# Speech, Language and Communicative Ability in School-Aged Children with Cerebral Palsy and Speech Impairment

Ann Nordberg

Division of Speech and Language Pathology

Institute of Neuroscience and Physiology

Sahlgrenska Academy at University of Gothenburg

UNIVERSITY OF GOTHENBURG

Gothenburg 2015

Cover photo by the author: *Anemone hepatica*, typical spring flowers of the mountain of Billingen, near the city of Skövde, Västergötland, Sweden, birthplace of the author.

To Björn and Erik,

My father Hans,

and in memory of my mother Maja

# Speech, Language and Communicative Ability in School-Aged Children with Cerebral Palsy and Speech Impairment

**Ann Nordberg**

Division of Speech and Language Pathology, Institute of Neuroscience and Physiology, Sahlgrenska Academy at University of Gothenburg, Sweden

**Abstract:** The overall aim of this thesis was to explore and describe speech, language and communicative ability in school-aged children with cerebral palsy (CP) and speech impairment. The medical records of a population-based cohort of 129 children with CP born 1999–2002 in western Sweden were reviewed. Type of CP, motor functions and neuroimaging findings were analysed.

Twenty-seven (21%) of the 129 children had speech impairment. Twenty-two (82%) of the 27 children took part in an assessment of speech, language, and communication skills.

Oral consonant production, dysarthria, hypernasality and narratives were assessed. The children's, the parents', the teachers' and the SLP's opinions about the children's communicative ability were also analysed.

More than half of the children had severe problems with articulation of oral consonants. Speech production and non-verbal cognitive level correlated significantly and severe retelling ability problems occurred. Language ability and auditory memory correlated significantly with retelling ability. The children were mostly positive about their own communication. Parents and teachers rated them with marked general communicative impairments. The parents' and SLP's ratings correlated significantly, whereas the parents and the teachers ratings did not.

A comprehensive speech, language and communication test battery including standardised tests is suggested. The children's own opinions and those of key persons in their environment are also important to consider when planning intervention.

**Keywords:** cerebral palsy, children, epidemiology, neuroimaging, narrative ability, communicative ability, dysarthria, consonant articulation

# SAMMANFATTNING PÅ SVENSKA

Cerebral pares (CP) är den vanligaste motoriska funktionsnedsättningen hos barn och orsakas av en tidig hjärnskada. Förutom varierande motoriska problem kan barn med CP ha olika grader av svårigheter med exempelvis kognition, syn och kommunikation. Barnens verbala och icke-verbala kommunikationsförmåga kan vara negativt påverkad. Nedsatt funktion kan förekomma gällande andning, fonation, velofarynx och artikulation. Kunskapen om tal, språk och kommunikation hos talande barn med CP är begränsad. Det övergripande syfte i denna avhandling var därför att undersöka detta hos skolbarn med CP och talstörning.

I Studie I klassificerades en populationsbaserad grupp av barn med CP i Västra Götaland födda 1999-2002 (n=129) genom journalgenomgång i kategorierna: 1) Utan talstörning 2) Talstörning 3) Icke-talande. Information om typ av CP, motorisk förmåga, kognitiv nivå och hjärnskadelokalisation fanns sedan tidigare. Resultatet visade att mer än hälften (53%) av den populationsbaserade gruppen av barn med CP saknade tal eller hade talstörning. Av de 27 barnen (21%) med talstörning undersöktes 22 (medelålder 11 år 3 mån) gällande tal-språk- och kommunikationsförmåga. I Studie II undersöktes talproduktion och icke–verbal kognitiv förmåga hos 19 (86%) av de 22 barnen. Grad av dysartri, hypernasalitet, procent korrekta orala konsonanter samt typ av artikulatoriska avvikelser analyserades. Majoriteteten (84 %) bedömdes ha åtminstone lätt dysartri, men bara några få hade hypernasalitet. Över hälften hade däremot stora eller mycket stora problem med konsonantproduktionen . I Studie III undersöktes muntlig återberättarförmåga och andra språkliga och kognitiva förmågor hos 15 (68 %) av de 22 barnen. Sambandsanalyser och fördjupad analys av barnens återberättarförmåga utfördes. Grava svårigheter med återberättarförmåga, receptiv och expressiv språkförmåga, minne, icke-verbal kognition och "theory of mind" förekom hos barnen som undersöktes. I Studie IV skattade barnen sitt eget tal och kommunikation, och barnens föräldrar, lärare och en logoped gjorde också skattningar av barnens kommunikation. Hälften av de 16 barn som deltog i studie IV var i stort sett positiva till sin kommunikation. Barnens skattningar samvarierade inte signifikant med hur deras föräldrar och lärare skattade dem. Föräldrar och lärare skattade att mer än hälften av barnen hade grava kommunikativa svårigheter, men även deras skattningar skilde sig åt. Däremot skattade föräldrar och logopeden barnens kommunikativa förmåga på samma sätt.

Sammanfattningsvis visar denna avhandling att mer än hälften av barnen med CP ur den populationsbaserade gruppen hade talstörning eller saknade tal.

saknade tal. Hos barnen med talstörning var omfattande generella språkliga svårigheter vanligt liksom nedsatt icke-verbal kognitiv nivå. Föräldrar och lärare noterade att de flesta av barnen hade generella kommunikativa svårigheter och att mer än hälften hade grava svårigheter trots att en majoritet av barnen själva inte tyckte att de hade några problem.

Barn med CP och talstörning behöver uppmärksammas mer. Logopeder bör göra en noggrann bedömning av talproduktion kombinerad med bedömning av olika språkliga domäner inför ställningstagande till behandling. Hänsyn behöver också tas till barnens egna och omgivningens åsikter angående deras kommunikation.

# LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I.     Nordberg A., Miniscalco C., Lohmander A., & Himmelmann, K. (2013). Speech problems affect more than one in two children with cerebral palsy: Swedish population-based study. *Acta Paediatrica,102,*161-166.

II.    Nordberg A., Miniscalco C., & Lohmander A. (2014). Consonant production and overall speech characteristics in school-aged children with cerebral palsy and speech impairment. *International Journal of Speech-Language Pathology, 16,* 386-395 (Invited Article, Special Issue Childhood Dysarthria).

III.   Nordberg A., Dahlgren Sandberg A., & Miniscalco C. (2015). Story retelling ability and language ability in school-aged children with cerebral palsy and speech impairment. *International Journal of Language & Communication Disorders*. Published online: 27 July 2015.

IV.    Nordberg A., Miniscalco C., Lohmander A., & Himmelmann, K. (2015). Perspectives of communicative ability in children with cerebral palsy and speech impairment. (Submitted).

# TABLE OF CONTENTS

# ABBREVIATIONS

CP              Cerebral Palsy

CFCS            Communication Function Classification System

GMFCS           Gross Motor Function System

ICF             International Classification of Functioning, Disability and Health

ICF-CY          International Classification of Functioning, Disability and Health for Children and Youth

SLP             Speech and Language Pathologist

BSCP            Bilateral Spastic Cerebral Palsy

USCP            Unilateral Spastic Cerebral Palsy

VSS             Viking Speech Scale

WHO             World Health Organisation

# 1 INTRODUCTION

## 1.1 Cerebral Palsy

Cerebral palsy (CP) is the most common type of motor impairment in children, affecting about two children per 1000 live births (Stanley & Watson, 1992; Himmelmann, Hagberg, & Uvebrant, 2010). CP is an umbrella term and is defined as a persistent impairment of motor function caused by non-progressive pathological processes in the immature brain (Surveillance of CP in Europe; SCPE, 2000). CP is classified into three main groups: spastic, dyskinetic and ataxic CP (SCPE, 2000). The time and reason the child receives the diagnosis of CP can vary, but the recommended age to determine the type of CP is 4–5 years. The motor impairment of CP is often accompanied by disturbances of sensation, perception, cognition, communication and behaviour, as well as epilepsy (Rosenbaum et al., 2007). The epidemiology of CP and its accompanying impairments has been studied in the health care region of western Sweden since 1954. (Hagberg, Hagberg, & Olow, 1975). This is one of the longest running studies of CP in the world. In the last decade, also the communication of children with CP has been added to the descriptions of the accompanying impairments. Communication and speech ability has been described in children with dyskinetic CP born in the 1990s (Himmelmann, Hagberg, Wiklund, Eek, & Uvebrant, 2007), and in all children with CP in western Sweden since the birth year 1999 (Himmelmann & Uvebrant, 2011). Communicative ability has also been studied in a group of adolescents born 1991–1997 (Himmelmann, Lindh, & Hidecker, 2013).

## 1.2 Clinical management of children with CP

Children with CP may have various communication impairments and experience difficulties with communicative ability in areas such as speech and language production, comprehension of language, gestures and facial expressions (Pennington et al., 2005). It has been reported that children with these impairments experience more limited participation in their daily lives than children with CP without communicative difficulties (Dickinson et al., 2007). There are currently no agreed standard assessment practices for children with CP and communication impairment in Sweden. However, there are recommendations made in the national care programme for children with CP (regional care programme cerebral palsy, 2014), a programme intended to

serve as a knowledge base and support for healthcare professionals in the practical everyday work for the development of the quality of care of children with CP. The National Quality Register for Habilitation is a Swedish quality register for all children (0–18 years) with disabilities (HabQ; Öhrvall, Eliasson, Löwing, Ödman, & Krumlinde-Sundholm, 2010). It is a systematic register for developing and securing the quality and results of the activities that take place at the habilitation centres in parts of Sweden. Speech, language, eating abilities, dysphagia and communicative effectiveness, i.e. total communicative ability including augmentative and alternative communication (AAC), are surveyed by the speech and language pathologists (SLPs) using the Therapy Outcome Measure (TOM; Enderby, 2014; Enderby, John, & Petherham, 2006). Assessments with TOM are performed at 3, 6 and 12 years of age (and when possible at 15 years).

Communication impairments of children with CP are sometimes identified by the general speech, language and communication screening at 2.5–3 and/or at 4 years of age at the general child care health centre. The children with CP and their families are offered care at the habilitation centres. Various health professionals, such as speech language pathologists (SLPs), psychologists, physicians, occupational therapists, education specialists and physiotherapists at the centres work closely together in teams in order to meet the special needs of the child and her/his family. For children with major difficulties, a thorough assessment of speech, language, communication, cognition and oral motor function is performed at about age 3. Hearing and visual skills ought to be checked. The assessment may need to be repeated during the child's language and communication development. Before starting school, additional information about reading and writing aids are provided, and when needed a new assessment of cognitive level is conducted.

