the conventions. Next, they independently transcribed three more sets of recordings of the *TOCS-30* stimuli for children who represented one of the three groups studied, but did not participate.

Phonetic transcriptions of each set of recordings were hand-printed on the *P.E.P.P.E.R* transcription form (PepForm) and then entered using *P.E.P.P.E.R* software. This was done to practice calculation of the phonetic measures and conduct a preliminary assessment of inter-rater transcription reliability. The two transcriptions were compared for each set of recordings to determine segment-by-segment agreement between raters (Schiavetti & Metz, 2005). Mean agreement was 90% for consonants and 85% for vowels. By group designation for each set of recordings, agreement was highest for TSL (100% for consonants and 94% for vowels), followed by

SSD-TL (91% for consonants and 85% for vowels), and lowest for SS-ELD (79% for consonants and 76% for vowels).

Several additional conventions for transcription were developed to increase the likelihood of inter-rater agreement: 1) The length diacritic (:) would only be used when it lengthened a vowel to where it became distorted; 2) Aspiration and nasality diacritics would only be used if the child's production was judged to be a distortion, as opposed to an acceptable allophonic difference; 3) The unreleased consonant diacritic would not be counted as an error; and 4) A sound would be transcribed as questionable if the transcriber was certain that a phoneme had been produced by the child but the transcriber could not be sure of the sound's identity. In these instances, the phoneme that was presumed to be heard was transcribed and marked using the 'questionable' diacritic (circled). The diacritics that counted as errors for calculation of percentage consonants correct, percentage vowels correct, percentage syllable shapes correct, and percentage whole word accuracy are listed in Table 3. Conventions for calculating the phonetic variables were finalized and are described in the following section.

Measures.

Phonetic accuracy.

Percentage of recognizable segments (PRS). Instances of when an examiner is unsure how to transcribe a consonant or vowel (i.e., cannot decide on one versus a second phoneme category, lacks confidence in how to transcribe what was perceived) or cannot identify it (unintelligible) are counted as unrecognizable segments. An exception to this is when the transcriber has sufficient confidence to make a presumption about the sound that is heard and this matches the expected target sound in the adult form. Omitted sounds are also counted as unrecognizable segments. The number of unrecognizable segments is subtracted from the total number of possible segments (86) in the 30 items to determine the number of recognizable segments and then converted to a percentage (PRS). For example, a child with 20 unrecognizable segments would have a PRS score of 76.7% ([86 possible segments minus 20] = 66/86 x 100).

Table 3. Diacritics used in phonetic transcription and classification of consonant and vowel accuracy.

	Diacritics	Classification
Consonants		
	nasalization	error
	glottalized	error
	lateralized	error
	dentalized	error
	frictionalized	error
	derhotacized	error
	devoiced	error
	lengthening	error if distorts the sound
	unreleased	correct
	aspirated	error if distorts the consonant
Vowels		
	nasalization	error if not acceptable allophonic production
	lengthening	error if distorts the vowel
	on-glide	error
	off-glide	error

Percentage of syllable shapes correct (PSSC). A correct syllable shape is defined as a match between the position of consonants and vowels in each target syllable in an utterance and the syllables the child produced in the utterance, regardless of vowel or consonant accuracy. That is, the specific consonant and vowel content do not need to match; however, the consonant and vowel "slots" in the syllable frame need to be the same to score a "match". Vowel and consonant omission and addition errors result in syllable shape mismatches. For example, if the orthographic word is 'zoo' where the target phonetic form is /zu/, it would be considered a match if the child produced /wo/ because they are both CV syllable shapes. Alternatively, if the child produced the word 'eat' (phonetic form is /it/) as /i_/, the VC shape of the target phonetic form does not match the shape of the child's production because the consonant has been deleted. The number of syllable shape matches out of the total number of possible syllables on the *TOCS-30* (33) is converted to a percentage of syllable shapes correct (PSSC). For instance, if the child matched 11 syllable shapes out of 33 target syllables, the PSSC would be 33.3%. Measures of syllable shape have been used to describe children's early speech behaviours (e.g., Paul & Jennings, 1992).

Percentage of vowels correct (PVC). A vowel is considered to be correct when the vowel produced by the child is the same vowel type as the vowel in the target utterance (with no distortion). For example, a match would occur if the child produced the vowel /ɑ/ for the word 'lock' (/lɑk/). An on-glide preceding (e.g., 'zoo' transcribed as /dⁱu/) or off-glide (e.g., 'bee' transcribed as /biᵊ/) following a vowel are penalized. These are classified as distortions and result in the vowel being coded as an error. Following the convention of Shriberg (1986), a sound addition following a vowel results in the vowel being scored as incorrect and is not a match. The number of vowel matches out of the total number of possible vowels (33) is converted to a percentage of vowels correct (PVC). For example, a child who matched 18 of 33 vowels would have a PVC score of 54.5%.

Percentage of consonants correct (PCC). A consonant is considered to be correct when the consonant produced is the same as the consonant in the phonetic transcription of the target utterance (with no distortion). For instance, if the child produced the /b/ for the first consonant in the target word 'boot', it would be marked as a match. As with vowels, a sound addition following a consonant results in the consonant being scored as incorrect and therefore not a match. The number of consonant matches out of the total number of possible consonants (53) is converted to provide a percentage of consonants correct (PCC). For example, if the child matched 13 out of the 53 target consonants, the PCC would be 24.5%.

PCC and PVC have been shown to be reliable measures when obtained from phonetic transcription of a five-to-ten minute spontaneous speech sample produced by children with speech disorders (Shriberg et al., 1997). To the authors' knowledge, reliability measures for PCC and PVC have not been reported for young preschool children's imitative word productions.

Percentage of whole word accuracy (PWWA). Whole word accuracy is defined as an exact match of the vowel and consonant content between the actual production and the phonetically transcribed target word (Schmitt, Howard, & Schmitt, 1983). An example of this is when the child produces /bo/, matching the phonetic transcription of the word 'bow'. The number of word matches out of the total number of possible words (31) on the *TOCS-30* is converted to a percentage of whole word accuracy (PWWA). For example, if the child matched 6 out of 31 words, PWWA would be 19.3%. Vihman and Greenlee (1987) included this as a measure of phonological development in one-year-olds. It is used in the *TOCS-30* analyses as an intelligibility estimate (Flipsen, Hammer, & Yost, 2005). The number of exact word matches has also been identified as a useful companion to the PCC (Ingram & Ingram, 2001).

Phonetic inventory. The syllable, vowel, and consonant types that occur in the phonetic transcription of the child's productions are listed and tallied. Monophthongs and diphthongs are each given single vowel type status. Distorted productions of vowel and consonant types are counted as a unique type only for phonemes where no undistorted productions occur. For example, a distorted production of /s/ would be listed as a consonant type if no undistorted production of /s/ occurred. For each measure, one occurrence of a type in a child's *TOCS-30* productions is sufficient to include it. If only one instance of a type occurs and is transcribed as 'questionable', it is not included. Inventory size has been reported to be a useful measure to describe early speech behaviors in children (e.g., Paul & Jennings, 1992; Vihman & Greenlee, 1987).

Transcription of study samples. The second author (MH) assigned the recordings of the *TOCS-30* samples randomly to each of the two transcribers and balanced them so that each transcriber had five children from each of the three groups (n=15), plus half of the second samples for the 12 children who were used to examine test-retest reliability (n=6), and three samples that had also been assigned to the other transcriber to estimate inter-rater transcription reliability, for a total of 24 samples per transcriber. The order in which the children's samples were transcribed was determined through random selection by the second author.

The digital audio recordings of the *TOCS-30* items from the children in the TSL and SSD-TL groups were played using Adobe Audition 1.5 via computer speakers. The video recordings of the children in the SS-ELD group were played on a VCR deck and viewed on a monitor. The audio signal was played through the speakers on the monitor. The transcription for all subjects' *TOCS-30* words took place in an acoustically-treated sound booth. Each item was listened to a minimum of two and a maximum of three times. The *TOCS-30* samples were transcribed phonetically using the procedures described by Shriberg (1986) and the conventions that were developed during the training phase of the study. In accordance with these guidelines, utterances were transcribed to give the children 'the benefit of the doubt'; that is, an error was transcribed as a distortion before a substitution, and as a substitution before an omission.

Once completed, the phonetic transcription for each *TOCS-30* was entered into *P.E.P.P.E.R*. for analysis and the phonetic measures were obtained. The denominators for the phonetic measures for the five children with fewer than the 30 items were adjusted to reflect the number of items in their *TOCS-30* samples (range of 27 to 29 items). PCC and PVC were obtained directly from the *P.E.P.P.E.R.* analysis output. Accurate whole words, syllable shape matches, and recognizable segments were highlighted in the transcriptions, hand counted, and converted to percentage correct scores as *P.E.P.P.E.R.* does not calculate these. A form was created to record sound and syllable types. It listed all consonant and vowel sounds in western Canadian English and the syllable types V, CV, VC, CVC, CCV, CCVC, and CVCC. For each *TOCS-30* sample, the vowels, consonants, and syllable types that the child produced (whether a correct match or not) were circled. Questionable sounds and syllable types were recorded on the form in a separate category. On average, across the 30 children, it took approximately 20 minutes to complete the transcription for the *TOCS-30* samples and an additional 22-25 minutes to count and calculate the measures of phonetic accuracy and inventory. Completion of the phonetic transcription of the *TOCS-30* items and determination of the values for the eight phonetic measures took longest for the children in the SS-ELD group.

Reliability. Inter-rater agreement was determined for the phonetic transcriptions of the *TOCS-30* items as follows. The phonetic transcripts for each of the six samples (two samples selected randomly from each group or 20% of the samples) that were transcribed and entered into *P.E.P.P.E.R* independently by each transcriber were compared for segment-to-segment agreement (i.e., broad transcription match and diacritic match for diacritics counted as errors in Table 3) by the second author (MH).

The availability of two separate recordings of the *TOCS-30* items for 12 of the 30 children (2 from the TSL, 2 from the SSD-TL, and 8 from the SS-ELD groups) afforded the opportunity to examine test-retest reliability of the phonetic measures obtained from the *TOCS-30* imitative sample. No child received speech treatment between the first and second recordings, which were obtained within a two-week period. Test-retest reliability was determined by calculating an intraclass correlation coefficient ($ICC_{(3,1)}$) (Shrout & Fleiss, 1979) between the first and second *TOCS-30* samples for each of the eight phonetic variables.

Validity. Construct validity was determined by comparing the three groups of children's scores on each of the eight phonetic variables obtained from the *TOCS-30* transcriptions. All data analyses were performed using SPSS version 21. MANOVA was used to evaluate the hypothesis that the two groups of children with speech disorders/delay (SSD-TL and SS-ELD) would score significantly lower than the group of children with typical speech development (TSL), and that the group of children classified as SS-ELD would have the lowest scores.

Results

Reliability

Mean inter-rater agreement was 87.1% (SD 7.9%) for consonants and 92.4% (SD 2.6%) for vowels across the six samples compared. Mean agreement was highest for the two children in the TSL group (96.2% for consonants and 95.5% for vowels) and lowest for the two children in the SS-ELD group (82.1% for consonants and 90.9% for vowels).

$ICCs_{(3,1)}$ obtained for test-retest reliability were as follows: percentage recognizable segments (0.99, $p < .001$), percentage syllable shapes correct (0.95, $p < .001$), percentage vowels correct (PVC) (0.84, $p < .001$), percentage consonants correct (PCC) (0.98, $p < .001$), percentage whole word accuracy (0.95, $p < .001$), syllable types (0.94, $p < .001$), consonant types (0.81, $p < .001$), and vowel types (0.71, $p < .01$). As shown in Table 4, the absolute mean differences between the 12 children's test-retest values ranged from 4.3% (PCC) to 8.5% (PVC) for the measures of phonetic accuracy and from 0.25 (number of syllables types) to 1.58 (number of consonant types) for measures of phonetic inventory. The group means and standard deviations for each phonetic measure for the test-retest sample comparisons are also shown in Table 4.

Validity

Table 5 reports the mean scores for each phonetic variable for the TSL, SSD-TL, and SS-ELD groups. As hypothesized, the SS-ELD group scored the lowest on all of the *TOCS-30* phonetic variables, followed by the SSD-TL group, with the TSL group scoring the highest. The only exception was for the number of vowel types. All group comparisons for the variables were significant at the $p < .001$ level with the exception of vowel types. Values of the F statistic and observed power for each phonetic variable are also reported in Table 5.

For the phonetic variables that showed significant differences in the MANOVA, post-hoc testing using Dunnett's C test (equal variances not assumed) revealed significant differences ($p < .05$) between each pairing of

Table 4. *TOCS–30* test-retest measurement error and means and standard deviations for the phonetic measures obtained from the first and second recordings of *TOCS-30* stimuli for the 12 children analysed for test-retest reliability.

Phonetic Measure	Time 1 – Time 2 Measurement Error (Mean Absolute Difference)	Time 1 Mean (SD)	Time 2 Mean (SD)
Percentage Recognizable Segments	4.5%	78.5% (22.4%)	77.0% (20.5%)
Percentage Syllable Shapes Correct	5.6%	56.1% (30.3%)	56.1% (31.1%)
Percentage Vowels Correct	8.5%	76.5% (18.2%)	77.0% (21.1%)
Percentage Consonants Correct	4.3%	45.8% (29.2%)	47.8% (30.0%)
Percentage Whole Word Accuracy	6.8%	28.9% (27.4%)	34.8% (32.1%)
Number of Syllable Types	0.25	3.7 (1.1)	4.0 (1.2)
Number of Vowel Types	0.83	8.8 (1.4)	8.3 (1.9)
Number of Consonant Types	1.58	11.8 (4.9)	11.8 (4.9)

Table 5. Group results of the MANOVA and group means and standard deviations for the phonetic variables obtained from *TOCS–30* .

Phonetic Variable	F Value (Observed Power)	SS-ELD M (SD)	SSD-TL M (SD)	TSL M (SD)
Percentage Recognizable Segments	16.17* (.999)	70.0% (19.3%)	93.0% (8.2%)	99.3% (0.8%)
Percentage Syllable Shapes Correct	32.85* (1.000)	38.6% (21.8%)	80.2% (18.4%)	97.0% (2.9%)
Percentage Vowels Correct	9.93* (.972)	73.6% (17.2%)	89.7% (6.4%)	94.5% (5.0%)
Percentage Consonants Correct	50.04* (1.000)	30.9% (15.9%)	66.0% (18.3%)	94.3% (4.0%)
Percentage Whole Word Accuracy	89.28* (1.000)	14.8% (8.5%)	50.8% (17.9%)	86.4% (6.2%)
Syllable Types	39.2* (.987)	3.1 (0.6)	4.3 (0.9)	5.8 (0.4)
Vowel Types	2.36 (p=.114) (.435)	8.8 (1.2)	9.6 (1.0)	9.6 (0.5)
Consonant Types	21.57* (1.000)	9.3 (3.0)	14.2 (2.6)	18.5 (0.7)

*(p < .001)

the groups (TSL vs. SSD-TL; SSD-TL vs. SS-ELD; TSL vs. SS-ELD) for percentage consonants correct, percentage whole word accuracy, percentage syllable shapes correct, and number of syllable and consonant types. Significant differences were found for percentage recognizable segments between TSL vs. SS-ELD and SSD-TL vs. SS-ELD groups, but not between TSL and SSD-TL groups. For percentage vowels correct, there was a significant difference for TSL vs. SS-ELD groups, but not for TSL vs. SSD-TL or SSD-TL vs. SS-ELD groups.

Discussion

This study developed conventions for generating phonetic transcriptions of young children's recordings of the *TOCS-30* items. It also examined the reliability and validity of several measures of phonetic ability obtained from phonetic transcriptions of 3 year-old children's imitated productions of these items. The children differed by speech and language diagnosis: age-typical speech and language development (TSL), speech sound disorder of unknown origin with age-typical language development (SSD-TL), and severe speech and expressive language delay of unknown origin (SS-ELD). Inter-rater agreement for phonetic transcription of the *TOCS-30* samples compared exceeded 80% for consonants and vowels. The highest agreement was obtained for recordings from the TSL group and the lowest for recordings from SS-ELD group. This pattern reflects the relative severity of involvement of the groups (i.e., the more severe the disorder, the greater the potential ambiguity of the speech signal and consequently, the lower the expected reliability of phonetic transcription).