Children with CP and severe communicative impairments can benefit from the provision of AAC systems, which can supplement existing speech or replace speech that is not functional. AAC methods vary and include for example signing, gestures, picture charts, books and special computers. However, children with CP and speeech impairment, communicating with spoken language, seem to be heavily underserved according to the results of a survey to SLPs at the Health Habilitation Services at Stockholm County Council (Egefors, 2012). In this survey children with CP and speech impairment were not even identified at the habilitation centres and accordingly, neither assessed, nor received any speech intervention This group is therefore the focus of this thesis.

## 1.3 International Classification of Functioning, Disability and Health (ICF)

The International Classification of Functioning, Disability and Health (ICF; WHO, 2001) is a way to describe and classify health and health-related domains (Figure 1). The focus expands from *Body Structures* and *Functions* to include the components *Activity* and *Participation* to describe how an individual takes part in society, and it is also used as a tool for looking at functional aspects of health. There is also a derived version of the ICF, the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY; WHO, 2001), designed to record characteristics of the developing child and the influence of the child's environments. Within the context of the ICF, 'participation' refers to the nature and extent of an individual's involvement in life situations. Restrictions in participation represent the difficulties individuals can experience in life situations due to the circumstances of their health condition. The environmental factors are the physical, social and attitudinal environments in which people live and conduct their lives and are either barriers to or facilitators of a person's functioning. Personal factors include race, gender and age and are not specifically coded in the ICF because of the wide variability across cultures. However, personal factors are included in the ICF framework (Figure 1), because although they are independent of the health condition they may influence how a person functions.

In clinical practice for children with CP, the use of the ICF structure can guide the choice of assessments and intervention. Decision makers in the field of childhood disability can use the ICF concept when developing policies and procedures for e.g. designing frameworks for care management tools that can be applied for health conditions such as CP. It would be desirable that research studies include the various interactive components of the ICF (Figure 1).

**Health condition**
**Cerebral Palsy**

**Body Structures &**
**Functions**

**Activities**

**Participation**
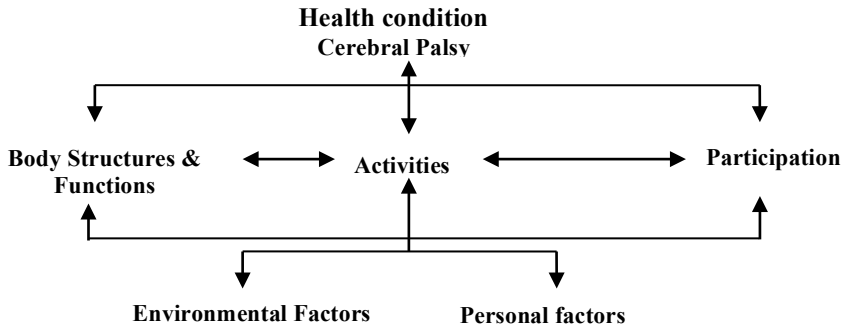
**Environmental Factors**

**Personal factors**

*Figure 1. Illustration of the interactions between the multidimensional components of the International Classification of Functioning, Disability and Health (ICF). Environmental factors and personal factors must always be taken into consideration as they affect everything in an individual's life (ICF; WHO, 2001).*

## 1.3.1 Neuroanatomical correlates to speech and language impairment

The brain lesions of children with CP can be classified under the *Body Structures* component of the ICF. Little is known and understood about the neural bases of speech and language impairments in children, including children with CP. Many factors determine the consequences of a lesion of the developing brain, such as the age when it occurred, the site, the size, and whether the lesion is unilateral or bilateral. Several methods are used for the evaluation of the brain structures and activity in children with CP, e.g. magnetic resonance imaging (MRI). MRI, and/or computed tomography (CT), is performed in about 90% of the children with CP in western Sweden (K. Himmelmann, personal communication, n.d., 2015). MRI findings in CP can be classified by timing of injury during gestation, which has provided a timetable for a structure-function relationship in CP (Krägeloh-Mann, 2004). The neuroanatomical correlate of the different types of CP and impairments can be studied and related to communicative ability and speech ability (Himmelmann, Lindh, & Hidecker, 2013). In a study of 68 children with CP (Himmelmann, Lindh, & Hidecker, 2013), periventricular lesions were associated with more functional and effective speech and communicative ability levels classified with the Communication Function Classification System (CFCS; Hidecker et al., 2011). Cortical/subcortical and basal ganglia lesions were, on the other hand, significantly associated with the absence of

speech and with less functional CFCS levels. Thus, the timing of the brain lesions seems important for communicative ability.

Liégeois, Mayes and Morgan (2014) reviewed recent studies on neuroimaging findings in children with speech and language impairment (without CP). Structural and functional anomalies in the left supramarginal gyrus were found, suggesting a possible deficit in sensory feedback or integration. In children with language impairment (also without CP), cortical and subcortical anomalies were reported in a widespread language network, but with little consistency across studies. The review highlighted the variability in neuroimaging technique in the studies as well as the heterogeneity within and across participants (Liégeois, Mayes, & Morgan, 2014). Only large-scale longitudinal studies of well-defined clinical subtypes will lead to a clearer picture of the neural bases of speech and language impairment in children, with or without CP.

## 1.3.2 Speech impairment

Descriptions of speech in children with CP can be classified under the *Body Function* component of the ICF. The motor speech impairment dysarthria is defined by Yorkston, Beukelman, Strand and Hakel (2010) as 'a neurologic motor speech impairment that is characterised by slow, weak, imprecise or uncoordinated movements of the speech musculature' (p.4). The motor impairments in children with CP may lead to dysarthria and the severity can vary from mild to severe involvement with inability to coordinate the respiratory, laryngeal, phonation, velopharyngeal, resonance and articulation subsystem. In general, reports on the occurrence of speech impairment in children with CP are scarce and the descriptions of speech ability differ considerably across studies. However, in four large-scale studies from Norway, Sweden, Iceland and Western Australia, impaired speech was reported in around 20% of children with CP (Andersen et al., 2008; Himmelmann, Hagberg, Wiklund, Eek, & Uvebrant, 2007; Sigurdardottir & Vik, 2011, Watson, Blair, & Stanley, 2006). In a recent population-based sample of children (4–6 years) with CP, 71 of 79 (90%) children had motor speech impairment (including children with severe speech impairment and without speech) (Mei, Reilly, Reddihough, Mensah, & Morgan, 2014).

Detailed descriptions of speech production in children with CP are rare. In an early study by Byrne (1959), it was shown that consonants in the medial and final positions were the most difficult. Workinger and Kent (1991) explored the speech characteristics of 18 children with CP (mean age 12;3 years) – nine with spastic CP, nine with dyskinetic CP. All children had severe gross motor impairment, but only one of them had cognitive impairment.

Consistent hypernasality, breathy voice and change of voice quality were the most common auditory perceptual speech characteristics for the children with spastic CP. For the children with dyskinetic CP, reduced stress, inappropriate voice stoppage/release and slow rate were most common. They also had more severe articulation problems. Similarities between the speech profiles of the spastic and dyskinetic children were also found in terms of phonation, such as strained voice quality and harsh voice.

Children with CP and speech impairment with a developing speech sound system may have even more problems than adults with consonants of high phonetic complexity, as both developmental factors and the speech motor impairment may affect production of these speech sounds (Kim, Martin, Hasegawa-Johnson, & Perlman, 2010; Platt, Andrews & Howie, 1980). Research on individuals with CP has mainly focused on adults and shows that high-complexity consonants, such as fricatives, requiring refined speech motor control, are more commonly misarticulated than speech sounds with lower complexity. Interestingly, Kim, Martin, Hasegawa-Johnson and Perlman (2010) showed that the speakers with CP with low speech intelligibility had more difficulties producing consonants of high complexity than the speakers with high intelligibility. The impact of phonetic complexity of words on intelligibility in children with CP has been explored by Allison and Hustad (2014). Sixteen children with CP (mean age 5 years, with and without motor speech impairment) participated in the study. Phonetic complexity was calculated using the consonant classification system described by Kim and colleagues (2010) in their study on speech in adults with CP. Consonants were assigned into different levels of articulatory complexity and each consonant had a phonetic complexity level value. The 119 naïve listeners made orthographic transcriptions of the children's sentence productions. It was shown that phonetic complexity affected the intelligibility of the children with CP and speech impairment with variation observed across individual children. The results of their study suggest that reducing the phonetic complexity of utterances may aid in enhancing intelligibility in children with CP and speech impairment (Allison & Hustad, 2014). This shows that more knowledge on consonant production and phonetic complexity in speaking children with CP is needed.

## 1.3.3   Language impairment

How a child with CP produces and understands language can be classified under the *Body Functions* component of the ICF. There has been little research on language impairment in children with CP, but some information

can be found in the few studies on how speech impairments in children with CP influence the use and development of language. Smith, Dahlgren Sandberg and Larsson (2009) found that children with CP (aged 5–13 years) without speech had significantly lower results than matched speaking controls on receptive grammar measured with TROG-2 (Bishop, 2003). Bishop, Brown and Robson (1990) showed that children with CP (aged 10–18 years) without speech and with severe motor speech impairment performed worse than typically developed (TD) children on a receptive vocabulary test, but performed equally well when receptive grammar was tested.

Receptive language comprehension is also required for story retelling (Dodwell & Bavin, 2008). A child's ability to understand and produce narratives relies on a complex interaction between several language and social abilities (Norbury & Bishop, 2003) and memory (Dodwell & Bavin, 2008). Only one study is found on narrative ability in speaking children with CP (Holck, Dahlgren Sandberg, & Nettelbladt, 2011). Story retelling ability was examined with the Bus Story Test (BST; Renfrew, 1997; Svensson & Tuominen-Eriksson, 2002) in ten Swedish-speaking children with CP without cognitive deficits (mean age 7;11 years). They were matched for age and gender with ten TD controls. There were no significant differences in scores of information or sentence length compared with the TD children. However, the grammar of the children with CP was less complex, with fewer subordinate clauses.

In this thesis, the short-term memory is the capacity of holding a small amount of information available in mind for a short period of time and working memory is the system that actively holds and manipulate multiple pieces of information in mind. The limited duration of short-term memory suggests that its contents spontaneously decay over time. The decay assumption is part of many theories of short-term memory, and the most notable may be Baddeley's model of working memory (Baddeley and Hitch, 1974; Baddeley, 1986). Auditory presented material is registered into the short-term phonological store of the articulatory loop and visually presented information may gain access to the articulatory loop via a subvocal articulatory translation and rehearsal process (e.g. Salame and Baddeley, 1982).

Baddeley, Thomson and Buchanan (1975) have suggested that articulation rehearsal rate decides the amount of verbal material that can be maintained in memory. Interestingly, White, Craft, Hale and Park (1994) demonstrated that normal speech rates did not play a crucial role in determining the capacity of memory span. Eleven children with spastic diplegic CP without cognitive

deficits, 5–11 years of age, and with subtle impairments in articulatory rate were compared with typically speaking controls. The children with CP did not show any memory span impairment compared with the children without speech rate deficits when tested with a memory span task that consisted of verbal repetition of one-, two- or three-syllable words (nouns). Quite different results have been reported for children with CP without speech. Fifteen children in a Swedish study (5–12 years without speech) were matched with typically speaking controls (Larsson & Dahlgren Sandberg, 2008). These children with CP had problems with most memory functions, which was seen as a support for the hypothesis that impaired speech ability affects the children's subvocal articulatory rehearsal (see e.g. Salame & Baddeley, 1982) and therefore causes them memory problems.

Theory of mind (ToM) is another important ability when retelling a story. It is defined as 'the complex ability to explain and predict people's behaviour with reference to mental states' (p.1, Slaughter & Repacholi, 2003). For a functional ToM, it is considered that language and cognitive abilities interact (Miller, 2004). In a study by Holck, Dahlgren Sandberg and Nettelbladt (2010), ten children with CP and intelligible speech (including two children with minor phonology and grammar impairment) had significantly worse results on ToM than matched TD children. Dahlgren, Dahlgren Sandberg and Larsson (2010) examined ToM in 16 children (mental age 4–9.5 years) with CP with such severe speech impairment that people outside their families did not understand them. They performed significantly worse on ToM than the matched comparison group of TD children. The low ToM results were discussed in terms of poor language abilities. Thus, the ability to predict and explain other people's actions, the ToM ability, has accordingly been proven to be difficult, both for children with CP with severe speech impairment (Dahlgren, Dahlgren Sandberg, & Larsson, 2010) and for children with CP and intelligible speech in the study by Holck, Dahlgren Sandberg, and Nettelbladt (2010).

## 1.3.4 Speech and language assessment

The majority of methods designed for assessing children with CP and speech and/or language impairment can be classified under the *Body Function* component of the ICF. Assessments of speech and language impairment can include both observations of spontaneous speech and language behaviour. Standardised tests of speech and/or language abilities are used to determinate the severity of the impairment, and the possible direction for intervention (Hansson & Nettelbladt, 2007). Sometimes standardised tests have to be adapted to accommodate the difficulties of the children with CP, for example when pointing to pictures.

*Speech assessment* of a child with CP often includes an overall rating of the severity of speech impairment. However, speech impairment in children with CP appears to involve all speech subsystems to some extent (e.g. Hustad, 2010) and consequently respiratory function, velopharyngeal function, phonatory function and articulation should be considered.

Regarding *respiration*, it is important to obtain information about any deficits affecting the speech production. The child's usual speech production can give some indications of speech breathing problems. According to Hardy (1983), such indications are use of short utterances with inhalations between utterances, use of considerable generalised effort for speech production, slow speech and the sound of being 'strained' at the end of phrases. Hardy (1983) also suggested various types of speech activities that may be used to assess the respiratory function of a child with CP including various types of valving of the airstream while speaking. For example, the speaker may count as long as possible on one breath and also produce voiced and voiceless consonants in order to examine the respiratory subsystem.

Enough information about deviant *velopharyngeal function* can usually be provided via auditory-perceptual ratings of hypernasality and audible nasal air escape (Hardy, 1983). However, the interdynamics of the entire speech physiology process must be considered and, for example, deviations of the velopharyngeal function may be present due to dysfunction of one or more of the other speech subsystems. Finally, Hardy (1983) recommends careful assessment of articulation using narrow phonetic transcription in order to detect misarticulations as precisely as possible. The importance of examining the *articulation* was shown by Lee, Hustad and Weismer (2014) when investigating speech acoustic characteristics in 22 children with CP (mean age 5;7 years). The articulatory subsystem was the most independent contribution to speech intelligibility when a multiple speech subsystems approach was used.

Speech in children with CP can be assessed using spontaneous speech, repetition, naming or reading single words or sentences (e.g. Kent, 1996). In Sweden, the articulation and nasality test, SVANTE (Lohmander et al., 2014) is available with measures on articulation skill (percent correct oral consonants), articulation errors and nasality. Phonetic transcription of consonants and ordinal scale rating of nasality can be performed on single words, sentences and connected speech. The obtained results can be compared with reference data from children with typical speech development.

*Language assessment* made by the SLP of a child with CP can include tests

of phonology, grammar, vocabulary (expressive and/or receptive) and receptive language comprehension. A variety of elicitation strategies are available, including imitation, naming, sentence supplementing, example sentences, retelling and spontaneous dialogues (Hansson & Nettelbladt, 2007). Expressive language can be tested with the 'LuMat' [Nya Lundamaterialet] (Holmberg & Stenkvist, 1983) or the Swedish test of grammar [GRAMmatiktest för Barn, GRAMBA] (Hansson & Nettelbladt, 2004), and phonology with the 'Phoneme Test' [Fonemtest] (Hellquist, 2013) or SVANTE (Lohmander et al., 2014) for consonant inventory and processes with normative data for preschool age children. Assessment of language comprehension is also important. Receptive grammar is commonly tested with the Test for Reception of Grammar Version 2 (TROG-2; Bishop, 2003) Receptive vocabulary can be assessed with the Peabody Picture Vocabulary Test (PPVT IV; Dunn & Dunn, 2007). Both receptive and expressive language can be evaluated with the Clinical Evaluation of Language Fundamental (CELF; Seme,Wiig, & Secord, 2004). Within clinical practice, all the above described instruments are used on a regular basis in order to assess children's language ability. Narrative abilities have been found to be related with literacy ability, a valid and important predictor of longitudinal language abilities (Botting, 2002). Therefore a retelling test instrument such as the Bus Story Test (BST; Renfrew, 1997; Svensson & Tuominen-Eriksson, 2002) can be appropriate to use for children from the age of 4 years.

## 1.3.5 Communicative activity and participation assessment

Communicative participation is defined by Eadie et al. (2006) as 'taking part in life situations where knowledge, information, ideas, or feelings are exchanged' (p.309). The social and cultural environment is important to consider, as we know that other people's attitudes, values and beliefs affect a child's participation in daily activities (Law et al., 1999). A link between activity and social participation restrictions and severe communication impairment has been demonstrated in research on individuals with anarthria with complex communicative needs (Thirumanickam, Raghavendra, & Olsson, 2011, Clarke et al., 2012; McFadd & Hustad, 2013). The importance of communication in order to facilitate participation in daily life activities is well known (Hidecker, 2010; Wilcox & Woods, 2011). However, there is limited knowledge about the activities and participation of children with CP and communication impairments.

Classification systems have been developed for individuals with motor speech impairment and communication functioning at an activity and participation level. Examples include the Viking Speech Scale (VSS;

Pennington, et al., 2013) and the Communication Function Classification System (CFCS; Hidecker et al., 2011). The CFCS and the VSS can be used by a wide number of users including allied health professionals such as SLPs. The VSS is used as a tool to classify the speech performance of children with CP (Pennington et al., 2013). Effectiveness of communication can be classified with the CFCS in order to determine the functional or daily impact of communication impairment (Hidecker et al., 2011). In a study by Mei, Reilly, Reddihough, Mensah and Morgan (2014), motor speech ability was classified in a community cohort of 79 children with CP (mean age 5;4 years) by the examiner and the parents using the VSS (Pennington, et al., 2013). Communicative abilities at an activity and participation level were also classified using the CFCS (Hidecker et al., 2011) and the Functional Communication Classification System (FCCS; Barty & Caynes, 2009). Both the CFCS and the FCCS have five levels and are designed specifically for children with CP. The FCCS includes classification of both the familiarity of the communication partner and settings, whereas the CFCS classifies communication merely according to how effectively an individual sends and receives messages with familiar and unfamiliar communication partners. The VSS was used to estimate the occurrence of motor speech impairment in the cohort. Ninety percent of the children with CP had some degree of motor speech impairment according to the VSS. Moreover, it was found that activity and participation limitations increased with greater reductions in motor speech ability. The children in the study with mild motor speech impairment (VSS level II) displayed participation comparable to children without motor speech impairment. Participation was measured only based on parent report, i.e. the opinions of the children with motor speech impairment themselves were not included in this study. The authors therefore emphasised that the children's own opinions about their communicative participation in various activities would have been a preferable complement (Mei, Reilly, Reddihough, Mensah, & Morgan, 2014).

## 1.3.6 Own and environmental opinions about communicative ability

Children with CP and speech impairment should be able to participate and communicate on equal terms with others in their family life and participate in all types of activities (UN, 1989).

Little is known about children's own opinions about their speech and communicative ability, especially in children with CP. Interviewed preschool children with speech impairment (without CP) and their communication partners reported frustrating speech and listener problems (McCormack, McLeod, McAllister, & Harrison, 2010). The strategies they used to reach

solutions, such as participating in speech intervention with SLPs, and also their use of informal strategies to address the listeners' problem were described. One reason for the lack of information on how children with CP feel about their own speech and communicative ability is that there are no formal standardised tests. The Communication Attitude Test (CAT; Brutten & Dunham, 1989), originally developed for children who stutter, has been used for this purpose. There is also a Swedish version of this test, CAT-S (Johannisson et al., 2009). It has been shown that children who stutter and children with voice and speech impairment related to cleft palate have more negative attitudes towards their own communication than children without these impairments (De Nil & Brutten, 1990; Havstam, Dahlgren Sandberg, & Lohmander, 2011). Children with articulation problems, however, had less negative attitudes towards their speech (De Nil & Brutten, 1990). The children with CP themselves have the expert knowledge of the impact that speech impairment has on activities and participation in their lives, and therefore more such data from them would be desired.