The transcription conventions developed and used in this study resulted in acceptable levels of inter-rater agreement and therefore it is recommended that users of the *TOCS-30* follow these conventions. This includes broad transcription with the following distortions counted as errors for consonants: nasalized, glottalized, lateralized, dentalized, frictionalized, derhoticized, devoiced, lengthened, and aspirated, and for vowels: nasalized, lengthened, on-glide, and off-glide. It is noted that transcribers who are less confident in identifying a specific type of distortion could use a 'catch-all' diacritic [$_x$] for consonant and vowel distortions. While information about the nature of consonant and vowel distortions is useful in treatment planning, it is not needed to calculate the measures of phonetic accuracy. It is also recommended to give 'the benefit of the doubt,' when transcribing a child's productions; that is, where an error is transcribed as a distortion before a substitution, and as a substitution before an omission.

The results also suggest that the *TOCS-30* test-retest reliability is acceptable. Intraclass correlation coefficients obtained for the phonetic variables from the first and second *TOCS-30* recordings were high (above 0.8) (Bloom & Fisher, 1982), with the exception of number of vowel types (0 .71). These results suggest that children demonstrated inconsistency in their production of different vowels and consonants between the two recordings of the *TOCS-30* items, with greater inconsistency for vowels. Mean absolute differences between the same phonetic variables for 'test' and 'retest' samples provide information about the smallest differences that might be interpreted as a 'real' difference, as opposed to differences attributable to measurement error. This ranged from 4.3% for percentage syllable shapes correct to 8.5% for percentage vowels correct for measures of phonetic accuracy and from 0.25 for number of syllables types to 1.58 for number of consonant types for measures of phonetic inventory. This information has clinical application in cases where *TOCS-30* is used as a measure of change over time for determining if differences observed in the various phonetic measures are greater than what would be expected from these respective measurement error values.

The results also provide support for the construct validity of the *TOCS-30*. Post-hoc testing revealed that five phonetic variables differentiated the SS-ELD group from the SSD-TL group, and the TSL group from each of these groups. Percentage consonants correct, percentage whole word accuracy, percentage syllable shapes correct, and number of syllable and consonant types differed significantly among all three groups of children. Percentage recognizable segments differentiated the SS-ELD group from the other two groups. Percentage vowels correct, and number of vowel types did not differentiate between the SSD-TL and SS-ELD groups. Children with age-typical speech and language development had the highest scores and children classified with SS-ELD had the lowest scores on the phonetic variables. The only exception was mean number of vowel types, which was similar across the three groups. It appears that while the children in the SS-ELD and SSD-TL groups had relatively large vowel inventories they were less accurate in using these compared to the TSL group.

The five measures of phonetic accuracy appeared to capture the range of possible scores for the 30 three-year-old children and followed a reasonably similar pattern. Across groups, percentage whole word accuracy had the lowest score and greatest range (14.8% for SS-ELD to 86.4% for TSL). The children in the TSL group did not reach a 'ceiling' on this measure. In contrast, percentage recognizable segments and percentage vowels correct were the phonetic variables with the highest scores in the TSL group (99.3%, 94.5%; respectively). While percentage recognizable segments and percentage vowels correct also had the highest scores of the five variables in the SS-ELD group, the scores were much lower (70.0%, 73.6%; respectively), suggesting that these measures may be more sensitive to change in children with severe speech and expressive language delays than percentage whole word accuracy.

Measurement issues and limitations

Shriberg and Kent (1995) reported that approximately 25% of English words are multisyllabic. A shortcoming of the *TOCS-30* is that only three of the items (10%) are multisyllabic. This bias for monosyllable words is due to the nature of the words selected for the *TOCS+* Word Intelligibility Measure, which were chosen to provide opportunities to sample a child's ability to make minimal pair contrasts for consonant manner, place and voicing, vowel height, place and manner and syllable shape, number, and stress identifiable to listeners (see Hodge & Gotzke, 2011).

Additionally, differences in how the samples of the *TOCS-30* items were elicited and recorded for the children in the TSL and SSD-TL groups, compared to the children in the SS-ELD group, may have affected the children's productions of the target items and the phonetic transcription of these. The productions were elicited using the examiner's model for the SS-ELD group. If children were watching the examiner's face, they would have received extra cues about the phonetic content of each item, compared to children in the other two groups who heard a standard, pre-recorded audio-only model to imitate. This advantage may have resulted in higher scores for the children's productions in the SS-ELD group compared to what they might have obtained when given a standard, pre-recorded audio-only model to imitate. In addition, transcription of the *TOCS-30* samples for the children in the SS-ELD group were made from video recordings, and as such provided extra cues about articulatory placement for the transcribers, compared to the audio-only recordings for the SSD-TL and TSL groups. It is possible that the SS-ELD subjects were given credit for unreleased and reduced sounds that may not have been discernible in the audio-only recordings for the children in the TSL and SSD-TL groups. In retrospect, covering the video monitor so that transcribers had access to only the audio playback of the recording would have addressed this latter issue. Despite these differences that would bias the scores of the children in the SS-ELD group to be higher, significant group differences were found.

Conclusions

Given the high inter-rater agreement for phonetic transcription of the *TOCS-30* samples in this study, confidence in the transcription data and dependent variable scores is high for all three groups. The training and transcription conventions developed for the study likely contributed to this high level of reliability. Similar training and use of these transcription conventions is recommended for users of the *TOCS-30*. In addition, it is recommended that users video-record the child's productions of the *TOCS-30* items so that online transcriptions can be checked and finalized for scoring at a later time. Intraclass correlation coefficients for test-retest reliability for the phonetic variables obtained from *TOCS-30* samples exceeded 0.8 on all measures, with the exception of number of vowel types. These results, together with relatively low absolute measurement error values between the first and second administrations of *TOCS-30*, suggest that it provides a relatively stable sample of speech behaviour of the children studied. The measurement error values also provide a guide for interpreting differences on *TOCS-30* measures.

As a group, the eight phonetic variables obtained from phonetic transcriptions of the children's *TOCS-30* recordings appeared to capture the range of speech ability across the three groups. The SS-ELD group differed significantly from both the TSL and SSD-TL groups on six of these variables (percentage recognizable segments, percentage syllable shapes correct, percentage consonants correct, percentage whole word accuracy, and number of syllable and consonant types). Group means for measures of phonetic accuracy were lowest for percentage whole word accuracy and did not reach a ceiling for the TSL group. The range of means for measures of phonetic accuracy was greatest for the SS-ELD group (14.8% for percentage whole word accuracy; 73.6% for percentage vowels correct), reflecting their sensitivity for this group. Overall this pattern of results supports the validity of *TOCS-30* in distinguishing children by level of severity of spoken language delay.

TOCS-30 with its associated phonetic measures was shown to be a reliable, valid, and efficient tool. It captured the range of phonetic abilities of, and was sensitive to differences among 3-year old children with age-typical speech and language production, speech sound disorder with age-typical language, and severe speech and expressive language delay.

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Using the Syllable Repetition Task to Reveal Underlying Speech Processes in Childhood Apraxia of Speech: A Tutorial

Utiliser une tâche de répétition de syllabes pour révéler les mécanismes sous-jacents du traitement de la parole dans la dyspraxie verbale : un tutoriel

KEY WORDS
CHILDHOOD APRAXIA OF SPEECH
PHONOLOGICAL PLANNING
MOTOR PLANNING
SPEECH SOUND DISORDER
SYLLABLE REPETITION TASK
NONWORD REPETITION
ASSESSMENT

Susan Rvachew
Tanya Matthews

Abstract

Purpose: To demonstrate the use of the Syllable Repetition Task (SRT) as a means to identify phonological versus motor planning difficulties in children with suspected Childhood Apraxia of Speech (CAS).

Method: Ten children (aged 4.1 – 9.6 years) with suspected CAS were recruited. An extensive assessment battery was administered including measures of speech accuracy, oral motor skills, speech perception and phonological awareness abilities, consistency of word production, and syllable repetition. The SRT yields a memory score (that suggests a phonological planning deficit) and a transcoding score (based on addition errors that suggest a motor planning deficit).

Results: Despite overlapping characteristics, especially in the domains of phonological processing, testing revealed three groups: (1) children with deficits in phonological planning, (i.e., low memory scores on the SRT and high word inconsistency); (2) children with deficits in motor planning, (i.e., low transcoding scores on the SRT and prosodic errors); and (3) children with other profiles (i.e., primary deficits in the domain of phonology or language rather than speech production per se).

Conclusion: The SRT coupled with a diagnostic measure of phonology and articulation may help to ascertain deficits in underlying speech processes so as to better target intervention procedures to meet the individual needs of these complex children.

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Objectif : Démontrer l'utilisation d'une tâche de répétition de syllabes (TRS) comme moyen pour distinguer les difficultés phonologiques des difficultés de planification motrice chez les enfants où l'on soupçonne une dyspraxie verbale.

Méthodologie : Dix enfants (âgés entre 4,1 et 9,6 ans) chez qui l'on soupçonne une dyspraxie verbale ont été recrutés. Une batterie d'évaluation complète leur a été administrée, ce qui inclut des mesures sur le plan de la précision de la parole, de la répétition de syllabes, des habiletés orales motrices, des habiletés de perception de la parole et de conscience phonologique. Les auteurs ont également regardé si la production de mots était constante. La TRS donne un résultat de mémoire (qui suggère un déficit dans la planification phonologique) et un résultat de transcodage (qui est basé sur les erreurs d'ajout et qui suggèrent un déficit dans la planification motrice).

Résultats : Bien qu'il y ait un chevauchement dans les caractéristiques, particulièrement en ce qui a trait au traitement phonologique, les évaluations ont fait ressortir trois groupes : (1) les enfants avec un déficit sur le plan de la planification phonologique (c'est-à-dire, présentant de faibles résultats de mémoire à la TRS et une inconsistance élevée dans la production de mots), (2) les enfants avec un déficit sur le plan de la planification motrice (c'est-à-dire, présentant de faibles résultats de transcodage à la TRS et des erreurs prosodiques) et (3) les enfants avec un autre profil (c'est-à-dire, présentant un déficit primaire de la composante phonologique ou du langage plutôt que de la production de la parole).

Conclusion : La TRS, jumelée à une mesure diagnostique de la phonologie et de l'articulation, peut aider à identifier la présence de déficits dans les mécanismes sous-jacents du traitement de la parole, permettant ainsi de mieux cibler les méthodes d'intervention et de répondre aux besoins individuels des enfants avec ce trouble complexe.

Childhood apraxia of speech (CAS) is defined by the American Speech-Language and Hearing Association (2002) as "a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits…" (p. 3-4). Three diagnostic features are identified as being characteristic of CAS, specifically difficulties in the areas of consistent word productions, coarticulation, and prosody. Although the report suggests clinical and research consensus on these signs, research continues to raise questions about their reliability as diagnostic markers (e.g., Murray, McCabe, Heard, & Ballard, 2015) and clinical diagnosis of this population remains a difficult task (Davis, Jakielski, & Marquardt, 1998).

Etiology of CAS

The diagnostic challenge of CAS reflects the complexity of the processes involved given that the acquisition of speech motor control and the tasks used to identify deficits in this area tap multiple linked speech processes and a network of broadly distributed neural networks. During assessment, the child may be asked to imitate a nonsense word or name a picture. In either case, current models hypothesize that a sound-based phonological code will be accessed through a bilaterally organized system for acoustic and phonological processing that terminates in the middle to posterior portions of the superior temporal sulcus before branching into ventral and dorsal pathways (Hickok & Poeppel, 2004). Production of the stimulus item is dependent upon the left-dominant dorsal pathway that maps sound-based codes to articulatory codes via a multistage process that involves prearticulatory planning in Broca's area (Flinker et al., 2015; Hickok & Poeppel, 2004); subsequently, articulatory coordination and execution require activation in the premotor and motor cortices. Finally, feedforward and feedback loops with primary auditory and somatosensory cortices that further involve the cerebellum and basal ganglia are also essential to speech execution (Guenther & Vladusich, 2012; Tanji et al., 2015).

Recent research on the genetic underpinnings of CAS also leads us to expect complexity at the level of explanatory speech processes. These studies reveal enormous heterogeneity as to possible causes of the disorder in individual children (Laffin et al., 2012). The picture is highly complex even in the case of the *FOXP2* gene, in which there are increasing numbers of known cases and the link between genetic mutations and apraxia is relatively clear. First, many different types of genetic variations in *FOXP2* have been observed (Turner et al., 2013; Zhao et al., 2010) and the exact form of the mutation affects the behavioral phenotype (Kurt, Fisher, & Ehret, 2012). Second, the gene is expressed in a neural network involving many brain structures and therefore children with *FOXP2* mutations have several developmental difficulties including oral-facial and verbal apraxia, language and reading impairments, and delayed nonverbal cognition (Vargha-Khadem, Gadian, Copp, & Mishkin, 2005). These cases of monogenetic causation apparently motivated a revision of the Speech Disorders Classification System to separate motor speech disorders from other forms of speech delay that are associated with multiple genetic and environmental risk factors (Lewis et al., 2006; Shriberg et al., 2010). However, very few cases of CAS are known to be caused by a single gene mutation. Therefore Lewis et al. (2004) proposed the verbal trait hypothesis whereby most children with CAS are on the severe end of a continuum of speech sound disorders but with a higher genetic loading. That is, an accumulation of diverse harmful gene alleles simultaneously affect multiple speech processes so as to cause CAS. In any case, CAS is clearly developmental and multifaceted. It can be expected that several speech processes are involved and that the observed signs will change as the child gradually acquires speech motor control. The developmental challenge that should be the highest priority for speech therapy at any given time should be driven not by the diagnostic label but by a comprehensive assessment of the child's speech processing deficits and linguistic capabilities.

Models of Speech Processing

Shriberg et al. (2009) developed the Syllable Repetition Task (SRT) as a nonword repetition test that would be specially adapted to the needs of patients and research participants with speech sound disorders. More importantly for the purpose of this paper, the test was designed to be scored so as to reveal information about the possible speech processes that explain the child's overall performance. The explanatory framework draws on psycholinguistic models of speech processing that, while varying in their details, share common components. These differentiate broadly between input processes and output processes, and within the output domain, between prearticulatory planning and subsequent planning of articulatory gestures prior to motor execution (for reviews see Baker, Croot, McLeod, & Paul, 2001; Rvachew & Brosseau-Lapré, 2012; more specifically, see Dell, Chang, & Griffin, 1999; Levelt, Roelofs & Meyer, 1999; Stackhouse & Wells, 1993). The processes specifically targeted by the SRT are encoding processes (mapping onto the various input processes described in these models), memory processes (implicating prearticulatory or phonological planning), and transcoding processes (in other words, transforming the phonological plan into a motor plan).

Syllable Repetition Task

A particular feature of the task is that the items are composed of a restricted repertoire of simple early developing phonemes, specifically: [ɑ, m, n, b, d]. The phonemes are combined to form 8 two-syllable items, 6 three-syllable items, and 4 four-syllable items. Four scores can be derived from syllable repetition performance: an overall competence score and three additional scores reflecting speech processes that presumably contribute to overall competence on the task; specifically, an encoding score, a memory score, and a transcoding score. These three speech processes will be discussed in relation to research findings on CAS.

Successful completion of the SRT requires that the child first listen to the auditory stimulus, thus implicating "auditory-perceptual *encoding* processes that transform auditory input into phonemic, sublexical, [or] lexical representations" (Shriberg, Lohmeier, Strand, & Jakielski, 2012, p. 447). The largest proportion of children with speech delay have difficulty encoding incoming phonological information (Rvachew & Grawburg, 2006; Shriberg et al., 2005) and benefit from approaches to speech therapy that strengthen acoustic-phonetic representations for speech (Rvachew & Brosseau-Lapre, 2010). Speech perception deficits are not typically considered to be a causal factor in motor speech disorders even though children with CAS are known to have poor speech perception and phonological processing (Maassen, Groenen, & Crul, 2003; Nijland, 2009). These studies do not take into account the generally lower language skills of children with CAS. However, there is a reciprocal relationship between the size of the lexicon and phonological processing; therefore we might expect that difficulties with encoding would be most likely to occur when CAS and receptive language impairment are comorbid. Language impairment, poor quality acoustic-phonetic representations, and delayed phonological skills may emerge over time because children with extremely poor spoken language skills will have poorer quality interactions with the language environment and fewer opportunities to hear themselves produce good quality speech. It is possible that the link between encoding skills and CAS is more direct however: speech motor control requires access to auditory and somatosensory feedback (Shiller, Rvachew, & Brosseau-Lapré, 2010) and it has been suggested that deficits in processing feedback in these areas play a role in CAS (Terband, Maassen, Guenther, & Brumberg, 2009; 2014). It is interesting to note that speech perception training improves children's ability to use auditory feedback control for speech motor learning (Shiller & Rochon, 2014). Therefore, it is important not to disregard the child's potential needs in this area when improved speech motor control is the goal of the therapy program.