Data in the area of children's quality of life (QoL) has historically been taken from parent proxy reports. However, the World Health Organization (WHO, 1993) has recommended that measures of children's QoL be obtained using subjective self-reporting whenever possible. Research involving healthy children has reported that parents generally proxy-report higher QoL than the children themselves (e.g. Theunissen et al., 1998), whereas parents of children with chronic conditions, such as epilepsy, proxy-report lower QoL than the children themselves (e.g. Ronen, Streiner, & Rosenbaum, 2003). This is in line with findings from the European Study of Participation of Children with Cerebral Palsy Living in Europé (SPARCLE), where the children with CP self-reported significantly higher than the parents concerning participation and quality of life (Dickinson et al., 2007). Children with CP and speech impairment communicate with adult persons, such as their parents and their teachers, who are important communication partners for them in different ways and in different settings. The parents communicate mostly with them at home and the teachers in learning situations at school. One way to document communicative abilities is to use questionnaires completed by an adult who knows the child well. Children's Communication Checklist-2 (CCC-2; Bishop, 2003) is an instrument for this purpose. CCC-2 is a tool for identifying children with specific and pragmatic language impairment, and can also distinguish children with communication impairments and social interaction deficits who are in need of autism neuropsychiatric assessment. Mei et al. (2015) interviewed parents about their views of the activities and participation of their children with CP (4–9 years) with and without communicative impairments. The content of the

interviews with the parents were mapped to the domains of the ICF-CY (WHO, 2001). They were primarily mapped to the domains of learning and applying knowledge, communication, mobility and interpersonal interaction. The parents highlighted the potential negative impact of communication limitations on the activities and participation of their children, especially in the areas of relationships and independence. The opinions of the children themselves, the parents, the teachers and other professionals about the children's communicative ability are important information in order to be aware of any discrepant opinions. This information might provide important knowledge in order to provide support in identified problem areas. Furthermore, it may be a base for mutual discussions about what kind of communicative intervention would be best for the individual child

## 1.4   Rationale

More than half of children with CP have accompanying impairments, such as communication disabilities (Himmelmann, Beckung, Hagberg, & Uvebrant, 2006; Himmelmann & Uvebrant, 2011), that may be more disturbing than the actual motor impairment. Children with CP and speech impairment are a neglected group (Pennington,1999; Hustad, 2010; Egefors, 2012). According to the United Nations Convention on the Rights of the Child (1989), it is a child's right to be able to communicate, children with CP and speech impairment included. It is therefore important to get an overview of the occurrence and distribution of speech, language and communicative disabilities and also explore both speech and language abilities thoroughly.

More understanding on these issues will increase the chances of finding appropriate intervention options for communicative improvements and participation in society. In addition, we do not know much about what the children themselves, or the important adults around them, think about their ability to communicate. There is therefore a need to learn more about this. In alignment with the need to explore speech, language and communicative ability in children with CP, the overall and specific aims outlined in Section 2 below have been chosen.

# 2 AIM

The overall aim of this thesis was to explore and describe the speech and language ability of school-aged children with CP and speech impairment. The aim was also to investigate, describe and compare the communicative ability of the children from different perspectives.

The specific aim of each study was:

**Study I:** to describe and explore speech ability in a population-based study of children with CP (born 1999–2002) in relation to CP subtype, motor function, cognitive level and neuroimaging findings.

**Study II:** to investigate some speech characteristics of children with CP and speech impairment and study the relation between speech production, gross motor function and non-verbal cognitive level.

**Study III:** to explore the retelling ability of children with CP and speech impairment and the impact of expressive and receptive language, narrative discourse dimensions, auditory and visual memory, theory of mind and non-verbal cognition.

**Study IV:** to describe and compare communicative ability in school-aged children with CP and speech impairment from the perspectives of the children themselves, their parents, their teachers and their SLP.

# 3  MATERIAL AND METHODS

## 3.1   Participants

The participants in Study I were 129 children (66 girls, 63 boys) with CP from a population-based cohort born in 1999–2002 in the county of Västra Götaland, which is part of the Panorama of CP in western Sweden study area (Himmelmann, Hagberg, & Uvebrant, 2010). The child's local paediatric neurologist diagnosed all participating children with CP when they were between 4 and 8 years old. CP was defined according to Rosenbaum et al. (2007) as a group of disorders of the development of movement and posture that are attributed to non-progressive disturbances in the foetal or infant brain. A flow chart (Figure 2) shows the number of children included in each of the four studies in the thesis.
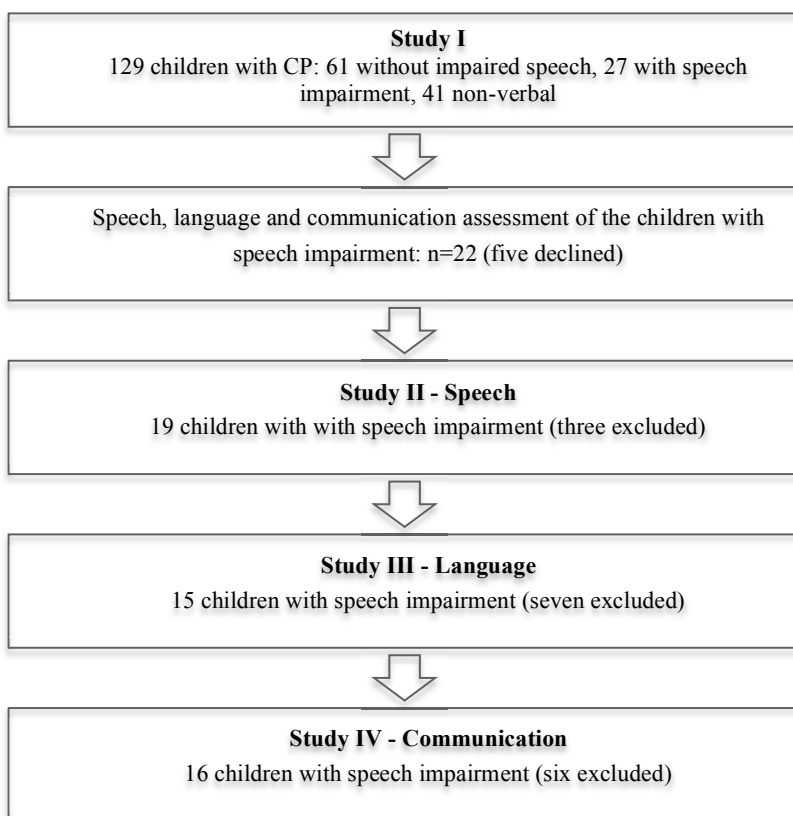


---

**Study I**

129 children with CP: 61 without impaired speech, 27 with speech impairment, 41 non-verbal

---

Speech, language and communication assessment of the children with speech impairment: n=22 (five declined)

---

**Study II - Speech**

19 children with with speech impairment (three excluded)

---

**Study III - Language**

15 children with speech impairment (seven excluded)

---

**Study IV - Communication**

16 children with speech impairment (six excluded)

---

*Figure 2. Number of children* participating *in each of the four studies.*

The 27 children (14 girls, 13 boys) ages 9;2 to 12;10 (mean 11;2 years ) with speech impairment, i.e. 21% of the 129 children, were invited to participate in an in-depth assessment of speech, language and communication. Twenty-two of them accepted the invitation and five declined. Table 1 gives an overview of the individual children participating in the studies in this thesis. It also provides background data, earlier reported by Himmelmann, Hagberg and Uvebrant (2010) and Himmelmann and Uvebrant (2011), on type of CP, level of gross motor function and neuroimaging findings.

In Study II, dealing with speech characteristics in children with CP, three of the 22 children from the population-based study were excluded. One child was not able to take part in the assessment due to epilepsy, one child did not produce enough speech during the assessment and one child could not participate due to visual impairment as the test included picture naming. Thus, 19 Swedish-speaking children (9 girls, 10 boys) age 9;2 to 12;9 (mean 11;2 years) participated.

In Study III, concerning the impact of language abilities on retelling ability, seven of the 22 children from the population-based study were excluded (Table 1). One child was not able to take part in the assessment due to epilepsy, five children did not use the five utterances required for the assessment of retelling, and one child did not participate due to visual impairment. The study group finally comprised 15 Swedish-speaking children (7 girls, 8 boys), age 9;2 to 12;9 (mean 11;0 years).

In Study IV, about different perspectives on communicative ability, 16 children (7 girls, 9 boys) age 9;2 to 12;10 (mean11; 2 years) met the criteria of speaking several sentences and participated (Table 1). Six of the 22 children from the population-based study were excluded (Table 1). One child was not able to take part in the assessment due to epilepsy, one child had severe cognitive impairment, the parents of one child did not speak/read Swedish and three children did not speak in several sentences, which was required for the assessment. The children themselves, their parents and teachers participated.

*Table 1. Description of the participants in Study II, Study III, and IV.*

| Study II n=19/22 | Study III n=15/22 | Study IV n=16/22 | Gender | Age | Type of CP | GMFCS[a] ** | VSS[b] |
|---|---|---|---|---|---|---|---|
| S1 | Child A | Participant 1 | F | 9;6 | USCP | I | II |
| S2 | Child B | Participant 2 | M | 9;9 | USCP | I | II |
| S3* | Child C* | Participant 3* | M | 12;8 | USCP | I | II |
| S4 | Child D | Participant 4 | M | 11;11 | USCP | I | II |
| S5 | Child E | Participant 5 | F | 12;9 | USCP | I | II |
| S6 | Child F | Participant 6 | F | 12;8 | USCP | I | II |
| S7 | Child G | Participant 7 | F | 9;8 | BSCP | IV | II |
| S8 | Child H | Participant 8 | M | 10;7 | BSCP | IV | II |
| S9 | Child I | Participant 9 | M | 11;3 | USCP | III | II |
| S10* | Child J* | **X** | M | 11;8 | USCP | I | II |
| S11 | **X** | **X** | M | 11;8 | BSCP | I | III |
| **X** | **X** | Participant 10 | M | 12;10 | BSCP | IV | II |
| S12* | **X** | **X** | F | 12;8 | BSCP | IV | III |
| S13 | **X** | **X** | F | 11;9 | BSCP | III | III |
| D1 | Child K | Participant 11 | M | 11;10 | Dys-kinetic | III | II |
| D2 | Child L | Participant 12 | F | 9;2 | Dys-kinetic | II | II |
| A1 | Child M | Participant 13 | F | 10;1 | Ataxic | I | II |
| A2 | Child N | Participant 14 | F | 9;2 | Ataxic | IV | III |
| A3 | **X** | Participant 15 | M | 10;7 | Ataxic | I | III |
| A4 | Child O | Participant 16 | M | 12;1 | Ataxic | I | II |

# 3.2   Ethical consideration

All studies were approved by the Regional Ethical Review Board in Gothenburg (Dnr: 145-07; Dnr: 639-10). The parents of the children participating in the studies received oral and written information before consent was obtained. The children themselves were given information about the study before they agreed to participate.

# 3.3   Procedures

In Study I, all available information about the population-based cohort of 129 children with CP wase reviewed, i.e. the medical records and information from SLPs working with the child concerning the speech ability of the participants. The data collection was conducted by an SLP (the author). In Studies II, III and IV, the same SLP met all children individually. The assessments took place in a separate room at the children's schools, except for one child, who was assessed at home. Audio and video recordings of the speech and language testing were performed in a standardised manner using high-quality equipment. In Study IV, data were collected via questionnaires directed to parents and teachers as well as questions/statements given to the children themselves.

## 3.3.1 Test instruments

The participants of the studies (n=22) took part in in-depth and broad assessment of speech, language and communication skills, and the following standardised test instruments were used:

- The Swedish Articulation and Nasality TEst (SVANTE; Lohmander et al., 2005) was used for assessment of consonant production and nasality. The SVANTE test includes pictures designed to elicit one- and two-syllable single words with target oral consonants (59), nasal

consonants (5) and s-clusters (10). The SVANTE test also includes the repetition of sentences and the elicitation of connected speech, but in this study the 59-single-word sample was used for assessment of the oral consonant production. The following consonants were assessed: /p, /t/, /k/, /b/, /d/, /g /, /f/, /s/ and /ɕ/. The speech sample thus includes all Swedish oral stops, the two sibilants and one labiodental voiceless fricative, all considered vulnerable to articulation impairments, For each consonant included there are seven possible realisations (three in initial position, two in medial and two in final position), except for /ɕ/ with three possible realisations in initial position.

- The Bus Story Test (BST; Renfrew 1997, Swedish version; Svensson and Tuominen-Eriksson, 2002) was used for the assessment of oral retelling ability. BST is a picture-based test instrument for the ages of 3;9 to 8;5 years. BST includes 12 cartoon pictures and no written words. The participants were told the story orally (by the author) while looking at each picture and then asked to retell the story as closely to the original as possible using the pictures as prompts.

- The Test for Reception of Grammar (TROG-2; Bishop, 2003) was used for the assessment of receptive grammar at sentence level. Receptive vocabulary was assessed with the norm-referenced instrument Peabody Picture Vocabulary Test (PPVT-IV; Dunn & Dunn, 2007) including 228 picture-based test items.

- Non-verbal cognitive level was tested with the Raven's progressive matrices (RCPM; Raven, Court, & Raven, 1986).

- The Corsi block-tapping task (CB) (Milner, 1971) was used to measure visuo-spatial memory. The examiner pointed to a number of blocks in a certain order and the participant was asked to point to the same blocks in their order of presentation.The forward version was a measure of visuo-spatial short-term memory (STM) and the backward for visuo-spatial working memory (WM).

- The Digit Span (DS) from the Wechsler Intelligence Scale for Children-III (Wechsler, 1999) was used to measure auditory memory. The participants were asked to repeat the numbers after they were presented to them orally. The forward version was used for auditory short-term memory (STM) and the backward for auditory working memory (WM).

- Theory of Mind (ToM) ability was measured with the false belief items of the two story tests Kiki and the Cat (Lewis, 1994) and Birthday Puppy (Sullivan, Zaitchik, & Tager-Flusberg, 1994).

- The Children's Communication Checklist-2 (CCC-2; Bishop, 2003) was used to assess the participant's communicative and language abilities in daily life. The parents and teachers of the participants answered the CCC-2 questionnaire. CCC-2 consists of ten subscales, four dealing with language structure, vocabulary and discourse: 'Speech', 'Syntax', 'Semantics', and 'Coherence'. Four scales concern the pragmatic aspects of language: 'Inappropriate Initiation', 'Stereotyped Language', 'Use of Context' and 'Nonverbal Communication'. Two subscales explore 'Social Relations' and 'Interests'.

- Ten statements or questions adapted by the author and inspired by the self-report instrument Communication Attitude Test (CAT; Brutten & Dunham, 1989) were answered by the participants. The focus of this assessment was to gain knowledge about children's opinions about their own general ability to speak and communicate.

- The participants' communicative ability was classified by an SLP (the author) using the CFCS (Hidecker et al., 2011). CFCS consists of five levels (CFCS I, II, III, IV, V) describing the effectiveness in communicating as a sender and receiver in daily interactions with familiar/unfamiliar communication partners.

- The participants' speech performance was classified by an SLP (the author) using the Viking Speech Scale (VSS), specifically designed for children over 4 years of age with CP (Pennington et al., 2013). The VSS consists of the following four levels: (I) speech is not affected; (II) speech is imprecise but usually understandable to unfamiliar listeners; (III) speech is unclear and not usually understandable to unfamiliar listeners out of context and (IV) no understandable speech.

Figure 3 illustrates how some of the measures used in the studies of this thesis are distributed over the various components of the ICF (WHO, 2001).
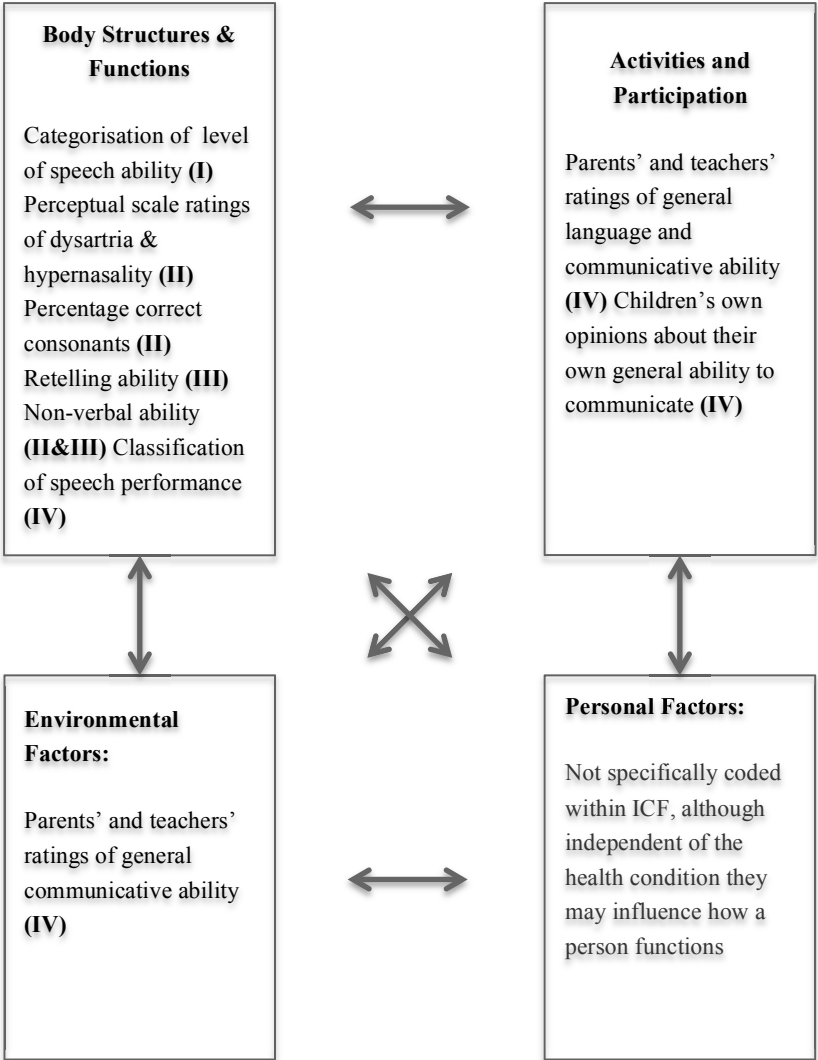
*Figure 3. Cerebral palsy is a multidimensional condition. Examples of measures used in this thesis are shown under the various ICF components, illustrated as separate boxes. After the measures, it is indicated in which study of the thesis they are used. Some of the measures can fit under more than one ICF component. The arrows (pointing in two directions) between the components show the complex, dynamic and often unpredictable relationship between the ICF entities.*

## 3.3.2 Analyses

After the review of the medical records in Study I, the children with CP were categorised into three different speech ability groups based on their ability to communicate functionally with speech (Hustad, 2010): (i) children without speech impairment (i.e. speech was not affected by the motor impairment), (ii) children with speech impairment, including stuttering, and (iii) nonverbal children (i.e. children unable to produce functional speech due to motor impairment and/or cognitive impairment, including mental retardation and autism). Speech ability was described in relation to type of CP, gross motor function, cognitive level and neuroimaging findings. Occurrence of speech impairment in children with CP was calculated. The following studies concern the group of children with speech impairment.

In Study II, the auditory perceptual speech assessments were made independently by two experienced SLPs. Narrow phonetic transcription based on the International Phonetic Alphabet (IPA) and the extended IPA for disordered speech [ExtIPA] conventions (IPA, 1999; IPA, 2005) of the target oral consonants was made. The phonetic transcription was preceded by nine hours of transcription calibration of four children with CP and speech impairment (children not included in the study), where the use of different phonetic symbols was discussed until consensus was reached.