As a means to identify possible difficulties with encoding, the SRT is scored to count the proportion of consonant substitution errors that are not within-class errors. In other words, if a child produced errors such as /badɑ/→[babɑ], in which the substitution and the target are both stops, encoding difficulties are not suspected. In the case of a child with an unmarked "favourite", not sharing manner features with the targets, as in /badɑ/→[bajɑ] and /banadɑ/→[bajajɑ], it may be that the child has not been able to process the phonetic content of the consonants after the first syllable. Therefore, a scoring procedure that derives the proportion of within-class substitutions against the total number of substitution errors is suggested. When a high proportion of substitution errors are within-class, it is assumed that encoding is relatively good; when a low proportion of substitution errors are within-class, it is assumed that encoding is relatively poor. Further research to determine the validity of the hypothesis against actual measures of children's phonological processing skills is required. Shriberg et al. (2012) found that encoding scores largely overlapped for children with typical speech and for children with speech delay but typical language. Children with CAS and children with speech delay combined with language delay achieved similarly low encoding scores.

Subsequent to encoding of the stimulus for repetition, this representation undergoes a second transformation during the phonological planning stage, which occurs prior to articulation (also referred to as the prearticulatory stage). During this stage, the target utterance must be held in memory while a prosodic frame for production of the utterance is constructed and articulatory representations for the required segments are slotted into the frame in the correct order. These prosodic and segmental units must be retrieved from memory. The neural network for prearticulatory planning includes the same structures that are responsible for short term memory (Flinker et al., 2015; Hickok et al., 2014) and therefore it is not surprising that these processes are referred to by Shriberg et al. (2012) as *memory processes*. Dodd, Holm, Crosbie, and McCormack (2005) suggest that a specific subgroup of children with speech sound disorders, the *inconsistent deviant phonological disorder* subgroup, has an underlying deficit in phonological planning. These children are described as a minority group of approximately 10 percent of children with a speech sound disorder who demonstrate significant inconsistency upon repetition of words in combination with highly atypical errors (in comparison to age peers). The errors can be described as being similar to the phonemic paraphasias that are observed in adult aphasia in that substitution errors involve phones far from the target and sequencing errors are common. Ozanne (1995) conducted a cluster analysis of a large number of children referred for suspected apraxia of speech and found a cluster that fit the characteristics of inconsistent deviant phonological disorder rather than apraxia, with the signs being: inconsistent productions of the same word; increased errors with increased performance load; atypical errors; poor maintenance of phonotactic structure; and vowel errors. It is arguable whether a speech disorder that is founded on difficulties with phonological planning and memory deficits (as opposed to motor planning deficits) properly fits the definition of apraxia provided by the American Speech-Language and Hearing Association (2002), as presented previously. However, inconsistent errors are considered to be a core feature of CAS and children diagnosed with CAS have been frequently observed to have difficulty with sequencing across speech and nonspeech domains as well as verbal memory (Nijland, Terband, & Maassen, 2015; Peter & Stoel-Gammon, 2008). The SRT provides information about the child's memory processing by permitting a comparison of performance on short versus longer items. It is assumed that a greater number of errors as item lengths increase is an indicator of deficits with memory processes. The interpretation of scores for children who are unable to repeat even two-syllable items is ambiguous; possibly this pattern of responding may reflect encoding and/or memory processes. Shriberg et al. (2012) compared performance across different groups of children on a score that is based on the ratio of consonants correct for three-syllable items versus two-syllable items. Mean scores for the children with CAS and children with speech delay combined with language delay were considerably lower than those achieved by the children with typical speech or uncomplicated speech delay. However, within group variance was extremely high.

The final stage before actual execution of the utterance involves "*transcoding processes* that plan and programme the representations for the motoric gestures of manifest speech..." (Shriberg et al., 2012, p. 447). Unlike encoding and memory processes, deficits in these transcoding processes are considered to be specific to CAS. Transcoding deficits manifest themselves in a variety of ways but include abnormal timing of speech gestures that may be heard as lengthened or disrupted coarticulatory transitions between individual segments or syllables. Alternatively, transcoding difficulties may emerge as abnormal prosody which requires the coordination of pitch, amplitude, and duration parameters to create language specific patterns of lexical and phrasal stress. A recent large sample study of the characteristics that were most predictive of CAS, as determined by clinical diagnosis, revealed that syllable segregation errors (defined as "noticeable gaps between syllables", p. 47), dysprosody, [pətəkə] inaccuracy, and multisyllabic word production accuracy had excellent predictive validity (Murray et al., 2015). In other words, this study confirmed that attention to prosody was key to accurate diagnosis of CAS, providing support for previous findings in this regard (e.g., Shriberg et al., 2003). Transcoding deficits are revealed on the SRT by a particular form of error, specifically, additions that often take the form of nasals inserted at syllable boundaries as in /bɑdɑ/→[bandɑ], although any addition error, including additions of entire syllables, can be counted. Notably, these additions are just as likely in two-syllable items as they are in longer items and children with CAS were more likely than children with speech delay to produce unusual addition errors beyond the homorganic nasals that were most common. As was expected, Shriberg et al. (2012) found that transcoding scores were significantly lower for their group of children with CAS in comparison to the other groups of children assessed in their study. Although low transcoding scores were the most distinctive SRT characteristic to be associated with the CAS group, some children in all three groups were observed to have low transcoding scores.

To summarize, the acquisition of speech motor control involves coordinated processing in three areas described here as encoding processes (deriving acoustic-phonetic representations from speech input), memory process (essential for prearticulatory phonological planning), and transcoding (transforming the phonological plan into a motor plan). Developmental deficits in any one area are likely to have implications for the development of any other processing area and the linkages among these processes. It is expected that children with CAS will have multiple deficits and that the nature of the disorder will change as the child grows older as a consequence of changing skill levels and increasing linguistic challenges. The role of the S-LP is to understand the underlying speech processes that are problematic for the child in relation to developmentally appropriate linguistic challenges. The framework of encoding, memory, and transcoding processes may be helpful in this task and the SRT provides a new tool to support the diagnostic process. The purpose of this paper is to illustrate the use of this new tool and the interpretation of assessment results in the case of suspected CAS in view of this theoretical framework. In contrast to several excellent and recent large sample studies, this report describes a very small sample which provides an opportunity for greater detail at the individual level. The tutorial will explain the administration and scoring of the SRT. The results of SRT administration with 10 children will be examined in relation to other test results that explore the children's performance with respect to their encoding abilities (i.e., as revealed by measures of speech perception and phonological awareness), their phonological planning abilities (i.e., as revealed by the word inconsistency assessment), and their motor planning abilities (i.e., as revealed by the oral motor exam, maximum performance test, and prosody errors in connected speech). Two case studies will demonstrate interpretation of test data to identify phonological versus motor planning impairments using the SRT in the context of a standard speech-language assessment. It is hoped that these case studies will help S-LP readers relate recent advances in research and theory to their own clinical caseloads.

Method

Participants

The participants in this study were recruited from one of two sources: (1) speech-language pathologists on staff at the local children's hospital or rehabilitation hospital in the English language health care sector; or (2) the Apraxia-Kids (Canada) Facebook page. The recruitment materials that were circulated through these networks indicated that we were seeking preschool-aged children (aged 4 through 6 years) with a primary SSD and suspected or confirmed CAS (usually characterised by producing many more speech errors than would be expected for the child's age and especially inconsistent speech errors). The children would receive an extensive assessment to determine their eligibility for intake into a treatment trial that consisted of 18 treatment sessions provided over six weeks. Ultimately, we included some children who did not meet our original selection criteria (i.e., up to age 9 years and with secondary SSD) although we excluded children with a primary sensory disorder (e.g., hearing impairment, blindness) or severe motor disorder that precluded therapy for the achievement of intelligible speech. The decision to assess a child was made after discussion with the child's parent, teacher, SLP, and receipt of a case history form. This report includes all 10 children who were recruited during a single academic term regardless of whether they ultimately met our criteria for inclusion in the treatment trial following their initial assessment (i.e., confirmed diagnosis of CAS). Only the intake assessment data are described in this report (excluding the intervention outcomes and follow-up data). This study was approved by all relevant institutional review boards including those providing oversight at the rehabilitation hospital where the children were assessed and treated and McGill University.

Preliminary information about these children, as determined from the case history forms, is provided in Table 1. It can be seen that the group is heterogeneous with respect to age and diagnosis. The presence of additional diagnoses, developmental delays, and health problems is common for the group. All but one had received speech therapy in the past and some continued to receive therapy during the course of our study. In all cases the home language was English at least 75% of the time. In addition, all of the children would have been exposed to some French at school even though they were attending preschool or school in the English sector as bilingual exposure is common in the province where the data was collected because the official language is French. As can be seen in Table 1, a second spoken language other than French was reported by five of the families.

Procedures

The children received an extensive assessment that required approximately 2 hours of testing. The preschool children received the tests in one or two assessment sessions in a single week. School-aged children were tested in more sessions spread out over a longer period of weeks because they could only be absent from class for short periods (30 to 40 minutes at a time). The assessment was conducted by a student speech-language pathologist under the supervision of an ASHA or SAC certified S-LP who was present during the entire assessment to ensure that the tests were administered according to the test manuals and study protocol. Furthermore, the presence of the student and the S-LP throughout the entire assessment with subsequent consultation enhanced accuracy in the transcription of responses and scoring of the tests. The entire assessment was video recorded with a Sony handy camera HDR-CX150. Parts of the assessment were audio recorded using a Zoom handy recorder H1 with settings 24-bit/96KHz in WAV format.

Syllable Repetition Task (SRT). The SRT as described in Shriberg et al. (2009) was administered and scored according to the instructions in the technical report (Lohmeier & Shriberg, 2011). The stimuli for the SRT can be obtained from the Phonology Project website (see Figure

Table 1. Participant Characteristics at Intake

Participant	Age	Gender	Maternal Education	Other Home Language	Diagnoses	Other Complications	Therapies
TASC16	4;1	M	20	Punjabi	SSD with Developmental delay	Premature birth; sensory, fine and gross motor deficits; feeding difficulties at birth	S-LP
TASC17	4;11	M	16	ASL	SSD secondary to Cleft palate	Heart problems and brain abscess surgically corrected; feeding difficulties	S-LP; OT
TASC18	6;7	M	16	French	Primary SSD	Family history of SSD, dyslexia; feeding difficulties at birth	S-LP
TASC20	5;2	F	19	Italian, Greek	Primary SSD	Family history; febrile seizures	None
TASC21	5;5	M	11	Arabic	Primary speech and language delay	Fine motor delays	S-LP
TASC23	9;6	M	11	Romanian	SSD with Developmental delay	No complications reported	S-LP
TASC24	4;0	M	19	French	Primary speech and language delay	Birth complications including asphyxia; family history	S-LP; special education
TASC25	6;10	M	13	None	Profound primary SSD	Kidney disease; probable traumatic brain injury	S-LP; OT; music therapy
TASC26	4;10	M	Not reported	None	Primary speech and language delay	Family history	S-LP; behavior therapist; OT
TASC27	5;2	F	14	None	Primary SSD	No complications reported	S-LP

Note. Maternal education represents the number of years the mother attended school.

1 notes) and the 18 test items of the task are embedded as WAV files in power point slides. This allows the assessor to present the stimuli one at a time when the child is ready to listen. The stimuli were presented to the child from a laptop (Hewlett-Packard Compaq Presario CQ50) with the laptop speaker volume set at the loudest comfortable and undistorted presentation level. The child's responses were recorded using the Zoom recorder and transcribed using the Audacity 2.0.3 Waveform editor. Scoring details are illustrated in Figure 1 using data from TASC27, a child whose performance on the SRT was within normal limits in every respect. The competency score is the most straightforward and reflects the percentage of consonants produced correctly across all items. Note that voicing errors are not counted as errors in scoring the SRT. The encoding score is the percentage of consonant substitution errors (excluding voicing errors) that are a within-manner class substitution. The memory score begins with the ratio of percent correct consonants for three-syllable items to percent correct consonants for two-syllable items, although this result undergoes some further calculation (with possible truncation to ensure that the resulting score is never less than 0 or greater than 100). The formula for calculating the memory score is shown in Figure 1. The transcoding score is

Item	Target	TASC27	Cs ✓
1	bada	bada	2
2	dama	dana	1
3	bama	bama	2
4	mada	mada	2
5	naba	naba	2
6	daba	daba	2
7	nada	nada	2
8	maba	maba	2
9	bamana	banada	1
10	dabama	dabana	2
11	madaba	madaba	3
12	nabada	mabada	2
13	banada	banada	3
14	manaba	manaba	3
15	bamadana	banadana	3
16	danabama	danabama	4
17	manabada	manabanda	4
18	nadamaba	madamaba	3

The SRT is available at the Child Phonology Project www.waisman.wisc.edu/phonology, along with reference data, administration and scoring details:

Lohmeier, H. L., & Shriberg, L. D. (2011). *Reference data for the Syllable Repetition Task (SRT).* Phonology Project, Waisman Center, University of Wisconsin-Madison.

Shriberg, L. D., Lohmeier, H. L., Strand, E. A., & Jakielski, K. J. (2012). Encoding, memorial and transcoding deficits in Childhood Apraxia of Speech. *Clinical Linguistics & Phonetics, 26*, 445-482.

Competency Score and Interpretation	
# consonants ✓	43
Total # consonants	50
PCC = competency score	(43/50)*100 = 86
For 5 year olds, z = (86 – 85)/11.1 = 0.09	
Cut-off for CAS is 65.	
TASC27 scores WNL and above the cut-off for CAS.	
Encoding Score and Interpretation	
# substitution errors	7
# within class substitutions	6
Encoding score	(6/7)*100 = 85.71
For 5 year olds, z = (85.71 – 65.1)/29.1 = 0.71	
Cut-off for CAS is 46.9.	
TASC27 scores WNL and above the cut-off for CAS.	
Memory Score and Interpretation	
2 syllable PCC	93.75
3 syllable PCC	77.78
4 syllable PCC	75.00
Memory score	100*1+(LN(77.78/93.75)) = 81.32
*scores are truncated to 0-100 range	
For 5 year olds, z = (81.32 – 90)/11.5 = -0.75	
Cut-off for CAS is 67.5.	
TASC27 scores WNL and above the cut-off for CAS.	
Transcoding Score and Interpretation	
# items with additions	1
% total items with additions	(1/18)*100 = 5.56
Transcoding score	100 – 5.56 = 94.44
For 5 year olds, z = (94.44 – 92.2)/8.4 = 0.27	
Cut-off for CAS is 80.	
TASC27 scores WNL and above the cut-off for CAS.	

Figure 1. Demonstration of scoring of the Syllable Repetition Task. Abbreviations include: Cs = consonants; PCC = percent consonants conect; CAS = childhood apraxia of speech; WNL = within nonnal limits; LN = natural log.

based on the calculation of the percentage of items that are produced with one or more additions, which in the TASC27 example is 1 of 18 items (specifically item 17) or 5.56%. This number is subsequently subtracted from 100 to yield the final transcoding score of 94.44. Interpretation can be accomplished by calculating z scores from the means and standard deviations that are found in the technical report (Lohmeier & Shriberg, 2011). However, we caution that the standard deviations can be very high for the younger age groups. The scores can also be compared to cut-off scores that are provided in Shriberg et al. (2012); these cut-off scores were the best score for differentiating children with the CAS diagnosis from children with concomitant speech delay and language impairment, after adjusting for age and intelligence. As reported in the introduction however, there was considerable overlap between these groups for competency, encoding, and memory scores, with only transcoding scores differentiating groups reasonably well with a cut-off score of 80. The clinical use of these cut-off scores for children in the age range that we are following (approximately 4 to 9 years of age), requires further validation but we are finding good correspondence with the z scores as shown in Table 2.