A four-point ordinal scale, where 0 meant no deficit and 4 severe, was used for perceptual overall ratings of dysarthria and hypernasality together with free field descriptions of other speech characteristics. The phonetic transcriptions of the target consonants were analysed as correct or not correct, based on the scoring rules for the percentage of consonants correct (Shriberg & Kwiatkowski, 1982; Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997). Percent correct oral consonants was calculated and the 10-year norms for the SVANTE test (Lohmander et al., 2014) were used for comparison. In addition, calculation of frequency of articulation errors was performed according to the procedure used by Workinger and Kent (1991). The free field comments of the speech characteristics were classified into respiration and speech breathing, voice quality and prosody. Non-verbal cognitive level was tested with Raven's progressive matrices (Raven, Raven, & Court, 1986), and scoring and analysis followed the procedures in the manual.

In Study III, the elicited narratives of the Bus Story Test (BST) (Renfrew, 1997) were transcribed orthographically. Swedish norms of the BST for the ages of 3;9 to 8;5 years were used (Svensson & Tuominen-Eriksson, 2002). The Information score (BSTinf), i.e. the number of relevant pieces of information in the child's retold story, was calculated. Then the five longest

sentences, in terms of number of words, were selected in each sample and the mean value was calculated as Sentence Length (BSTsl). Finally, as a measure of expressive grammatical complexity, the number of Subordinate Clauses (BSTsc) was calculated. The Narrative Assessment Profile (NAP) (Bliss, Mc Cabe, & Miranda, 1998) was used for further analysis. The results of the NAP analysis reveal whether the narratives are well organised and coherent. Six separate dimensions of the narrative were analysed. These dimensions are considered necessary when producing structurally appropriate narrative discourse (Stubbs, 1983; Van Dijk, 1981). The children's retold narratives were analysed on the following six NAP dimensions: Topic Maintenance, Event Sequencing, Explicitness, Referencing, Conjunctive Cohesion and Fluency.

Furthermore, the scores of the assessments of the children's receptive grammar (TROG-2; Bishop, 2003) the Swedish norms for the ages of 3;9 to 8;5 years were used. For receptive vocabulary (PPVT-IV; Dunn & Dunn 2007) the US norms for the ages 2;6-90+ years were used as no Swedish norms were available and for non-verbal cognitive level (RCPM; Raven, Raven, & Court, 1986) the British norms were used as no Swedish norms were available, as well. Assessments of memory functions (Corsi block-tapping task; Milner, 1971 and Digit Span; Wechsler, 1999) and the scores of Theory of Mind tests ('Kiki and the Cat'; Lewis, 1994 and 'Birthday Puppy'; Sullivan, Zaitchik, & Tager-Flusberg, 1994) were analysed.

In Study IV, the participants responded to ten statements/questions about their own speech and communication. The higher the score, the more negative their opinions about their own speech and communication. The parents' and teachers' ratings of the CCC-2 (Bishop, 2003), with the Swedish/Danish norms for the ages 4-16;11 years used, were analysed and the SLP (the author) classified the children according to the five levels of the classification system CFCS (Hidecker et al., 2011). Finally, a classification of speech impairment was made using the Viking Speech Scale (VSS) (Pennington et al., 2013) in order to verify the categorisation of the children into the 'speech impairment group' made after the review of the medical records in Study I.

## 3.3.3 Statistical analyses

Statistical analyses of the data were carried out using the SPSS (Statistical Package for Social Sciences) version 19 and 22 for Windows (SPSS Inc., Chicago, IL). Non-parametric statistical methods were used due to small sample sizes in the studies. Descriptive statistics were used. Furthermore, independent and dependent variables were compared and the differences

between subgroups and effect size were analysed. Table 2 gives an overview of the statistical methods used in the thesis.

In order to reduce the number of variables in Study III, composite scores were computed into the two variables *expressive* and *receptive* language. The individual test scores were transformed to z-scores and used in the further analyses of *expressive language* (the scores of BST Sentence Length and BST Subordinate Clauses) and *receptive language* (the scores of TROG-2 and PPVT-IV). These scores were used together with non-verbal cognitive level (Raven's progressive matrices), Visual Memory (Corsi block forward and backward) and Auditory Memory (digit span forward and backward) to examine the relationship between these variables and narrative ability operationalised as narrative assessment profile (NAP), total score.

*Table 2. Overview of the statistical methods used in the four studies.*

| Study | Research objectives | Stastistical methods |
|-------|--------------------|--------------------|
| I | Test of differences between the "speech ability groups" by -type of CP, -gross motor function,-cognitive level, -type of neuroimaging findings | Chi-square test or Fisher's exact test (in case of small numbers) |
| I | Strength of associations between speech ability and type of CP, cognitive level, and neuroimaging findings respectively | Cramér's V test |
| I | Degree of correlation for level of speech ability and gross motor function | Two-tailed Kendall's $\tau$ (b) |
| II | Associations between speech production (PCC and dysarthria/hypernasality ratings), gross motor function and non-cognitive level | Spearman's rank correlation coefficients |
| III | Associations between narrative ability (NAP scores) and scores of language ability, memory functions and non-verbal cognition | Spearman's rank correlation coefficients |
| IV | Associations between the parents' and the teachers' ratings of communicative ability, between the children's and the parents' ratings on communicative ability, and between the SLP's and the parents' ratings on communicative ability. | Spearman's rank correlation coefficients |

## 3.3.4 Reliability

The reliability of the assessments in Studies II, III and IV was investigated. In Study II, both SLPs independently assessed the speech of all children. The assessments were compared and inter-reliability calculated. In addition, six randomly selected recordings (32%) were duplicated for re-assessment of each of the SLPs, compared and intra-reliability calculated. The intra- and inter-transcriber reliability of the transcriptions and the overall scale ratings of dysarthria and hypernasality were calculated using exact percentage agreement, point-by- point. The intra-transcriber agreement for the re-transcription of 32% of the material was excellent for both transcribers: 95 and 100%, respectively. The intra-rater agreement of the ratings of dysarthria and hypernasality was 100% for both raters.

The inter-transcriber agreements were good (80–90%), although for three children the agreement was below 70% and regarded as not acceptable. A third experienced SLP therefore performed complementary transcriptions for six of the 19 children (32%), i.e. for the three children the transcribers did not

agree on and another three randomly added transcriptions. The median value of the three observers for each variable was used as the result. The inter-rater reliability for ratings of dysarthria and hypernasality was poor (68%). The third SLP therefore performed complementary speech material ratings for 13 of the 19 children (68%) and the median value of the three observers' ratings were used as the result. For dysarthria, this revealed full agreement between two raters and for hypernasality 95%.

In Study III, inter-judge reliability was assessed by two SLPs for 40% of the transcriptions of the Bus Story Test (Renfrew, 1997). A correlation analysis was performed and the ratings for all the BST subtests made by the two SLPs correlated significantly: Information (Rho= .940 $p<0.01$), Sentence Length (Rho= .829 $p<0.05$) and Subordinate Clauses (Rho= .904 $p<0.05$). In Study IV the 16 children's expressed opinions about their own speech, and communicative ability were rated by an SLP (the author) with 0 for the children's opinions reflecting positive opinions and 1 negative opinions. Another SLP, without any previous knowledge of the children, re-rated all 16 children (from video recordings) and comparison using exact percentage agreement, point-by-point showed 100% agreement with the first SLP.

# 4 RESULTS

## 4.1 Speech ability in relation to type of CP, motor function and neuroimaging findings (Study I)

The chart review showed that 61 children (47%) had no speech impairment (i.e. speech not affected by the motor impairment), whereas 27 children (21%) had speech impairment. The remaining 41 children (32%) were unable to produce functional speech.

Speech impairment occurred in all types of CP (Figure 4). Data on gross motor function showed that almost half (48%). i.e. 13 of the 27 children with speech impairment, walked without difficulty and were assigned to GMFCS level I (Figure 5). Speech impairment and motor impairment were significantly related (Kendall's tau (b) = 0.64; $p < 0.01$). The brain lesions were bilateral for 17 (65%) of the children with speech impairment. Table 3 shows the distribution of neuroimaging findings in the children with CP and speech impairment. In the cohort of 129 children the cerebellar lesions were only found in the group of children with CP and speech impairment.
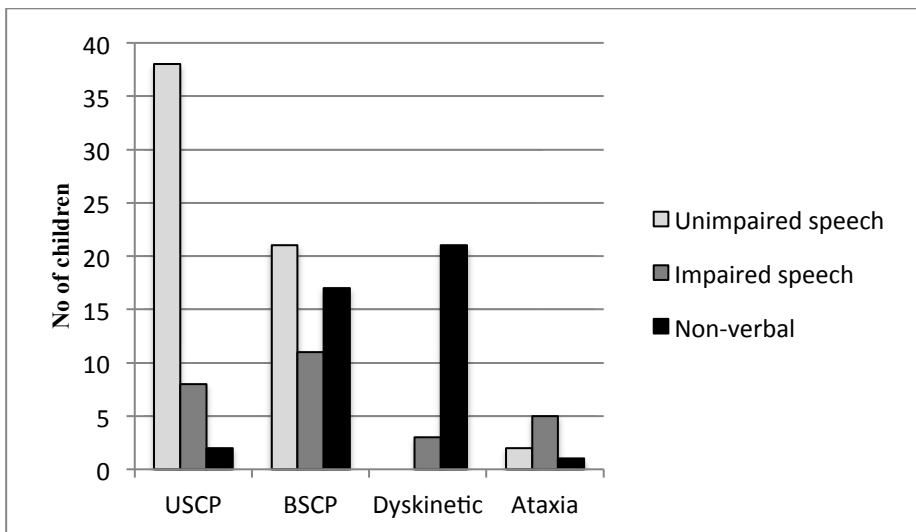


Figure 4. The number of children of the population-based cohort of 129 children, with different levels of speech ability, distributed over the different types of CP.
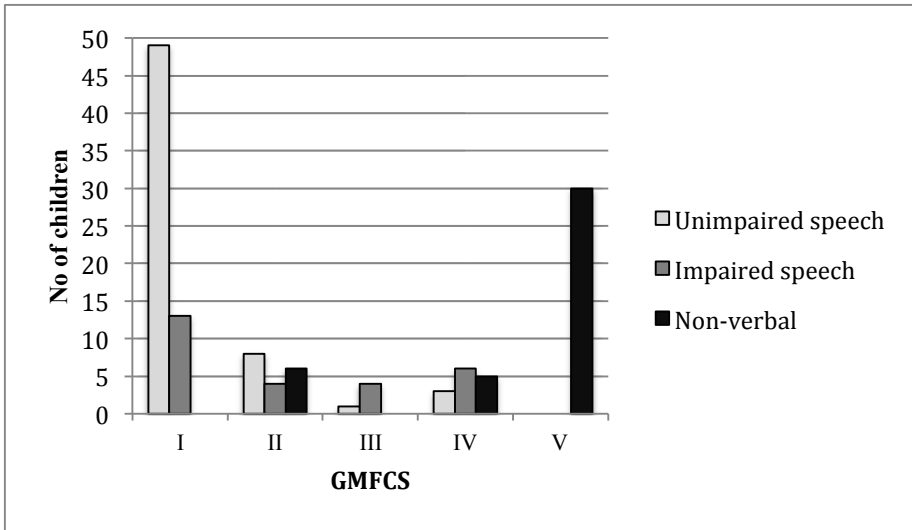
*Figure 5. The number of children of the population-based cohort of 129 children with CP, with different levels of speech ability, distributed over the different levels of gross motor function.*

*Table 3. Neuroimaging findings in 26 of the 27 children with CP and speech impairment (data is missing for one child).*

| Neuroimaging findings | Children with speech impairment | Unilateral lesion | Bilateral lesion |
|---|---|---|---|
| Malformation | 1 | 0 | 1 |
| Periventricular white matter lesion | 5 | 0 | 5 |
| Cortical-subcortical lesion | 8 | 2 | 6 |
| Basal ganglia lesion | 2 | 0 | 2 |
| Cerebellar lesion | 3 | 1 | 2 |
| Normal finding | 6 | - | - |
| Post tumour | 1 | 0 | 1 |
| **Total** | 26 | 3 | 17 |

## 4.2 Speech characteristics (Study II)

A majority of the children were rated as having mild to moderate dysarthria (70%) and about one third had hypernasality. Degree of hypernasality correlated significantly with level of gross motor function (Rho = .484, $p$ = .036), but gross motor function was not significantly associated with the severity of dysarthria.

The mean value of the percentage of correct oral consonants was 83.7% (49.6–100). This is below -2 SD for typically developing 10-year-olds (Lohmander et al., 2014). The mean value of the percentage of correct oral consonants was 83.7% (49.6–100). This is below -2 SD for typically developing 10-year-olds (Lohmander et al., 2014). Voicing errors were the most frequent type of consonant errors for the 13 children with spastic CP. The percentage of total articulation errors were as follows for the children with spastic CP: voicing errors (34.3%), substitutions (26.9%), and omissions (23.1%). The two children with dyskinetic CP had none or few articulation errors. For the four children with ataxic CP, the most frequent consonant errors were substitutions: (60.6%) and voicing errors (27.9%). Non-verbal cognitive level correlated significantly with consonant articulation (Rho = .561, $p$= .015) but not with gross motor function.

## 4.3 The impact of language abilities on retelling ability (Study III)

The children had severe difficulties retelling a story. The mean raw score for the BST measure Information was 20.6 (SD 11.7; range 4–42), corresponding to an age equivalent of 5;2 years (range 3;8–8;5). The mean raw score for Sentence Length was 8.6 words (SD 3.08; range 4–14), corresponding to an age equivalent of 6;11 years (range 3;8–8;5). The mean raw score for Subordinate Clauses was 3.3 (SD 3.11; range 0–9), corresponding to an age equivalent of 5;9 years (range 3;10–8;5). Furthermore, the children had marked difficulties with receptive language abilities i.e. receptive grammar (TROG-2) with an age equivalent of 7;1 years (range 3;11–14;7) and receptive vocabulary (PPVT-IV) corresponding to an age equivalent of 8;4 years (range 4;7–16;11). Problems with non-verbal cognition (Raven's matrices) were also present with an age equivalent of 8;2 years (range 5;0–11;6). In addition, there were low mean raw scores for auditory, visual memory and theory of mind ability.

The relationship between narrative ability (NAP total score) and possible background factors were computed. There were statistically significant relationships between the NAP total score and the composite scores expressive language (r = .825**; n = 15; $p$ = 0.01), receptive language (r = .719**; n = 15; $p$ = 0.03) and with auditory memory, forward condition (r = .588, n = 15, $p$ = .021). There was also a significant relationship between the explicitness dimension of the NAP and the BST Information score (r =.532*; n=15; $p$ = 0.04). No other dimension of the NAP correlated with any of the BST scores.

# 4.4   Perspectives on the children's communicative ability (Study IV)

More than half of the children responded positively to the ten statements and questions concerning their ability to speak and communicate. Fifteen of the 16 children had more positive than negative responses. The parents rated 11 (69%) and the teachers 13 (81%) children with low general communication composite scores (GCC scores), i.e., they had marked general language and communicative impairments according to the CCC-2. No significant associations were found between the children's own opinion regarding their speech and communicative ability and the general GCC scores assigned by parents (n=16; Rho=-.06, $p$=.836) and teachers (n=16; Rho=-.38, $p$=.146).

For both the parents and the teachers, the mean score of the speech subscale ratings corresponded to the 3rd percentile (in relation to norms). There was no significant associations between the parents' and the teachers' GCC scores on the CCC-2 (n=16; Rho =.28, $p$=.302). The parents' scores on the CCC-2 speech subscale correlated significantly with the teachers' ditto (n=16; Rho =.68, $p$=.004; $rho^2$=.46).

The functional communicative ability was classified by the SLP. Eleven children (69%) were effective communicative senders and receivers, according to the CFCS classification (I-II). Two children were rated with the most severe communicative impairment according to the CFCS. Both had bilateral brain lesions according to neuroimaging. The SLP's CFCS scores and the parents' GCC scores on the CCC-2 correlated significantly (n=16; Rho=-.72, $p$=.006; $rho^2$=0.52).

# 5 DISCUSSION

There is limited research on communicative ability in children with CP and speech impairment (Pennington, 1999; Hustad, 2010; Egefors, 2012). In this thesis, the intention was to obtain knowledge about speech, language and communication in this group of children and to compare the children's own view of their communicative ability with the opinions of some key persons around them.

## 5.1 Speech ability in relation to type of CP, gross motor function and neuroimaging findings

Reports on the occurrence of speech impairment vary across studies (e.g. Andersen, 2008; Cockerill et al., 2014; Parkes, Hill, Platt, & Donnelly, 2010) and there is also a lack of agreement concerning the use of terms. For example, when classifying speech, the distinctness of speech was rated in Andersen et al. (2008), whereas Cockerill et al. (2014) used a speech intelligibility rating scale. Furthermore, differentiation between specific speech impairment (e.g. dysarthria, apraxia) and language impairment is not always evident when communicative abilities are reported in register studies. Consensus on definitions of speech, language and communication impairments would make important international comparisons between studies easier, an issue also stressed by Morgan (2015). In Study I, 21% of the children had CP and speech impairment, and these children need to be identified early in order to facilitate appropriate intervention.

Type of CP is an important factor for the ability to speak. In Study I, speech impairments were present in all types of CP. In addition, the majority of the children with dyskinetic CP in the cohort of 129 children with CP were nonverbal or had speech impairment, while the majority of children with Unilateral Spastic Cerebral Palsy (USCP) did not have any speech impairment. This is in line with earlier findings, e.g. from the Norwegian study by Andersen et al. (2008) and from the Icelandic study by Sigurdardottir and Vik (2011).

Gross motor function was also explored in Studies I and II and for the children with CP, speech ability and gross motor function were found to be significantly related, i.e. the severity of speech impairments increased with increasing gross motor impairment. This has also been observed in earlier studies (e.g. Andersen et al., 2008; Himmelmann & Uvebrant, 2011;

Sigurdardottir & Vik, 2011). However, for the children with speech impairment in Study II, no significant association between articulation of consonants or perceived severity of dysarthria and gross motor ability was found. Thus, the well-known relationship between gross motor function and speech ability for children with CP does not apply to the specifically selected group of children with CP and speech impairment included in Study II.

Another important aspect is the location of the brain lesions in children with CP and speech impairment. In Study I**,** the locations of brain lesions varied within all the speech ability groups, but cerebellar lesions were actually only found in the group of children with speech impairment. The role of the cerebellum in speech has previously been studied in children after brain surgery, and was then found to be associated with speech impairment (Morgan et al., 2011). Furthermore, in Study IV periventricular white matter injury (WMI) were most common in the children who were effective communicators according to the CFCS classification (I-II). In Himmelmann, Lindh and Hidecker's (2013) study on communicative ability in a group of older children with CP, WMI was also associated with the most functional communicative levels of the CFCS. Other studies have arrived at similar findings (e.g. Martinez-Biarge et al., 2012; Liégeois & Morgan, 2012).

## 5.2 Speech characteristics

Speech impairment can originate from several of the speech subsystems, or in the coordination between them (Smith, 2004). However, the articulatory subsystem is particularly important in order to make speech intelligible, as Lee, Hustad and Weismer (2014) also have stated. Nine speech acoustic characteristics of 22 children with CP were examined with a multiple speech subsystems approach. Speech intelligibility was evaluated using a prediction model in which acoustic measures were selected to represent three speech subsystems. The articulatory subsystem showed the most substantial independent contribution (58%) to speech intelligibility. A conclusion from their study was that the articulatory subsystem makes the primary contribution to speech intelligibility variance in dysarthria, with minimal or no contribution from other systems (Lee, Hustad, & Weismer, 2014). Therefore, detailed descriptions of articulation, as done in Study II, are necessary to perform in order to obtain more knowledge about the articulatory subsystem of children with CP. It was found in Study II that more than half of the children had severe problems with the articulation of oral consonants, and the children with ataxic CP were most affected.