Diagnostic Assessment of Articulation and Phonology (DEAP). The DEAP (Dodd, Hua, Crosbie, Holm, & Ozanne, 2006) comprises several subtests that were all administered to the children. The Articulation Assessment probes articulation accuracy for consonants in word-initial and word-final position of single words, yielding a Percent Consonants Correct (PCC) and a Percent Vowels Correct (PVC) measure along with standardized scores. Administration of this test is followed by an Oral-Motor screen that consists of repetition of "pattycake" (scored for accuracy, intelligibility, and fluency) and performance of single and sequenced nonspeech movements. The Phonology Assessment is used to code for frequency of occurrence of 10 commonly occurring phonological patterns during the naming of 50 pictures. Atypical error patterns are also counted as they are important to the diagnostic scheme associated with this test. Atypical errors are any errors that did not occur frequently in the normative sample for the test. Therefore /k/ → [t] in the coda of the word "snake" is coded as atypical even though velar fronting is a common phonological pattern. Gliding of fricatives, an uncommon phonological pattern is also considered to be atypical. Normally if the child's error patterns consist

Table 2. Syllable Repetition Test scores by Participant

Score	TASC16	TASC17	TASC18	TASC23	TASC24	TASC21	TASC25	TASC26	TASC20	TASC27
2-syllable raw (%)	87.50	37.50	87.50	18.75	75.00	50.00	75.00	50.00	62.50	93.75
3-syllable raw (%)	50.00	44.40	77.78	27.78	27.28	27.78	44.44	33.33	44.44	77.77
4-syllable raw (%)	25.00	25.00	31.25	18.75	37.50	31.25	37.50	37.50	18.75	75.00
Competency raw	54.00	36.00	66.00	22.00	46.00	36.00	52.00	40.00	42.00	86.00
Competency z	-1.60	-4.41	-4.26	-7.07	-2.12	-4.41	-6.91	-4.05	-2.37	0.09
Encoding raw	44.04	30.00	56.25	40.00	46.15	26.92	54.17	44.83	37.50	85.71
Encoding z	-0.35	-1.21	-1.12	-0.66	-0.30	-4.29	-1.23	-0.70	-0.62	0.71
Memory raw	45.00	100.00	88.22	100.00	67.00	41.22	47.68	59.45	65.91	81.32
Memory z	-1.10	0.83	-0.12	0.74	-2.86	-1.31	-5.06	-2.66	-0.22	-0.75
Transcoding raw	77.78	77.78	77.78	72.22	77.78	94.44	94.44	88.89	88.00	94.44
Transcoding z	-0.36	-1.72	-1.90	-7.62	-0.90	0.26	0.23	-0.39	0.16	0.27

Note. 2, 3, and 4 syllable raw scores are percent consonants correct, disregarding voicing errors. The remaining scores are transformations of these scores as described in Figure 1.

solely of consonant distortion errors this test would not be administered; but, in this study all subtests of the DEAP were administered to all children. The third subtest is the Word Inconsistency Subtest in which the child produces a list of 25 words, many quite difficult multisyllable words, three times during the assessment (with intervening tasks). The child's productions are coded as being the same or different across all three repetitions. Inconsistency that takes the form of alternations between correct forms and common phonological patterns can be discounted for this analysis. More than 40% inconsistency (especially with atypical errors on the Phonology Assessment) would lead to a diagnosis of *inconsistent deviant phonological disorder.* Finally, a free speech sample is obtained using pictures that probe some of the same words that were previously elicited in single word naming tasks. In this way, the tendency to produce more errors under conditions of greater cognitive-linguistic load can be examined. Responses to all DEAP subtests were scored from the child's live-voice responses during the assessment and then rescored from the video by a second independent observer to obtain reliability measurements.

Maximum Performance Tasks (MPT). The children were asked to complete tasks to provide an estimate of their best performance with respect to maximum phonation duration while producing [a] and [mama] on a single breath, maximum fricative duration while producing [f], [s], and [z] on a single breath, maximum monosyllabic repetition rate while repeating [pa], [ta], and [ka] on a single breath, and maximum trisyllabic repetition rate while repeating [pataka] on a single breath. The child's responses were recorded using the Zoom recorder and scored using the Audacity 2.0.3 Waveform editor. The procedures for administration and scoring of these tasks are described in Thoonen, Maassen, Wit, Gabreels, and Schreuder (1996) and in Rvachew, Hodge, and Ohberg (2005). As reported in Rvachew, Ohberg, and Savage (2006), young children's phonation and fricative durations are often not reliable and therefore in this report we will focus on trisyllabic accuracy data.

Speech perception (SAILS). Speech perception was assessed using the Speech Assessment and Interactive Learning System (SAILS; AVAAZ Innovations, 1995), a computer game that assessed the child's ability to identify words that were pronounced correctly and words that were pronounced incorrectly, each beginning with a commonly misarticulated consonant. The test words were organized into modules consisting of 10 to 30 tokens recorded from children and adults, and digitized at a sampling frequency of 20 kHz and a 16-bit quantization rate. Half were articulated correctly (e.g., *lake* → [lek]) and half were articulated incorrectly (e.g., *lake* → [wek]), and all were presented in random order. The recorded words were presented one at a time over headphones. The children were also presented with two response alternatives on the computer monitor: a picture of the target word and a picture of a large X. Using the *lake* module as an example, the children were instructed to point to the picture of the lake if they heard the word lake and to point to the X if they heard a word that was "not lake". Test trials were preceded by a 10-trial practice block that contrasted the words *lake* and *make*. Corrective feedback was provided if necessary and the children were required to achieve a level of at least 80% correct before proceeding to the test trials. All children in this study were presented with the test modules targeting the words *lake, cat, rat,* and *Sue* in order as written. Across the four modules, 70 items were presented in total, not including practice trials. Normative data in the form of means and standard deviations for prekindergarten, kindergarten, and first grade children for each of these four modules and all four modules together are published in Rvachew and Brosseau-Lapré (2012). Previous research has demonstrated the internal validity of this measure and demonstrated its close relationship with other measures of phonological processing (Rvachew & Grawburg, 2006). TASC23 was older than the norms for this test; however, his performance was interpreted in relation to the first grade norms, in keeping with his receptive vocabulary age and nonverbal intelligence.

Phonological Awareness (PAT). The Bird, Bishop, and Freeman (1995) phonological awareness test was administered to all participants. This test consisted of three subtests: rime matching, onset matching, and onset segmentation and matching. The first subtest administered to each child was rime matching (RA). The child listened to the name of a puppet and then selected from an array of four pictures the one whose name rhymed with the name of the puppet. For example, the child was shown a puppet named "Dan". They were then told, "Dan likes things that sound like his name" and asked which he would like from "house", "boat", "car", and "van". The pictures were named for the child and the child was required to point to the picture of the word that matched the rime of the puppet's name. For the onset matching subtest (OA), the child was shown a puppet and told that everything it owned began with the same sound. The child was told the relevant sound and then asked to select the picture whose name began with that sound. Finally, for onset segmentation and matching (OS), the child was again told the puppet's name and then asked to point to the picture whose name "began with the same sound as the puppet's name". In this case, the child was given the puppet's name but not told the specific target sound. Before each of the three sections, the children were given five practice questions with feedback. The instructions were repeated and the response alternatives named for every item on the test. There were 34 test items in total across the three subtests (14 RA, 10 OA, 10 OS), involving the target rimes /æn, ʌg, æp, æt/ and target onsets /p, ʧ, m, t, s/. The test items and administration procedures and instructions were exactly as described in Bird et al. (1995) except that we replaced the item *settee* with *soap*. Normative data in the form of means and standard deviations for prekindergarten, kindergarten, and first grade children for this test are published in Rvachew and Brosseau-Lapré (2012). This test has very little memory or speech load (with no spoken responses and repetition of items and instructions) and results closely correlate with our speech perception measure in previous studies (Rvachew & Grawburg, 2006). TASC23 was older than the norms for this test; however, his performance was interpreted in relation to the first grade norms, in keeping with his receptive vocabulary age and nonverbal intelligence.

Free Speech Samples. Speech samples were recorded using a picture book (*Carl Goes Shopping;* Day, 2007). The children were asked to "talk about the pictures" and, if necessary, the examiner prompted with open-ended questions, primarily "What is happening here?" and "What do you think is going to happen next?" These samples were phonetically transcribed and coded to obtain the Percentage of Consonants Correct (Shriberg & Kwiatkowski, 1982) and the Mean Length of Utterance (MLU) in morphemes.

Peabody Picture Vocabulary Test-III (PPVT-III). The PPVT-III (Dunn & Dunn, 1997) was administered as a measure of receptive vocabulary skills. The children were shown black and white plates with four pictures and asked to point to the word named by the examiner. The five practice items were given before the test. The children's performance is reported as a standard score.

Kaufman Brief Intelligence Test, Second Edition (KBIT2). The Matrices subtest of the KBIT2 (Kaufman & Kaufman, 2004) was administered to screen nonverbal intelligence. Children were presented color plates with a target picture at the top and six pictures at the bottom. They were asked to point to the picture among the six choices that completed a target sequence. The practice items of each section were administered according to the instructions in the test manual. The children's performance is reported as a standard score.

Reliability. Twenty percent of all recordings (specifically, free speech samples and sentence level treatment probes) in the project were routinely submitted to independent transcription by two research assistants in the laboratory who were responsible for transcribing the data recorded in the project. Transcription reliability was calculated as point-by-point agreement for consonants and was 81% for the academic term described in this report. The majority of disagreements concerned voicing of segments, although inclusion of /l/ in syllable nuclei (e.g., *told, bottle*) and the consonants in certain unstressed words (*the, and*) were also common sources of disagreement. Furthermore, agreement for the calculation of percent consonants correct (PCC) and percent vowels correct (PVC) on the DEAP Articulation Test was calculated from independent retranscriptions of every DEAP test administered (the first transcription provided by the assessing student speech-language pathologist and the second obtained by a research assistant who observed the video-recorded assessment session). The intra-class correlations were .97 for PCC and .87 for PVC. When considering the absolute value of the differences between pairs of scores, the mean difference in PCC was 6.5 (SD = 4.01) and the mean difference in PVC was 7.7 (SD = 10.76). Every SRT file was independently scored twice, first by the student S-LP that administered the test and then by the first author with rare discrepancies resolved by consensus of the team including the student and the first and second authors.

Results

The results are presented as descriptive data by individual child with some subgroup summaries. No statistical analyses are provided. First, test scores for the group are summarized to illuminate patterns of performance on the SRT. Subsequently, deficits in transcoding, memory, and encoding are related to the children's performance on the other assessment measures. Specifically, it will be seen that five children achieved low transcoding scores that corresponded to unusual prosody in their spontaneous speech, although this group showed mixed scores with respect to phonological planning; three children demonstrated primary difficulties in the area of phonological planning (i.e., low SRT memory scores) with a corresponding profile of high inconsistency and atypical phonological errors on the DEAP; two remaining children did not fit into either of these profiles. Subsequent to summarizing the assessment performance for these children, two case studies will be presented to describe the phonological planning and motor profiles in greater detail.

Syllable Repetition Task. SRT scores are provided by child in Table 2. Raw scores refer to the percentage scores obtained using the procedures described for scoring the SRT. Percent consonants correct are reported separately for 2-, 3-, and 4-syllable items followed by the raw scores and z scores for competency, encoding, memory, and transcoding. The children are organized in groupings to reflect the primary area of difficulty. Children with low transcoding scores are shown in the first columns, namely TASC16, TASC17, TASC18, TASC23, and TASC24. All five of these children scored below the raw score cut-off of 80 for differentiating CAS from other children with SSD and three children in the group obtained z scores that were below normal limits for their age. Children with good transcoding scores but low memory scores are shown in the next columns, namely TASC21, TASC25, and TASC26. All three children scored below the raw score cut-off of 67.5, and obtained z scores that were below normal limits. All three demonstrated the characteristic pattern of many more errors on longer items compared to the two-syllable items on the SRT; only TASC25 achieved reasonably good performance on the two-syllable items however. Notably, two of the five children with transcoding difficulties also obtained low memory scores (TASC16, TASC24). TASC20 obtained anomalous scores because her raw scores were below the cut-off for encoding and memory but her z scores were within normal limits for her age. TASC27 scored above the cut-off and obtained age appropriate z scores for competency, encoding, memory, and transcoding. TASC27 was the only child to obtain an age-appropriate competency score on the SRT.

Oral-Motor Skills and Prosody. Transcoding deficits should be expected to co-occur with other signs of apraxia of speech which are, as discussed in the introduction, inability to repeat [pataka], syllable segregation errors, difficulty with prosody such as lexical stress errors, and groping during nonspeech tasks. Therefore, Table 3 reports the outcome of the DEAP Oral-Motor Screen and the trisyllable repetition task from the maximum performance task assessment. The percentage of items produced with perceived segregation and prosodic errors is reported for ten words taken from the DEAP, produced during single word naming and in connected speech: umbrella, elephant, orange, giraffe, basket, strawberry, spider, monkey, toothbrush, and apple. Only two children passed the DEAP oral-motor screen and produced an accurate [pataka] sequence, specifically TASC20 and TASC27. All of the children with low memory or transcoding scores failed the DEAP oral-motor screen and were unable to repeat [pataka] accurately. Four children had difficulty with nonspeech oral-motor tasks, namely TASC16, TASC17, TASC18, and TASC24. These nonspeech difficulties included poor differentiation of articulators (e.g., overflow of lateral tongue movements to the jaw), hesitation and pauses between sequenced movements, and groping (observed specifically for TASC16 and TASC24). Of the five children with low transcoding scores (see first five columns of Table 3), four showed high percentages of inappropriate lexical stress on multisyllabic words and three produced a noticeable frequency of syllable segregation. TASC16 produced a very high frequency of segment and syllable repetition when attempting multisyllabic words.

Table 3. Indicators of Oral Motor Skills by Participant

Score	TASC16	TASC17	TASC18	TASC23	TASC24	TASC21	TASC25	TASC26	TASC20	TASC27
DEAP oral motor	(F)15	(F)11	(F)39	(F)31	(F)40	(F)44	(F)46	(F)40	(P)44	(P)51
Trisyllable repetition	I	I	I	I	I	I	I	I	A	A
Groping	yes	no	no	no	yes	no	no	no	no	no
Syllable segregation	100	27	0	15	4	0	7	0	9	0
Lexical stress errors	100	36	0	70	9	0	7	4	0	0

Note. DEAP oral motor screen is reported as total score and (P) for pass and (F) for fail; Trisyllable repetition is reported as "I" for inaccurate and "A" for accurate production of [pataka]; groping scores are "yes" if groping was observed during the nonspeech portion of the DEAP; Syllable segregation and lexical stress scores reflect percentage of items produced with these errors (see text for details).

Table 4. DEAP Test Scores by Participant

Score	TASC16	TASC17	TASC18	TASC23	TASC24	TASC21	TASC25	TASC26	TASC20	TASC27
DEAP Percentile	2	.1	.1	.1	5	.4	.1	1	16	5
DEAP PCC	49	27	67	43	66	61	70	55	82	76
DEAP PVC	69	92	94	64	92	86	89	86	94	100
Inconsistent	yes	yes	no	yes	yes	yes	yes	yes	no	no
Atypical error patterns	yes	yes	no	yes	yes	yes	yes	yes	no	no

Note. DEAP is the Diagnostic Evaluation of Articulation and Phonology (Dodd et al., 2006); the percentile rank, PCC (percent consonants correct), and PVC (percent vowels correct) are taken from the DEAP Articulation Assessment; Inconsistent is scored "yes" when the child produces more than 40% of words on the DEAP Word Inconsistency Assessment inconsistently; Atypical error patterns is scored "yes" when atypical patterns were observed on the DEAP Phonology Assessment.

DEAP test results. The DEAP test yields several test scores that are intended to be indicative of *inconsistent deviant phonological disorder*, a subtype of phonological disorder that is hypothesized to arise from a breakdown in phonological planning. Therefore, the children with low SRT memory scores should also have high inconsistency scores, many atypical errors, and vowel errors. Table 4 presents selected DEAP test scores for each child in order: PCC, PVC, classification of inconsistent (yes/no), and presence of atypical error patterns on the phonology test (yes/no). Five children achieved low memory scores on the SRT (TASC16, TASC24, TASC21, TASC25, and TASC26) and all of these children demonstrated inconsistent atypical errors with an average of 81% vowel accuracy for this subgroup. Five children had higher memory scores (TASC17, TASC18, TASC23, TASC20, and TASC27) but two of these children demonstrated inconsistent atypical errors nonetheless; vowel accuracy for this subgroup was 93% overall. The association between low SRT memory scores with inconsistency and atypical error patterns on the DEAP is clear. However, these diagnostic markers do not seem to be a perfectly reliable indicator of phonological versus motor planning difficulties since some children with motor planning problems also demonstrate these signs.

Phonological processing. Low encoding scores could be expected to be associated with performance on measures of phonological processing such as our measures of speech perception and phonological awareness. These tests require the child to listen to an aurally presented word and make a nonverbal response that reflects the quality of their acoustic-phonetic or lexical representation for the target. However, the SRT encoding scores are difficult to interpret because the standard deviations in the normative data are very large and it is common, as seen in Table 2, for children to achieve very low encoding raw scores but average z scores in relation to age peers. There were only two children (TASC 17, TASC 21) who obtained a z score below normal limits and an SRT encoding score below the cut-off. Two other children obtained a z score below normal limits and an SRT encoding score slightly above the cut-off with respect to encoding on the SRT (TASC18, TASC25). Performance on the speech perception and phonological awareness tests is presented in Table 5 along with the results of the language test and the nonverbal IQ information to support interpretation. In contrast, this table shows that only one child achieved age appropriate speech perception and phonological awareness performance (TASC27). All other children had difficulties with one or both aspects of phonological processing regardless of receptive vocabulary or encoding scores.

Table 5 also presents nonverbal and verbal IQ (receptive vocabulary) information for these children. Poor verbal skills are common among the children with low memory scores on the SRT. The majority of children with low transcoding scores on the SRT also had low nonverbal IQ.

Summary. Tables 2 through 5 give the impression of two subgroups of children with correlated signs. First there is a subgroup of children with either nonverbal intelligence or receptive vocabulary scores within the normal range who appear to have difficulties with phonological planning: TASC21, TASC25, and TASC26 exhibited a coherent pattern of low SRT memory scores, high inconsistency, and atypical error patterns and vowel errors, in contrast to high SRT

Table 5. Nonverbal Intelligence, Language tests, Speech Perception and Phonological Awareness Test Scores by Participant

Score	TASC16	TASC17	TASC18	TASC23	TASC24	TASC21	TASC25	TASC26	TASC20	TASC27
KBIT2 NV SS	71	107	72	68	100	81	ND	100	112	96
PPVT-III SS	78	104	95	74	83	69	86	70	109	108
Speech Sample PCC	45.00	NM	84.10	54.00	67.20	75.00	66.40	74.00	75.70	76.10
Speech Sample MLU	1.48	NM	6.62	2.40	3.95	1.14	3.11	3.00	4.00	2.77
Speech Perception	-3.14	-0.73	-2.22	-1.28	-2.68	-2.68	-4.77	-4.35	-1.82	-0.26
Phonological Awareness	-4.00	-0.33	-2.23	-6.44	ND	-2.71	-5.76	-1.20	-2.92	-0.55

Note. KBIT2 NV SS is the Kaufman Brief Intelligence Test (Kaufman & Kaufman, 2004), Nonverbal Subtest, expressed as a standard score; PPVT SS is the Peabody Picture Vocabulary Test-III (Dunn & Dunn, 1997) expressed a standard score; the Speech Perception and Phonological Awareness Test scores are presented as z scores. ND indicates no data because the test was not completed. NM indicates that the data obtained were not measurable (child's unintelligibility precluded a reliable gloss for obtaining a valid PCC and MLU from the free speech sample).

transcoding scores. Second, there is a subgroup of five children with low SRT transcoding scores who appear to have difficulties with motor planning. Two of these five children had nonverbal intelligence within the normal range (TASC17, TASC24) and also demonstrated segregation and prosodic errors during the production of multisyllabic words. Two of the three children with nonverbal intelligence scores below the normal range and low SRT transcoding scores (TASC16, TASC23) also demonstrated segregation and lexical errors. In keeping with the idea that CAS is explained by deficits in multiple domains, these four children exhibited additional difficulties with memory and/or encoding. TASC18 obtained a normal SRT memory and encoding score. He achieved a low SRT transcoding score but he did not produce any segregation or syllable stress errors, although, he did have some difficulties producing simple and sequenced nonspeech oral movements. The remaining two children, TASC20 and TASC27, did not fit into either profile. Thus it seems that scores obtained from the SRT and the DEAP can be used to identify children who fit a profile of (1) a primary deficit in the area of *phonological planning*, i.e., *inconsistent deviant phonological disorder*, or (2) a primary deficit in the area of *transcoding or motor planning*, i.e., *childhood apraxia of speech*, that may or may not involve a concomitant deficit in phonological planning. One case study illustrating each of these profiles will be presented in the next section.

Case Studies

TASC23 – Motor Planning Impairment. This case, exemplifying profound difficulties in the domain of motor planning, was the oldest child in our group. His parents are immigrants who provided rather limited information about his birth and developmental history. He was attending school in a special education setting that provided extra support for his educational needs but no direct speech and language therapy beyond consultation to the classroom teacher. He communicated in class using speech and a portable electronic AAC system. He was attentive and cooperative throughout all assessment and intervention sessions. His receptive vocabulary and nonverbal skills were both approximately three years behind age expectations, but his expressive speech and language skills were even more profoundly delayed.

With respect to SRT performance, Table 2 indicates an exceptionally low competency score overall and a very low transcoding score with no specific signs of encoding and memory difficulties in that he had equal difficulty with items of all lengths. A qualitative analysis can be made by examining the individual responses shown on the left side of Figure 2 and acoustic details shown for Item 4 on the right side of this figure. It is interesting to note (even though these errors are not counted in the competency score) that he produced many voicing errors and at least

Item	Target	TASC23	Cs ✓
1	bada	ada	1
2	dama	maba	0
3	bama	bata	1
4	mada	pæda	1
5	naba	bada	0
6	daba	bada	0
7	nada	bana	0
8	maba	bada	0
9	bamana	badana	2
10	dabama	batata	0
11	madaba	nadbana	0
12	nabada	badada	1
13	banada	patata	2
14	manaba	padata	0
15	bamadana	patadadata	2
16	danabama	padanta	0
17	manabada	padanka	0
18	nadamaba	tatanka	1

Multisyllabic Word Production	
1. zebra	ˈwẽˈdʌː
2. zebra	ˈweˈdʌː
3. zebra	ˌwenˈdʌː
1. parrot	ˈpæʲʌːt
2. parrot	ˈpæˈlʌt
3. parrot	ˈpæit
1. umbrella	ˈdʌnˌdʌlə
2. umbrella	ˈdɑnˌdæwʌ
3. umbrella	ˈdoˈwʌ

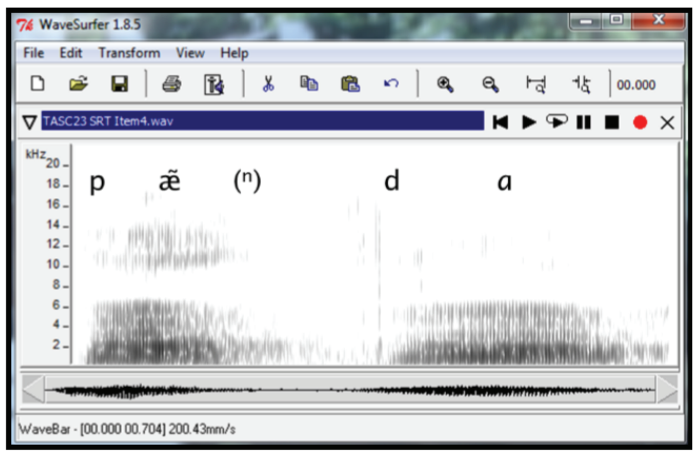

Figure 2. Selected test data to illustrate Case StudyTASC23 - Motor Planning Impairment: Individual SRT responses (left); three responses from the DEAP Word Inconsistency test (top right); wave form and spectrogram of item 4 from the SRT (bottom right).

one vowel error (pervasive issues with unusual vowel resonance were not transcribed for this test). Addition of segments at syllable boundaries – the classic sign of transcoding difficulties – occur frequently. There is one item with an entire syllable added and several cases of syllable deletion. The spectral analysis of item 4, /mada/→[pæ̃da], illuminates issues with gestural timing: the voicing error on the [p] indicates failure to coordinate timing of vocal fold vibration with release of the consonant; nasalization of the vowel reflects miscoordination of velar articulation between the consonant [m] and the vowel; the spectral analysis reveals 41 ms of nasal energy at the end of the first syllable that is suggestive of an inserted [n] although it is too short to be perceived as a consonant addition; the stop gap preceding the release burst for the [d] is an excessive 101 ms in duration, consistent with "lengthened and disrupted coarticulatory transitions between syllables" as is characteristics of CAS according to the ASHA technical report (AHSA technical report, 2002; definitions of CAS, para. 2).

When listening to this child's production of multisyllabic words, or indeed any of his speech, pervasive difficulties with resonance and prosody are perceived. Every word was perceived to be unusual. Even though efforts to create alternations in stress patterns were evident, in that trochees were often perceptually different from iambs for example, his speech retained a robotic character throughout. He was able to manipulate some of the aspects of prosody but he could not coordinate all three (duration, fundamental frequency, and amplitude) so as to produce speech that met expectations for prosody. In words with simple structure, his phonetic repertoire consisted of phonemes from most manner classes: [m, n, p, b, t, d, (ŋ, θ), f, s, z, ʃ, w, j, h, l]. In multisyllabic words, as shown in the examples on the upper right side of Figure 2, his phonetic repertoire was more restricted and he had difficulty maintaining the target phonotactic structure or stress pattern. His repetitions of the same word were not consistent but they were similar.

TASC26 – Phonological Planning Impairment. This child was also attending a special education classroom but he received speech and language therapy directly due to his younger age. His family also provided relatively few details about his history, although a family history of speech and language difficulties was revealed. He had received brief periods of speech therapy and occupational therapy through the public health sector before starting kindergarten. His receptive language skills were significantly delayed but his nonverbal intelligence was average. He spoke in sentences but with many morphosyntactic errors. He had very significant difficulties with word finding and therefore the assessment tasks were quite difficult for him. When he was unable to name pictures he would attempt to distract with charming stories or off-task behaviors and therefore he was quite challenging to assess. A large part of the assessment was administered using forced choice or direct imitation procedures.

With respect to SRT performance, Table 2 indicates a very low competency score and a low memory score. His performance declines with item length although even the two-syllable items were a challenge as is shown in Figure 3. The individual item responses shown on the left of Figure 3 reveal much perseveration in syllable productions within and across items. There are two addition errors (not enough to indicate a significant problem with transcoding). The acoustic analysis of item 4, shown in the lower right side of Figure 3, reinforces the point that this child does not have difficulties with transcoding, when compared to that presented for TASC23. Although the item contains a segment substitution error, /mɑdɑ/→[mɑnɑ], there is no evidence of nasal assimilation from consonant to vowel within the individual syllables; neither is there evidence of syllable segregation and the waveform reveals clear modulation of stress between the two syllables with higher amplitude on the first syllable but greater duration on the second.

Interestingly this child's word inconsistency score was not that high, being 52%, during the intake assessment because the words were elicited in imitation (even with several presentations of a forced choice prompt he persisted in responding "giraffe" to "zebra" for example and therefore a direct imitation prompt was used to elicit the target). He was able to produce the words spontaneously during a second administration following intervention but his rate of inconsistent productions rose to 82%. This pattern of greater accuracy and consistency in imitation compared to spontaneous speech production is typical of children with phonological planning problems according to Dodd et al. (2005). It is notable that although he had difficulty matching the phonotactic structure of the words, he usually reproduced the target prosodic structure. He seemed aware of his phonetic mismatches because, without prompting, he produced multiple attempts at many of the words on each trial; however, without getting closer to the target. A broad range of errors occurred including both phonemic and semantic paraphasias. Even though his phonetic repertoire was large [m, n, p, b, t, d, k, g, f, v, s, z, ʃ, ʧ, ʤ, w, j, h], difficulties with matching phonotactic structure led to many atypical errors on the DEAP Phonology test: many segments and syllables were deleted that fell outside the typical patterns of weak syllable or final consonant deletion; other atypical error patterns involved spreading of features across consonants within a word; (e.g., /spaɪdɚ/→ [ʃpaɪɚ]; /væn/ → [æm]). Vowel errors were not as frequent as might be expected for this profile but they did occur (e.g., /swɪŋ/ → [twein]).

Discussion

Recent research leads to the conclusion that CAS is a multiple domain disorder that implicates encoding, memory, and transcoding processes (Shriberg et al., 2012). The small sample of children described in this report highlight this perspective. This complex interaction of underlying speech processes may explain the diagnostic challenge that CAS presents to SLPs. We suggest that the diagnostic protocol illustrated here, combining the SRT with the DEAP and interpreted within a psycholinguistic framework, may help the S-LP to identify the child's most pressing current needs when CAS is suspected. The assessment protocol described here is clearly most useful for those children who have achieved spontaneous multisyllable words and multiword speech utterances. While the assessment protocol would require different procedures, the psycholinguistic framework that is presented here might still be relevant for diagnosis of children who are younger or have lower speech proficiency. Our study involved children who were referred because

Item	Target	TASC26	Cs ✓
1	bada	bada	2
2	dama	danda	1
3	bama	mama	1
4	mada	mana	1
5	naba	mama	0
6	daba	danga	1
7	nada	nana	1
8	maba	mama	1
9	bamana	bamama	2
10	dabama	dadaba	1
11	madaba	babama	0
12	nabada	mamaba	0
13	banada	bababa	1
14	manaba	mamaba	2
15	bamadana	dabadai	1
16	danabama	dababa	2
17	manabada	mamababa	2
18	nadamaba	mamababa	1

Multisyllabic Word Production	
1. zebra	ˌviˈfʌ
2. zebra	ˌwiˈvɹʌ
3. zebra	ˌβiˈvʌ
1. umbrella	bəˈlɛˌlʌ
2. umbrella	bəˈlɛˌlʌ
3. umbrella	bəˈlɛˌlʌ
1. helicopter	ˈkatəˌ
2. helicopter	ˈhatˌdag
3. helicopter	ˌhɛˈpatɚ

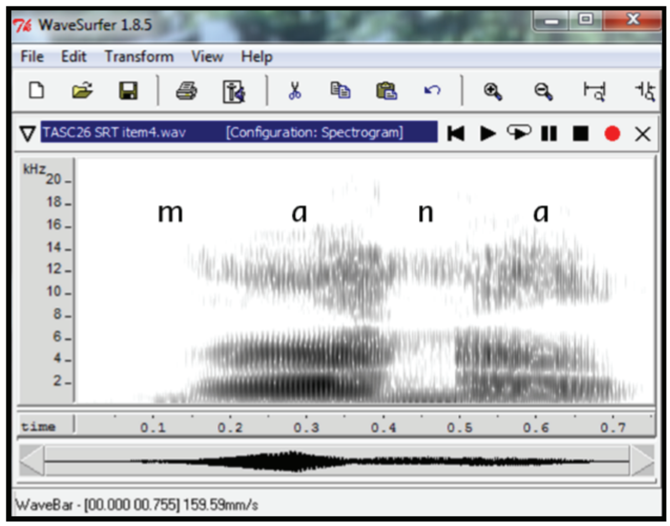

Figure 3. Selected test data to illustrate Case Study TASC26 - Phonological Planning Impairment: Individual SRT responses (left); three responses from the DEAP Word Inconsistency test (top right); wave form and spectrogram of item 4 from the SRT (bottom right).

a S-LP believed that they had CAS. In many cases, as is common with these referrals in typical S-LP practice, diagnosis was complicated by heterogeneous cognitive profiles and difficult behavior on the part of the children. Simple test procedures with limited linguistic load may assist diagnosis in these cases. Here we summarize the interpretation of the SRT in relation to other standard speech and language assessments to determine whether a child fits best with the encoding, phonological planning, or motor planning profile.

Regarding encoding, we found that all but one child demonstrated poor encoding performance on the SRT and all but one of those children performed poorly on measures of speech perception and phonological awareness. One child scored well on these phonological processing measures and obtained a high encoding score as expected. This leaves one child with an anomalous profile of good speech perception and phonological awareness test performance but a low encoding score on the SRT. The data suggest that direct measures may be more reliable for determining the child's auditory-perceptual encoding abilities; the SRT measure, based on the child's pattern of speech errors, may complement such measures but should not replace them. Our findings are consistent with those of Shriberg et al. (2012) in that the children's profiles were generally characterized by additive complexity; in other words, most children had difficulties with encoding (one having her primary deficit in this area); those who had low memory scores also had low encoding scores; and those with low transcoding scores in most cases obtained poor scores in encoding and sometimes also in memory.

Turning now to the memory domain, the children with low memory scores on the SRT tended to conform to the profile described by Dodd et al. (2005) as *inconsistent deviant phonological disorder*. Five children obtained a low memory score on the SRT and also produced inconsistent errors on the Word Inconsistency Assessment along with vowel errors and atypical errors on the Phonology Assessment. Inconsistent speech errors were produced by 7 of the 10 children, suggesting that this characteristic was considered to be diagnostic by the referring SLPs. Forrest (2003) found that SLPs consider inconsistent speech errors to be the most defining characteristic of CAS whereas a recent large sample study (Murray et al., 2015) did not support the diagnostic validity of inconsistency even though there was an association between inconsistency and a CAS diagnosis in their study. In keeping with the framework put forward by Dodd et al. (2005), we agree that these two characteristics may well be important for differentiating children with less complex phonological disorders from those who will require more intensive and specialized interventions (Namasivayam et al., 2015). However, it is important to sort out whether the child with inconsistent errors and trisyllabic repetition inaccuracy is having difficulties with phonological planning or motor planning in order to choose the best treatment approach.

Phonological planning might be considered the first stage in the speech output process. An abstract representation for production of the utterance is constructed by retrieving hierarchically organized units at multiple levels of the phonological hierarchy, ensuring correct ordering of syllables and segments and appropriate lexical and phrasal stress patterns. The process is triggered by activation of the sound based code in the superior temporal gyrus but takes place in brain networks that are typically associated with motor activity, especially Broca's area. The children we described who had difficulties with phonological memory and planning obtained very low memory scores on the SRT. These scores reflect significantly better repetition of two-syllable items than three-syllable items. Some of these children were able to repeat the two-syllable items quite well whereas others found even the two-syllable items to be difficult. These low SRT memory scores were accompanied by high inconsistency scores on the DEAP as well as atypical errors. Qualitatively, the children appear to have difficulty setting up the syllabic frames for words and then tend to fill the segmental "slots" in an almost random fashion so that the resulting words can be quite far from the intended target (e.g., see TASC26, Figure 3). In our experience these children also experience significant word finding difficulties.

Once the child has constructed a phonological plan for the intended utterance, this plan must be transcoded into a motor plan. We described children in this report whose primary problem seems to be at this stage of the speech output process. The children achieved low transcoding scores on the SRT because they produced addition errors when repeating the nonsense words. The addition errors were as likely to appear on short items as long items. Often the addition errors involved the insertion of a nasal at a syllable juncture although stop consonant insertions occurred as well and sometimes whole syllables were added to the utterance. These difficulties with transcoding were confirmed by the presence of segregation and prosodic errors in the children's speech, notable in the production of multisyllabic words or multiword connected speech samples. We agree with Murray et al. (2015) that unusual prosody is a reliable cue to motor planning problems. Consistent with Thoonen, Maassen, Gabreels, and Schreuder, (1999), the children with low transcoding scores on the SRT were also unable to repeat [pataka] (i.e., trisyllabic inaccuracy), suggesting that this may be a characteristic that is considered to be of diagnostic significance which is not unreasonable given the published literature on the relationship between diadochokinetic rate and CAS. However, the children whose primary difficulties were in the area of phonological planning, as described above, also had significant difficulties with the multisyllable repetition task. Therefore, failure to repeat [pataka] accurately is not indicative of CAS in every sense unless we consider phonological and motor planning to be equally consistent with CAS.

Four of our five children with transcoding difficulties had inconsistent errors on the DEAP Word Inconsistency Test, suggesting that they appeared to have concomitant difficulties with phonological and motor planning. However, it is possible that children with motor planning difficulties produce a qualitatively different kind of inconsistency than children with phonological planning problems. Iuzzini and Forrest (2010) suggested that variability calculated at the level of the phoneme might better reflect inconsistency in CAS than variability across productions of the same word. Our case studies reveal two types of variability in word production: (1) instances of markedly varied production at the word level, e.g., "helicopter" → [ˈkɑtə] and [ˌhɛˈpɑtɚ]; and (2) instances of varied production of specific phonemes within the word, e.g., "zebra" → [ˌviˈfʌ], [ˌwiˈvɹʌ], and [ˌβiˈvʌ]. Both kinds of mismatches to target were produced by the same child (TASC26, Figure 3) but it is possible that the latter type of speech error is more characteristic of motor planning impairment while the former type of speech error is more characteristic of phonological planning impairment. Traditionally, apraxia in adults or children is expected to involve miscoordination of the timing among multiple articulatory gestures resulting in single feature errors such as oral/nasal and voiced/voiceless confusions (Canter, Trost & Burns, 1985; Thoonen, Maassen, Gabreels, & Schreuder, 1994). These kinds of errors were exactly the kinds of errors that we observed in TASC23's SRT attempts (Figure 2) and they spilled over to his word productions as well. It seems likely that these kinds of miscoordination errors and the previously described difficulties with syllable segregation and prosody will co-occur. Further studies using instrumental analyses may be instructive as to the possibility of a common source (e.g., Grigos, 2009; Grigos & Kolenda, 2010).

Although we have been suggesting that the SRT may assist the S-LP to determine whether the child's primary deficit (at a given point in time) is primarily in the phonological planning or motor planning domain, it is clear given the overlapping symptom profiles described in this report, that it is not wise to expect clear demarcations between categories. Ongoing research is required to determine how important the diagnostic distinction is for the selection of appropriate treatment options. With regard to diagnosis, the presence of inconsistent errors may well identify children whose problems are more in the domain of phonological planning whereas the presence of transcoding errors may well identify children whose difficulties are more motoric in nature, given the understanding that a child may present with concomitant problems in both planning domains.

Conclusions and limitations. A number of large sample quantitative studies have suggested that CAS involves deficits at multiple domains of speech processing (Shriberg et al., 2012). These studies also suggest that the population of children with severe speech sound disorders is a heterogeneous group, some of whom might have primary difficulties with phonological planning (Dodd et al., 2005; Ozanne, 2005) whereas others have primary difficulties with motor planning (Murray et al., 2015; Vick et al., 2014). The small sample that we described here is meant to be illustrative rather than probative. We have attempted to provide ample detail to support clinical application of recent research to clinical practice. Although the DEAP is relatively new in North America it has a long history of use elsewhere and a good quality normative base. The SRT is new tool and further research is required to establish the norms and reliable standardized scores for clinical use. Nonetheless qualitative interpretation of children's performance as described here provides useful diagnostic information, in particular, when used together the DEAP and the SRT provide assessment data that is informative with regard to children's phonological and motor planning abilities.

Our conclusions are limited by the lack of longitudinal data with these children. It is not likely the profiles that we have described here will be stable with time. We would hope in fact that interventions would serve to change the children's profiles. We do not know how best to order treatment approaches so as to best serve the children's needs as they develop and grow older. Notwithstanding these limitations in our knowledge about the best way to select and order treatment procedures to meet the needs of these complex children, it is hoped that the case studies presented provide some new options for the S-LP in their efforts to better understand those needs.

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Emergent Literacy Skills in English-Speaking Preschoolers with Suspected Childhood Apraxia of Speech: A Pilot Study

Étude pilote sur les habiletés d'éveil à l'écrit d'enfants anglophones d'âge préscolaire chez qui une dyspraxie verbale est soupçonnée

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Abstract

This study piloted a sample protocol to assess phonological awareness, print awareness, and handwriting readiness in eight 4- to 5-year-old children suspected of having childhood apraxia of speech (CAS) by their speech-language pathologists. These children's performance on the protocol is described and compared to that of age-and gender-matched peers with typically developing speech, language, and motor skills. All participants with suspected CAS demonstrated some difficulties in phonological awareness, print awareness, or handwriting readiness. As a group, participants with suspected CAS performed significantly more poorly than their typically developing peers on rhyme awareness, print awareness, letter knowledge, hand grasp, and motor coordination. These results highlight the importance of including a broad set of emergent literacy skills, in addition to speech production, when assessing preschoolers with suspected CAS and in intervention, if warranted.

Abrégé

Cette étude a mis à l'essai un protocole d'évaluation de la conscience phonologique, de la conscience de l'écrit et de l'éveil à l'écriture chez des enfants de 4 à 5 ans soupçonnés par leur orthophoniste de présenter une dyspraxie verbale (DV). La performance de ces enfants aux tâches de ce protocole est décrite et comparée à celle de leurs pairs du même âge et du même sexe qui présentent un développement typique de la parole, du langage et des habiletés motrices. Tous les participants soupçonnés d'une DV démontraient des difficultés en conscience phonologique, en conscience de l'écrit ou en éveil à l'écriture. En tant que groupe, les participants chez qui une DV était soupçonnée avaient une performance inférieure à leurs pairs au développement typique sur la conscience de la rime, la conscience de l'écrit, la connaissance des lettres, la préhension manuelle et la coordination motrice. Ces résultats démontrent l'importance de cibler un large ensemble d'habiletés d'éveil à l'écrit, en plus de la production des sons de la parole, lors de l'évaluation des enfants d'âge préscolaire soupçonnés d'une DV, et lors de l'intervention, lorsque nécessaire.

Given that children with speech sound disorders (SSD) are more at risk for problems in developing their literacy skills than their typically developing peers (Anthony et al., 2011), the evaluation of emergent literacy skills such as phonological awareness, letter-sound knowledge, and print awareness in preschoolers with SSD is recommended clinical practice for speech-language pathologists (American Speech-Language-Hearing Association, 2016). One subgroup of preschoolers with SSD are those who are suspected of having childhood apraxia of speech (CAS) by their treating speech-language pathologist. These children usually present with motor planning deficits (Bradford & Dodd, 1996; Peter & Raskind, 2011) that could affect other emergent literacy skills such as handwriting. Therefore, the current study aimed at piloting an assessment protocol that includes a broader set of emergent literacy skills for preschoolers with suspected childhood apraxia of speech (sCAS) than what is typically used for this population. The results of this study could shed light on the need for early intervention targeting multiple early literacy skills to reduce future academic difficulties for these children.

Emergent Literacy Skills in Preschoolers With SSD

A research synthesis conducted by the National Early Literacy Panel (2008) showed that phonology-related emergent literacy skills such as phonological awareness and letter-sound knowledge, when measured in preschoolers, are good predictors of word recognition and spelling achievements in early grades of primary school. Phonological awareness refers to the ability to recognize and manipulate sub-lexical speech units such as syllables, rhymes, and phonemes (Gillon, 2003) and letter-sound knowledge refers to the correspondence between graphemes and phonemes of a language (Foy & Mann, 2006). Multiple studies have shown that preschoolers with SSD usually demonstrate deficits in the development of these skills irrespective of their language abilities (Anthony et al. 2011, Bird, Bishop, & Freeman, 1995; Gernand & Moran, 2007; Rvachew & Grawburg, 2006; Rvachew, Ohberg, Grawburg, & Heyding, 2003), putting them at risk for later literacy underachievement.

Other skills such as print awareness (including letter knowledge) and handwriting readiness were also identified as good predictors of word recognition and spelling success (National Early Literacy Panel, 2008; Weintraub & Graham, 2000). Print awareness refers to children's knowledge and skills related to print functions (e.g., we write to avoid forgetting something), conventions (e.g., we read from left to right in English), and forms (e.g., what we read is the print, not the pictures) (Justice & Ezell, 2001). Forms also include letter knowledge (i.e., recognition and identification of letter shapes and names (van Kleeck, 2006). Children with SSD usually display a delay in letter knowledge development compared to their peers without SSD (Anthony et al. 2011, Bird et al., 1995; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004; Webster, Plante, & Couvillion, 1997). However, it would appear other print awareness skills develop adequately in children with SSD (Rvachew et al., 2003).

Handwriting is defined as a system that provides easy access to mental representations of letters in order to perform motor planning and production of hand movements required for writing strings of letters (Berninger et al., 1997). Fine graphomotor and visual-motor integration skills have been assessed to judge handwriting readiness (Daly, Kelley, & Krauss, 2003; Dinehart & Manfra, 2013; Ratzon, Efraim, & Bart, 2007; Weintraub & Graham, 2000). Handwriting readiness has not been studied in preschoolers with SSD in the literature reviewed at the time of the current study.

Literacy Development in Children With sCAS

A subgroup of preschoolers with SSD who may be at an even higher risk for problems in their future literacy achievements, are those with sCAS. The identification of idiopathic CAS is based currently on inconsistency of speech sound errors across repeated productions, difficulties in sequencing sound units, and problems with prosody (American Speech-Language-Hearing Association, 2007; Davis, Jakielski, & Marquardt, 1998). However, those features are neither operationalized, nor standardized, and no clear indicators are yet validated (American Speech-Language and Hearing Association, 2007). Moreover, symptoms of CAS observed in the preschool population change over time (Velleman & Strand, 1994). Symptoms observed at a young age can only serve as a basis for a hypothesis of CAS; follow-up is usually required to confirm the exact nature of preschoolers' SSD (Hall, 1989).

Lewis, Freebairn, Hansen, Iyengar, and Taylor (2004) examined differences in speech, language, and literacy skills between children with CAS and children with other types of SSD. The latter included a group of children with isolated speech sound disorder and children with combined speech sound and language disorders. The children were assessed during the preschool years (between the ages of 4-6 years) and again at school age (between the ages of 8-10 years). Speech and language skills of preschoolers with CAS were similar to those of the group with combined speech sound and language disorders but inferior to those of the group with isolated speech sound disorders. These results confirm that the speech and language profile of children with CAS and those with combined speech sound and language disorders are difficult to differentiate in the preschool years. Once they entered school, the performance of students with CAS on all speech, language, and literacy measures were poor compared to children with isolated SSD. The performance on word recognition, word decoding, and reading comprehension measures was not significantly different between students with CAS and those with combined speech sound and language disorders. However, students with CAS performed more poorly on the spelling measure than students with combined speech sound and language disorders. These results suggest that children with CAS tend to experience increased deficits in their literacy development compared with children with other types of SSD because of the co-occurrence of motor speech planning and language deficits observed in children with CAS.

Several hypotheses have been proposed to explain this co-occurrence. According to Maassen, Nijland, and Terband (2010), these language deficits stem from a core motor speech impairment that hinders speech development, which in turn hinders the child's acquisition of phonology, vocabulary, morphology, and syntax. This perspective is based on a dynamic interaction view of speech and language development (Mitchell, 1995). However, in their longitudinal study of infants at risk for CAS, Highman, Hennessey, Leitão, and Piek (2013) proposed two types of CAS profiles, based on the analyses of two single cases. One type displays only motor speech deficits that hinder language development according to the dynamic interaction view, and the other type shows both motor speech and language deficits from infancy. The deficits of the latter profile are best described by the multiple domain explanatory view of CAS proposed by Shriberg, Lohmeier, Strand, and Jakielski (2012). These authors found evidence that the core deficits of both idiopathic and neurogenic CAS are not only motoric in nature; they also include deficits in speech sound auditory-perceptual encoding, memory, and transcoding processes.

There is increasing evidence that children diagnosed with CAS also present with motor deficits other than those affecting speech, which could affect their writing skills. Bradford and Dodd (1996) reported that children with CAS showed poorer performances, as a subgroup of children with SSD, on non-speech tasks that required speed and dexterity of fine motor movements. It is important to highlight that, in their study, Bradford and Dodd distinguished developmental verbal dyspraxia (referred to in North America as CAS) from the diagnosis of inconsistent phonological disorder. According to Dodd and McCormack (1995), children with inconsistent phonological disorder have a deficit in phonological planning while those with CAS demonstrate problems with phonetic planning. These authors claim that speech inconsistency is not restricted to CAS and that performance on oro-motor tasks requiring sequenced oral movements could differentiate between the two disorders. More recently, Tükel, Björelius, Henningsson, McAllister, and Eliasson (2015) found that children with CAS displayed heterogeneous motor problems, including non-speech oral motor functions, manual motor functions, and adaptive behaviour, in addition to impaired motor speech output. Peter and Raskind (2011) also identified a family history of low performance on hand task movements among children with CAS, supporting a multimodal view of motor-based disorders of CAS. According to Peter, Button, Stoel-Gammon, Chapman, and Raskind (2013) and Button, Peter, Stoel-Gammon, and Raskind (2013), CAS stems from a global deficit in sequential processing that hinders both language and motor development.

Emergent Literacy Skills of Preschoolers With sCAS

To date, the scientific literature examining emergent literacy skills in preschoolers with sCAS has been limited to phonological awareness and letter-sound correspondence knowledge. According to McNeill, Gillon, and Dodd (2009a), young students with CAS display literacy acquisition difficulties that are related to their weak phonological awareness skills and letter-sound knowledge. Marquardt, Sussman, Snow, and Jacks (2002) provided theoretical accounts supporting the notion that underlying deficits of CAS can also include poor phonological representations in addition to speech-motor impairment. Given that these representations must be stable and well specified to perform phonological awareness tasks correctly, this might explain why children with CAS have poorer performances on these tasks. Another explanation was also provided by Button and colleagues (2013); these authors presented evidence that the underlying deficit of CAS results from difficulty with high load sequential processing tasks that involve multiple modalities such as speech, language, and reading. A task that requires high load processing is one that puts a heavy demand on executive functions, memory, attention, and metacognition. In this view, the phonological representations themselves are not problematic, rather it is the sequential processing of these representations that is thought to be deficient.

Goal of the Study

As illustrated in the literature reviewed here, preschoolers with sCAS are at great risk for literacy difficulties because there is evidence that they present with more general language and motor deficits. Prior research on children with sCAS has focused mainly on a limited set of emergent literacy skills, namely phonological awareness and letter-sound correspondence knowledge. It is reasonable to suppose that other important skills that are predictive of word identification and spelling achievements, such as print awareness (including letter knowledge) and handwriting readiness, could also be hindered given the co-occurring language and motor deficits in children with sCAS. According to Harris, Botting, Myers, and Dodd (2011), one needs to be aware of emergent literacy deficits in children with SSD when planning for early intervention in literacy development. Therefore, it is expected that a more detailed picture encompassing a larger set of emergent literacy skills would shed new light on the profile of deficits in children with sCAS and better equip clinicians, teachers, and parents to prevent or lessen academic difficulties in these children.

The purpose of this study was to pilot a sample protocol to assess phonological awareness, letter-sound knowledge, print awareness, and handwriting readiness in a small sample of 4- to 5-year-old children suspected of having CAS by their speech-language pathologists. These children's performance on the components of the protocol is described and compared to that of age-and gender-matched peers with typically developing speech, language, and motor skills. It was hypothesized that the children with sCAS would show problems in all emergent literacy skills, individually, based on standard test scores, and as a group, compared to their typically developing peers.

Methods

Participants

Ethical approvals from the University of Ottawa and the Children's Hospital of Eastern Ontario (CHEO) were obtained prior to the study. A convenience sample was used; CHEO/First Words Preschool Speech and Language Program of Ottawa staff were provided with posters and e-mails describing the study to use in recruiting participants with sCAS and typically developing peers matched on age and sex. In order to participate, all children needed to meet the following four inclusionary criteria: to be between 48 and 72 months of age, to be monolingual English-speaking, to attend either a preschool or a kindergarten program with an educational curriculum, and to have no history of sensory, cognitive, or neurological impairment.

Children who were suspected of presenting with CAS by their treating speech-language pathologist at CHEO/First Words were recruited as potential participants. A confirmed diagnosis of CAS was not required because of the young age of the participants. These children underwent testing with a certified speech-language pathologist to verify that they met two additional inclusion criteria: demonstration of normal receptive language skills and speech sound production difficulties. No criteria regarding the exclusion of expressive language delays were used because children with sCAS are also likely to present with expressive language disorders (Lewis et al., 2004). Standard scores above 85 (-1 *SD*) on the Peabody Picture Vocabulary Test-Revised (PPVT-R: Dunn & Dunn, 1981) and a standard score above 7 (-1 *SD*) on the Sentence Structure subtest of the Clinical Evaluation of Language Fundamentals: Preschool 2 (CELF-P2: Wiig, Secord, & Semel, 2004) were necessary to classify these potential participants as having normal receptive language skills. Their standard scores had to be less than 85 (-1 *SD*) on the Sounds-in-Words section of the Goldman Fristoe Test of Articulation, 2nd Edition (GFTA-2: Goldman & Fristoe, 2000) to confirm that they demonstrated speech sound disorders. Table 1 displays the scores of the participants with sCAS on the PPVT-R, the Sentence Structure subtest of the CELF-P2, and the Sounds-in-Words section of the GFTA-2.

All participants with sCAS demonstrated normal receptive language skills on the PPVT-R and on the Sentence Structure subtest of the CELF-P. On the Sounds-in-Words section of the GFTA-2, all participants performed below age expectation at the 10th percentile or lower.

A comparison group of children was recruited to meet the following criteria: matched to the eight participants with sCAS for sex and age (within two months of age); no academic, speech, or language concerns confirmed by parent and teacher report; and no current or past history of assessment or treatment in speech-language pathology or occupational therapy, confirmed by parent and teacher report. Six male pairs and two female pairs participated. The mean age of the participants was 58 months for the sCAS group and 58.5 months for the typically developing group. Table 2 displays data collected through a phone interview conducted by a research assistant using a

Table 1. Scores on the Peabody Picture Vocabulary Test-Revised (PPVT-R: Dunn & Dunn, 1981), the Sentence Structure subtest of the Clinical Evaluation of Language Fundamentals: Preschool 2 (SS-CELF-P2: Wiig, Secord, & Semel, 2004), and the Sounds-in-Words section of the Goldman Fristoe Test of Articulation, 2nd Edition (SW-GFTA-2: Goldman & Fristoe, 2000) for Participants with Suspected Childhood Apraxia of Speech

ID	PPVT-R[a]	SS-CELF-P2[a]	SW-GFTA-2[a]	SW-GFTA-2[b]
1	97	10	78*	10
2	98	8	64*	4
3	101	12	72*	7
4	96	8	47*	<1
5	95	9	76*	9
6	114	12	62*	3
7	99	9	49*	1
8	94	8	47*	1

Note. ID = pair identification number.
[a]standard score. [b]percentiel rank.
*score equal or below 1*SD*.

Table 2. Demographic Characteristics of the Participants

ID	Group	Sex	Age[a]	School attendance	Mother's level of education
1	sCAS	M	51	JK	U
	TD	M	51	JK	U
2	sCAS	M	54	JK	HS
	TD	M	54	JK	U
3	sCAS	M	55	JK	U
	TD	M	56	JK	U
4	sCAS	F	56	JK	C
	TD	F	58	JK	U
5	sCAS	M	58	SK	C
	TD	M	59	SK	U
6	sCAS	F	59	JK	U
	TD	F	61	JK	U
7	sCAS	M	61	JK	C
	TD	M	61	JK	U
8	sCAS	M	70	SK	U
	TD	M	69	SK	U

Note. ID = pair identification number; sCAS = children with suspected childhood apraxia of speech; TD = children with typical development; M = male; F = female; JK = junior kindergarten; SK = senior kindergarten; HS = high school diploma completed; C = college degree completed; U = university degree completed.
[a]Age in months

demographic questionnaire developed for the study (see Appendix A) for all participants. McNemar's Tests revealed that children's school level, $p = 1.00$, was equivalent for the two groups. However, mothers' level of education was higher for the group of typically developing children than for the children with sCAS.

For descriptive purposes, the Inconsistency Assessment and the Oro-Motor Assessment tasks of the Diagnostic Evaluation of Articulation and Phonology, UK Version (DEAP: Dodd, Hua, Crosbie, Holm, & Ozanne, 2002) were also administered by a certified speech-language pathologist to the eight participants with sCAS. According to McNeill et al. (2009a), a score above 40% on the Inconsistency Assessment is an important characteristic of both CAS and inconsistent phonological disorder. To meet the criteria for CAS, the children must also obtain a standard score below 8 on the three subtests of the Oro-Motor Assessment (isolated movements, sequenced movements, and diadochokinetic) or obtain a standard score below 8 on the diadochokinetic subtest and show articulatory groping during connected speech. To meet the criteria for inconsistent phonological disorder, the children must obtain a standard score of 8 and above on the three subtests of the DEAP and show no evidence of articulatory groping during connected speech. Table 3 presents the scores of the participants with sCAS on the two DEAP assessments.

All children in the group with sCAS scored above the cut-off on the Inconsistency Assessment. One participant with sCAS (pair 1) did not show impairment in any of the three subtests of the Oral-Motor Assessment; this child would be classified as having inconsistent phonological disorder according to McNeill et al. (2009a). Only one participant with sCAS (pair 7) scored below normal limits on all three subtests of the Oro-Motor Assessment; this child would be classified as having CAS according to McNeill et al. (2009a). Four participants with sCAS (pairs 2, 3, 5, and 8) scored below normal limits on the diadochokinetic subtest of the Oro-Motor Assessment. However, only the participant with sCAS from pair 2 displayed some groping during connected speech as noted by the speech-language pathologist during the DEAP assessment. Therefore, amongst those who underperformed on the diadochokinetic subtest of the Oral-Motor Assessment, only the child with sCAS from pair 2 would be classified as having CAS according to

Table 3. Scores on Selected Assessments of the Diagnostic Evaluation of Articulation and Phonology, UK Version (DEAP: Dodd, Hua, Crosbie, Holm, & Ozanne, 2002) for Participants with Suspected Childhood of Apraxia of Speech.

ID	Inconsistency Assessment [a]	Oro-Motor Assessment		
		Isolated Movement [b]	Sequenced Movements [b]	Diadochokenetic [b]
1	48*	8	10	8
2	56*	3**	8	7**
3	52*	10	12	7**
4	72*	3**	12	8
5	72*	8	9	7**
6	56*	4**	9	8
7	44*	3**	6**	6**
8	68*	10	12	4**

Note. ID = pair identification number.
[a]inconsistency percentage. [b]standard score.
*score greater than the cut-off criterion of 40%
** score at or below1*SD* below the mean

McNeill et al. (2009a). Children with sCAS from pairs 3, 4, 5, 6, and 8 would not be classified as having either CAS or inconsistent phonological disorder. However, as mentioned earlier, the diagnostic features of CAS are neither operationalized, nor standardized, which poses a dilemma for making a clinical diagnosis of CAS, especially during the preschool years (Hall, 1989). Hence, the qualifier 'suspected' is often used by speech-language pathologists to indicate that a child demonstrates a set of characteristics that have been identified as potential indicators of CAS.

Assessment Protocol and Procedures

Emergent Literacy Questionnaire.

Parental report of emergent literacy exposure and skills of all 16 participants were collected through a phone interview conducted by a trained research assistant using the Emergent Literacy Questionnaire (ELQ: Boudreau, 2005). The ELQ is a parent questionnaire that includes 36 items. Cumulated scores from items 2, 8, 10, and 15 provided an early literacy exposure score. The EQL also yields information about emergent literacy skills development in children as perceived by their parents. Items 3, 4, 5, 6, and 7 provided information on interaction with books, items 21, 22, and 23 on alphabet knowledge, items 13 and 14 on response to print in the environment, items 16, 17, 18, and 19 on phonological awareness, items 24, 25, 26, 27, and 28 on writing letters or words, and items 1, 9, 11, 12, and 26 on orientation to literacy.

Emergent Literacy Skills Assessment.

All children also participated in a 90-minute individual assessment of emergent literacy skills conducted by a certified speech-language pathologist in a quiet room at CHEO. The emergent literacy skills assessed and corresponding assessment tools are described in the following paragraphs.

The Pre-Reading Inventory of Phonological Awareness (PIPA: Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2003) was used to assess phonological awareness. The performance of children with speech sound disorders can be underestimated on phonological awareness tasks, not because of their poor phonological awareness skills, but because of their poor speech sound production skills (Sutherland & Gillon, 2005; Preston & Edwards, 2010). To minimize the impact of speech sound production errors, only tasks for which no spoken response is required were administered (i.e., the Syllable Segmentation, Rhyme Awareness, and Alliteration Awareness tasks). The Syllable Segmentation task assesses the student's ability to segment words of 2 to 5 syllables in length. The Rhyme Awareness task assesses the student's ability to identify the non-rhyming word from a set of 4 words. The Alliteration Awareness task assesses the student's ability to compare onsets.

The Preschool Word and Print Awareness Assessment (PWPA: Justice & Ezell, 2001) was used to assess print awareness. It examines beginning readers' knowledge of print and book reading conventions, such as left-to-right directionality of print, and their emergent knowledge about letter sounds, words, and other print symbols. This task is administered within the context of an examiner–child shared book reading session using the book "Nine Ducks Nine" (Hayes, 1990). The authors of this instrument used it to describe early print awareness concepts that young children exhibit (Justice, Bowles, & Skibbe, 2006; Justice & Ezell, 2001).

The Alphabet Knowledge subtest of the Phonological Awareness Literacy Screening PreK (PALS-PreK: Invernizzi, Sullivan, Meier & Swank, 2004) was administered to assess the letter knowledge component of print awareness. Participants were asked to name the 26 capitalized letters of the alphabet in random order shown on a sheet of paper.

Two handwriting readiness skills were assessed: hand grasp and visual-motor integration. The Shore Handwriting Screening for Early Handwriting Development (SHS: Shore, 2003) was used to assess hand grasp. The SHS examines functional skills that a child uses daily in school. The children were required to colour in a line drawing with coloured pencils. The SHS provides a classification system to describe the child's hand grasp on the pencil. Three types of hand grasp were defined: immature (1 point), transitional (2 points), and mature (3 points). Each child's hand grasp was classified by a certified occupational therapist using pictures of the children while engaged in writing/colouring tasks.

The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (Beery-VMI: Beery, Buktenica, & Beery, 2010) was used to assess the extent to which children could integrate their visual and motor skills. The child was asked to copy geometric forms, arranged in order of increasing difficulty. The supplemental Visual Perception and Motor Coordination subtests of the Beery-VMI were also administered to compare the children's performance on isolated visual and motor tasks. During the Visual Perception subtest, the child was shown an image of a line or shape and asked to find a copy of the target when presented within a linear array of similar images. During the Motor Coordination subtest, the child was asked to copy shapes by following dotted lines and using guiding visual cues. These supplemental tasks provide a means of assessing the independent contributions of visual skills (Visual Perceptual subtest) and motor skills (Motor Coordination subtest) to the overall performance on the Beery-VMI.

Results

Table 4 shows the results for each participant on the ELQ. The median emergent literacy exposure score was 15 for the group with sCAS and 14.5 for the group with typical development. A Wilcoxon Signed Rank Test revealed that these scores were equivalent between the two groups, z = - 0.85, p = .93. The median emergent literacy skills development scores of the participants with sCAS and those with typical development were, respectively, 17 and 19.5 on interaction with books, 12 and 13.5 on alphabet knowledge, 5.5 and 7.5 on response to print in the environment, 5 and 12.5 on phonological awareness, 14.5 and 16.5 on writing letters or words, and 12 and 17.5 on orientation to literacy. Wilcoxon Signed Rank Tests revealed that emergent literacy development of the two groups were perceived as equivalent with respect to interaction with books, z = -1.80, p = .09, alphabet knowledge, z = -1.26, p = .21, writing letters or words, z = -0.42, p = .67, and orientation to literacy, z = -1.52, p = .13. However, typically developing children were perceived by their parents as more advanced than children with sCAS in response to print in the environment, z = -2.38, p = .02, r = .60, and phonological awareness, z = -2.53, p = .01, r = .63.

Table 4. Parents' Perception of Participants' Emergent Literacy Development as Measured by the Emergent Literacy Questionnaire (Boudreau, 2005)

ID	Group	IB[a]	AK[b]	RPE[c]	PA[d]	WLW[e]	OL[f]	ELE[g]
1	sCAS	8	6	2	4	10	6	15
	TD	24	14	8	19	14	19	19
2	sCAS	22	11	5	15	16	21	18
	TD	23	15	10	16	21	19	19
3	sCAS	16	6	3	5	13	15	13
	TD	19	13	6	8	17	19	14
4	sCAS	25	15	6	8	21	13	19
	TD	19	13	7	12	16	13	15
5	sCAS	18	14	7	5	21	18	15
	TD	20	15	7	10	14	16	14
6	sCAS	20	12	8	9	20	11	13
	TD	22	15	9	13	20	14	18
7	sCAS	9	14	8	4	10	8	13
	TD	17	13	10	16	18	20	13
8	sCAS	11	12	4	4	11	10	16
	TD	12	9	6	5	9	11	10

Note. ID = pair identification number; sCAS = children with suspected childhood apraxia of speech; TD = children with typical development; IB = interaction with book; AK = alphabet knowledge; RPE = response to print in the environment; PA = phonological awareness; WLW = writing letters and words; OL = orientation to literacy; ELE = emergent literacy exposure.
[a]cumulated score from items 3, 4, 5, 6 and 7. [b]cumulated score from items 21, 22, and 23. [c]cumulated score from items 13 and 14. [d]cumulated score from items 16, 17, 18, and 19. [e]cumulated score from items 4, 25, 26, 27, and 28. [f]cumulated from items 1, 9, 11, 12, and 26. [g]cumulated from items 2, 8, 10, and 15.

The standard scores of each participant on the emergent literacy skills assessment tasks were compared to the respective test norms to verify if their performances were within normal limits or not. Table 5 shows the scores of each participant. The scores that were equal to or greater than one standard deviation below the mean according to the tests' norms are marked with an asterisk.

Regarding phonological awareness, the children with sCAS performed as follows: one scored below age expectations on the Syllable Segmentation task of the PIPA, five demonstrated below age expectation on the Rhyme Awareness task of the PIPA, and two on the Alliteration Awareness task of the PIPA. Regarding print awareness, the children with sCAS performed as follows:

Table 5. Participants' Scores on Emergent Literacy Tasks

ID	Group	PIPA-SS[a]	PIPA-RA[a]	PIPA-AA[a]	PWPA[b]	PALS-PreK[c]	SHS[d]	Beery-VMI[e]	Beery-VP[e]	Beery-MC[e]
1	sCAS	5-9*	0-4*	40-44	2*	0*	1*	99	85*	98
	TD	70-74	95-99	20-24	13	26	1*	101	117	92
2	sCAS	40-44	5-9*	20-24	11	1*	1*	116	91	90
	TD	55-59	75-79	35-39	13	24	3	110	111	98
3	sCAS	25-29	10-14*	60-64	9	19	2	100	85*	76*
	TD	30-34	50-54	35-39	13	26	3	98	99	94
4	sCAS	45-49	5-9*	50-54	5	7*	1*	90	76*	80*
	TD	40-44	50-54	95-99	17	26	3	113	110	117
5	sCAS	40-44	35-39	60-64	12	25	3	107	111	77*
	TD	85-89	50-54	70-74	13	26	2	103	99	94
6	sCAS	55-59	65-69	10-14*	10	25	1*	107	107	96
	TD	15-19	40-44	60-64	18	25	3	103	93	96
7	sCAS	30-34	10-14*	10-14*	15	26	3	85*	100	69*
	TD	95-99	90-94	80-84	18	26	3	119	96	100
8	sCAS	30-34	35-39	20-24	5	1*	1*	80*	91	63*
	TD	45-49	20-24	5-9*	14	24	3	110	131	102

Note. ID = pair identification number; sCAS = children with suspected childhood apraxia of speech; TD = children with typical development; PIPA-SS = percentile rank on the Syllable Segmentation task of the Pre-Reading Inventory of Phonological Awareness (PIPA: Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2003); PIPA-RA = percentile rank on the Rhyme Awareness task of the PIPA; PIPA-AA = Percentile rank on the Alliteration Awareness task of the PIPA; PWPA = raw score on the Preschool Word and Print Awareness Assessment (Justice and Ezell, 2001); PALS-PreK = raw score on the Alphabet Knowledge subtest of the Phonological Awareness Literacy Screening PreK (Invernizzi, Sullivan, Meier & Swank, 2004); SHS = raw score about hand grasp on the Shore Handwriting Screening for Early Handwriting Development (Shore, 2003); Beery-VMI = standard score on the Beery-Buktenica Developmental Test of Visual-Motor Integration, Fifth Edition (Beery-VMI: Beery, Buktenica, & Beery, 2010; Beery-VP = Standard score on the Visual Perception supplemental task of the Beery-VMI; Beery-MC = Standard score on the Motor Coordination supplemental task of the Standard score of the Beery-VMI.

[a]a score equal to or lower than the 15th percentile was considered below norms. [b]a score equal to or lower than 3 was considered below the norms (Justice, 2006). [c]a score equal to or lower than 11 was considered below the norms (Invernizzi, Sullivan, Meier & Swank, 2004). [d]a score of 1 (immature hand grasp) was considered below the norms. [e]a score equal to or lower than 85 was considered below the norms.
*score below the norms for a given measure

one child scored below normal limits on print awareness as measured by the PWPA and four children scored below age expectations on the Alphabet Knowledge subtest of the PALS-PreK. One typically developing child scored below age expectations on the alliteration awareness task of the PIPA. No other typically developing children displayed difficulties on any other tasks.

Regarding handwriting readiness, hand grasp on the pencil, as measured by the SHS, was immature for five children with sCAS. Only one typically developing child had an immature hand grasp. Two children with sCAS performed below age expectations on the Visual Motor Integration task of the Beery-VMI, three on the Visual Perceptual supplemental task of the Beery-VMI, and five on the Motor Coordination supplemental task of the Beery-VMI. All typically developing children performed within the average range on all three of the Beery-VMI tasks.

The results of the statistical comparisons of the performance between the sCAS and the typically developing groups using Wilcoxon Signed Rank Tests are reported in Table 6 for each task.

The Wilcoxon Signed Rank Test revealed that the sCAS group scored significantly lower than the typically developing group on rhyme awareness as measured by the PIPA, on print awareness as measured by the PWPA, and on letter knowledge as measured by the PALS-PreK. The effect sizes (*r* in table 6) were calculated by dividing the z value by the square root of the number of observations. These analyses demonstrated a large effect size for the three aforementioned measures according to Cohen's (1988) criteria. The sCAS group scored significantly lower than the typically developing group on hand grasp as measured by the SHS and on motor coordination as measured by the Motor Coordination supplemental subtest of the Beery-VMI, also with a large effect size for both measures. No other scores were significantly different.

Discussion

This study piloted a sample protocol to assess a broad range of emergent literacy skills in preschoolers judged by their speech-language pathologists as presenting with sCAS. These children's performances on the components of the protocol were compared to

Table 6. Results of the Statistical Comparisons of the Emergent Literacy Scores Between the sCAS Group and the Typically Developing Group Using Wilcoxon Signed Rank Tests

Measure	sCAS *Md*	TD *Md*	*z*	*p*	*r*
PIPA-SS	5	7	-1.76	.08	.44
PIPA-RA	2.5	6	-2.25	.02*	.56
PIPA-AA	2.5	4	-1.36	.17	.34
PWPA	9.5	13.5	-2.52	.01*	.63
PALS-PreK	13	26	-2.21	.03*	.55
SHS	1	3	-1.95	.05*	.49
Beery-VMI	99.5	106.5	-0.63	.52	.16
BEERY-VP	91	104.5	-1.61	.11	.40
Beery-MC	78.5	97	-2.20	.03*	.55

Note. sCAS *Md* = median score for children with suspected childhood apraxia of speech; TD *Md* = median score for children with typical development; PIPA-SS = Syllable Segmentation task of the Pre-Reading Inventory of Phonological Awareness (PIPA: Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2003); PIPA-RA = Rhyme Awareness task of the PIPA; PIPA-AA = Alliteration Awareness task of the PIPA; PWPA = Preschool Word and Print Awareness Assessment (Justice and Ezell, 2001); PALS-PreK = Alphabet Knowledge subtest of the Phonological Awareness Literacy Screening PreK (Invernizzi, Sullivan, Meier & Swank, 2004); SHS = hand grasp on the Shore Handwriting Screening for Early Handwriting Development (Shore, 2003); Beery-VMI = Beery-Buktenica Developmental Test of Visual-Motor Integration, Fifth Edition (Beery-VMI: Beery, Buktenica, & Beery, 2010; Beery-VP = Visual Perception supplemental task of the Beery-VMI; Beery-MC = Motor Coordination supplemental task of the Standard score of the Beery-VMI.
**p* < or = .05.

test norms and to performances of typically developing peers. The results revealed that the participants with sCAS displayed heterogeneous profiles of difficulties. Three children (participants from pairs 1, 2, and 4) presented with difficulties in phonological awareness (on at least one of the tasks of the PIPA), print awareness (either on the PWPA or the Alphabet Knowledge task of the PALS-PreK), and handwriting readiness (on the SHS or one of the tasks of the Beery-VMI). Three other children (participants from pairs 3, 6, and 7) presented with difficulties in phonological awareness and handwriting readiness. One child (participant from pair 8) presented with difficulties in print awareness and handwriting readiness. Finally, one child (participant from pair 5) presented only with difficulties in handwriting readiness. No clear relation was observed between the performance of children with sCAS on the emergent literacy tasks and on the Oro-Motor Assessment of the DEAP. For example, the participant with sCAS from pair 1 performed within the normal range on the Oro-Motor Assessment, but showed problems in all emergent literacy domains.

The results also showed that as group, participants with sCAS performed significantly more poorly than their typically developing peers on phonological awareness (on the rhyme awareness task of PIPA), print awareness (both on the PWPA and the Alphabet Knowledge tasks of the PALS-PreK), and handwriting readiness (on hand grasp in the SHS and the motor coordination supplemental task of the Beery-VMI). These results are not in full agreement with parents' perception of their child's emergent literacy development, which did not differ between the two groups for alphabet knowledge and writing letters or words on the ELQ. The results on the ELQ and the child measures agree that the groups differ only for phonological and print awareness. These findings suggest that for the group of children with sCAS, parents overestimated their child's emergent literacy development, even on skills that are easy to observe such as letter knowledge and handwriting readiness. One hypothesis is that this group of parents is more concerned with their children's speech sound production than with emergent literacy skills.

In general, these results are in agreement with previous research showing that children with speech sound disorders, including CAS, display difficulties in phonological awareness skills (Anthony et al. 2011, Gillon & Moriarty, 2007; McNeill et al., 2009a). In the current pilot study six out of eight children with sCAS had problems on at least one of the phonological awareness tasks of the PIPA. Furthermore, the current findings highlight that difficulties may be present in other emergent literacy skills such as print awareness and handwriting readiness. These results, although preliminary, support the multiple domain explanatory view of CAS proposed by Shriberg et al. (2012). Prior to entering grade 1, all but one child in the sCAS group showed problems in both linguistic and motor skills, which are important for formally learning to read and write.

Limitations

The sample size of this pilot study was small, limiting the possibility to generalize these findings to a larger population of 4- and 5-year-old English-speaking children suspected of having CAS by their speech-language pathologists. A more important limitation relates to the criteria used to include participants in the current study. More stringent criteria proposed by the American Speech-Language-Hearing Association (2007) such as evidence of difficulties in sequencing sound units on diadochokinetic tasks and problems with prosody could have been used to recruit children in the sCAS group. According to Murray, McCabe, Heard, and Ballard (2015), those features would more accurately identify CAS than inconsistency of speech sound errors across repeated productions. According to McNeill et al.'s criteria (2009a), only two of the participants from the group with sCAS would clearly meet the criteria for CAS. Moreover, information about the children's prosody was not obtained. Confidence in the diagnosis of CAS for the children in the sCAS group would be rated as 'low' using the rating system proposed by Murray, McCabe, and Ballard (2014). The lack of operationalized procedures for classifying study participants with sCAS may have resulted in over diagnosis of sCAS by the speech-language pathologists who referred the participants in the study. Therefore, the participant sample may include children with other speech sound disorders, such as inconsistent phonological disorder. According to Dodd, Holm, Crosbie, and McCormack (2005), this speech sound disorder is characterized by problems with phonological planning, while CAS is characterized by problems with speech motor planning at the phonetic level. The American Speech-Language-Hearing Association's (2007) definition of CAS does not distinguish between these two disorders at present. However, the results of Shriberg et al. (2012) provide evidence that CAS is characterized by both phonological processing and motor planning deficits.

Additionally, the typically developing children had mothers with a higher level of education than the participants with sCAS. The better performance of typically developing children on emergent literacy tasks compared to the children with sCAS might be partially explained by the positive influence that higher maternal level of education has on emergent literacy development (Catts, Fey, Zhang, & Tomblin, 2001). This influence should have been reduced based on the parents' report of similar emergent literacy exposure for both groups on the ELQ. In addition, some participants with sCAS may have received emergent literacy intervention during their speech and language therapies, given that some evidence-based interventions for children with CAS include phonological awareness instructions (McNeill, Gillon & Dodd, 2009b; Murray et al., 2014). Because no data were collected about exposure to emergent literacy intervention, the results might not reflect the natural emergent literacy development of children with sCAS.

Another major limitation of the current study relates to measurement tools used for assessing motor-related emergent literacy skills. Recent research has shown that general fine motor skills such as pencil grasp are not predictive of handwriting speed and legibility (Schwellnus et al., 2012), which in turn predict general writing success in school (Berninger et al., 2006). Therefore, in subsequent studies, it will be more appropriate to use direct letter writing tasks such as the Alphabet Task (Berninger & Ruthberg, 1992) or the Quick Brown Fox Task (Berninger et al., 1997).

Most importantly, for future study on the topic, it would be important to include expressive language measures of the participants to improve the interpretation of the results. As demonstrated by Lewis et al. (2004), children with CAS also present with language deficits that hinder their literacy development. Furthermore, the inclusion of specific language-related skills, such as literary vocabulary knowledge, inferencing, metalinguistic, and metacognition, on which reading comprehension and text production rely (Oakhill & Cain, 2012; Shanahan, 2006), would provide a broader portrait of emergent literacy skills that are predictive of literacy achievement in school, not only in early, but also in later primary grades.

Clinical Implications

The results of this study identify the need for a flexible and comprehensive assessment and treatment approach for preschoolers with speech sound disorders who are suspected by their speech-language pathologists as having CAS. The results also highlight the importance of including a broad set of emergent literacy skills such as phonological awareness, print awareness (including letter knowledge), and handwriting readiness, in addition to speech production and oral language in assessment protocols for these children and in intervention planning, as warranted, to help mitigate later reading and writing difficulties.

The results of this study also underline the importance of providing parents with advice and services that address their children's multiple needs. Preschool children with sCAS have severe speech sound disorders, and their families invest considerable resources for the remediation of such problems. However, these children may miss out on important experiences in the emergent literacy and motor domains if time spent on speech home practice reduces time available for activities such as sports, library visits, bedtime stories, scribbling, invented spelling, and so on. These children are likely to have multiple developmental needs and are at risk for delays in many developmental areas. Support for families to access services in these areas is important so that their children can experience emergent literacy learning opportunities like those of children with more typical development.

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Appendix
Child Demographic Form

Child Information

Name: ____________________ Date of Birth: ____________

Gender: ☐ Female ☐ Male

Language(s) spoken at school or daycare setting: ____________________

Language(s) spoken at home: ____________________

Do you feel your child has difficulty:

speaking or expressing him/herself?	☐ No	☐ Yes
understanding what is said to him/her?	☐ No	☐ Yes
hearing sounds and words or seeing?	☐ No	☐ Yes
walking, jumping, running?	☐ No	☐ Yes
manipulating objects?	☐ No	☐ Yes
learning?	☐ No	☐ Yes
Has your child ever been seen by a speech language pathologist?	☐ No	☐ Yes
Has your child ever been seen by an occupational therapist?	☐ No	☐ Yes

Parent or Legal Guardian 1

Name: ____________________ ☐ Male ☐ Female

What language(s) do you speak with your child at home?: ____________________

Level of Education:

☐ high school grade 12 not completed ☐ high school grade 12 completed

☐ college diploma completed ☐ university degree completed

Parent or Legal Guardian 2

Name: ____________________ ☐ Male ☐ Female

What language(s) do you speak with your child at home?: ____________________

Level of Education:

☐ high school grade 12 not completed ☐ high school grade 12 completed

☐ college diploma completed ☐ university degree completed

Phone number where you can be reached in case of cancellation: ____________________

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