The speech production of 18 children with spastic and dyskinetic CP was described in one of the few studies on this issue (Workinger & Kent, 1991). However, the procedure for assessing hypernasality was not described in detail by the authors, who presented hypernasality as the most common speech characteristic among children with spastic CP. Yet, in Study II, more than half of the children with spastic CP were rated without hypernasality. Difficulties in the auditory perceptual assessment of speech may be one explanation for the disparate findings in the two studies. It is well known that the reliability of perceptual assessments of hypernasality has often been reported as low, with poor agreement between listeners (Kent, 1996). The heterogeneity of the selection of children between the two studies, with variation in the levels of the children's gross motor function and cognition, is another possible explanation for the dissimilar results. There has been some interest in the velopharyngeal subsystem in individuals with CP. For example, different patterns of velopharyngeal dysfunction in five children with CP and speech impairment were presented in a study in the late 1960s (Netsell, 1969). Another difference between Workinger and Kent (1991) and Study II in this thesis was that Workinger and Kent (1991) used short speech material based on imitation as well as assessment by broad transcription. In Study II, on the other hand, a comprehensive single-word naming test and narrow transcription was used. The result of the analysis of the correctness of articulated consonants was accordingly based on a large number of realisations of each target consonant in different positions, making measurements of occasional realisations unlikely.

Another important aspect regarding studies on speech production in children with CP was highlighted by Hustad, Gorton and Lee (2010). They stressed the importance of inclusion of children with CP with cognitive impairments when examining speech in children with CP, especially since earlier studies on speech in this group have usually targeted children without cognitive impairments. In Study II, non-verbal cognitive level was significantly associated with the articulation of consonants and the severity of dysarthria, a finding that supports this view.

There are some treatment programmes for improving speech in children with CP. For example, Pennington, Miller, Robson and Steen (2010) implemented a systems-based intervention protocol that focuses on stabilising respiratory and phonatory control and effort as well as adjustment of phrase length, speech rate and syllables per breath. It is also used for younger children (Pennington et al., 2013). Boliek and Fox (2014) have adapted the Lee Silverman Voice Treatment (LSVT) programme for paediatric populations, called LSVT LOUD. There is also the motor speech treatment approach Prompts for Restructuring Oral Motor Targets – PROMPT (Ward, Leitão, &

Strauss, 2014). Electropalatography (EPG) is another treatment tool for remediating residual articulatory errors in older children with CP (Nordberg, Carlsson, & Lohmander, 2011; Gibbon & Wood, 2003).

## 5.3  The impact of language abilities on retelling ability

The children in Study III had severe problems with retelling ability, with low scores on all three of the BST narrative subtests. Håkansson and Hansson (2007) pointed out that when it comes to grammatical problems for Swedish-speaking children in general, it is always about quantitative issues. Grammatical structures are rarely missing; instead the children do not use them very often and do not vary between different kinds of structures. This was also shown for the children included in Study III, i.e. they used few subordinate clauses in their retold stories and the stories were fragmentary with very limited sentence length. However, typically developing children use subordinate clauses from the age of 2;6 years (Håkansson, & Hansson, 2007) and many aspects of Swedish grammar, for example the use of irregular verbs in past tense, are usually completed at about age 4. Still, the complexity of grammatical forms and constructions continues to develop gradually (Håkansson, & Hansson, 2007). In light of this, it is important to consider that the chronological mean age of the children in Study III was 11 years and still they had such great grammatical difficulties.

Referencing contributes to discourse coherence because it enables the listener to identify important individuals, locations or events in, for example, an orally retold story (Mc Tear, 1985). The ability to reference can be assessed with the analytic procedure NAP (Bliss, Mc Cabe, & Miranda, 1998), which can be used in research in connection with the BST (Renfrew, 1997). Mc Tear (1985) suggested difficulties with referencing to be caused by problems integrating linguistic and contextual information. In Study III, the NAP total result was used as a measure of narrative ability and was significantly related both to the composite scores of expressive and receptive language and to auditory memory. This finding illustrates the importance of assessing both language production and comprehension when assessing oral retelling in children with CP. Furthermore, it indicates that assessment of other language abilities and memory functions (especially auditory memory) is important in this group of children.

Narrative retelling skills, temporal pictorial, sequencing skills and language skills were examined in a Swedish study on children (6–9 years old) with various neurodevelopmental and communicative impairments (Åsberg

Johnels, Hagberg, Gillberg, & Miniscalco, 2013). They found that not only language level but also non-verbal temporal sequencing functions were important for narrative ability. It was concluded that narrative skill rests on both language and cognitive skills. The severe problems with language and cognition in the children with CP in Study III resulted in a similar conclusion as that drawn by Åsberg Johnels, Hagberg, Gillberg and Miniscalco (2013).

The retelling ability scores of the children with CP with intelligible speech (without cognitive impairment) in the study by Holck, Dahlgren Sandberg and Nettelbladt (2011) were just a little inferior to those of typically developing children on both linguistically and cognitively related narrative measures. In contrast, the children in Study III with CP and speech impairment had severe retelling ability problems. This is not surprising due to the differences between the participants' nonverbal cognitive level and their various speech and language abilities. However, in the case of the score for the NAP explicitness dimension, i.e. difficulties creating narratives containing sufficient information for the listener, the children in both studies had difficulties. Despite differing cognitive levels and ability to speak, the children with CP perform equally poor on this discourse dimension. The NAP explicitness dimension requires an ability to understand others' minds and the children in both studies showed limited theory of mind ability, which could explain the low results.

Language treatment is sometimes necessary for children with language impairment and should always be based on an accurate and detailed analysis of the child's language ability. Focus can be on phonological, grammatical, lexical or pragmatic aspects of the language, and parental involvement is always of utmost importance (Nettelbladt, Håkansson, & Salameh, 2007). Language intervention can be performed by an SLP, other professionals or the parents (Nettelbladt, Håkansson, & Salameh, 2007).

## 5.4 Perspectives on the children's communicative ability

It is important to find out what children with CP and the persons around them think about their communicative ability. In Study IV, the children were mostly positive about their own speech and communicative ability. Their parents and teachers, on the other hand, rated the children to have marked general language and communicative impairments according to the CCC-2 (Bishop, 2003). Also in the European SPARCLE project, which concerns the

participation and quality of life of 500 children with CP (8–12 years) in seven countries, the children self-reported significantly higher than the parents concerning a majority of the included quality of life domains. In eight of the ten included quality of life domains (physical well-being, psychological well-being, self-perception, autonomy, parental relations, school environment, social acceptance/bullying and social support and peers), the children self-reported significantly higher levels than their parents (White-Koning et al., 2007). Similar results were shown in a study by Schiariti et al. (2014). They investigated strengths and limitations in functioning of children with CP using the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY; WHO, 2001) in all areas of life. Semi-structured interviews were conducted with 10 children with CP (mean age 10; 6) and their caregivers. It was concluded that the children and their caregivers actually described the same areas of life, but had different and unique perspectives. The children talked more about their abilities, whereas the caregivers described more their concern over the children's limited abilities.

An explanation of the parents' discrepant and more negative rating of their children's abilities could be related to the societal view of disability as a personal tragedy. The dominant traditional model of disability in Western society has been a medical or individual model where disability is seen as a problem located within the individual, similar to an illness, and reliant on medical intervention. Disabled people are not necessarily ill and most are not likely to be cured of their disability. Oliver (1986) described how this view of disability dominates in our society, assuming that disabled people cannot possibly feel good about themselves when being disabled. This view could affect parents as well as other members of society and assumes that individuals with a disability cannot be happy (Woolfson, 2004). The children's positive opinions about their communication in Study IV contradict the social view of disabled persons not being able to feel good and be positive.

An additional interesting finding in Study IV was a significant relationship between the two scores on the CCC-2 speech subscale of the parents and the teachers of the children with CP and speech impairment. Forty-six percent of the total variation could be explained by the linear relationship between the two variables, yet 54% remains unexplained. Furthermore, there was a significant relationship between the SLP's scores of communicative ability on the CFCS scale and the parents' GCC scores (general communicative/language ability) on the CCC-2. The total variation, in this case, could be explained to a bit higher extent (52%) by the relationship between the two variables, thus 48% remained unexplained.

## 5.5   Methods used in the studies

A mix of quantitative methods exploring speech, language and communication abilities in school-aged children with CP and speech impairment were used in the four studies. In Study I, a retrospective chart review was conducted collecting data on speech ability and related health conditions such as gross motor function and localisation of the children's brain lesions. There is always a risk that the medical notes are scarce and unclear, and to prevent this the data on speech ability was verified by the local SLPs and speech impairment was verified by classification of the participating children by an SLP (the author).

In Study II, auditory perceptual assessments of speech of the children with CP and speech impairment were performed. Sometimes it is not possible to predict in what area and how the speech of the children with CP was impaired. Heselwood and Howard (2008) have stated that narrow transcription is preferred for children with these types of unpredictable speech impairments. Narrow phonetic transcription by two independent experienced SLPs and error analysis were therefore used in Study II. The methods for descriptions of articulation and speech characteristics selected in Study II were similar as in the study on children with CP and speech impairment by Workinger and Kent (1991).

Furthermore, at the time of Study IV, no formal tests measuring children's opinions about their speech and communication were available. Ten statements/questions designed to measure these opinions were therefore created (by the first author) inspired by the self-report instrument the Communication Attitude Test, originally developed for children who stutter (CAT; Brutten & Dunham, 1989). It is important to take into account, from a methodological point of view, that a standardised test was not used in Study IV. Nevertheless, the data obtained from the children in this study are considered valuable, because of the lack of knowledge about the opinions about communicative ability in children with CP.

# 6 LIMITATIONS AND FUTURE RESEARCH

In Study I, only the children with CP in the population-based cohort who were noted to have speech impairment in their medical records were selected for further assessment of communicative ability. It would have been of great interest to investigate communicative ability also in the other 'speech ability groups', i.e. children without impaired speech and children without speech. Language and communication impairments may be present also in children without speech impairments. Unfortunately, the available resources did not allow for examination of all children in the cohort within the limited scope of this thesis.

Studies II, III and IV are exploratory studies with a small study sample, which calls for caution in interpreting the results. However, an important strength of the studies is that the group of children with CP and speech impairment were taken from a population-based study, and more than 80% of the target group consented to participate.

The literacy of the children with CP and speech impairment was not investigated in this thesis, which is a limitation. The association between low BST scores, as the children in Study III had, is a valid predictor of persistent language impairment (Bishop & Edmundsson, 1987) and associated with literacy disabilities (Stothard, Snowling, Bishop, Chipcase, & Kaplan, 1998; Miniscalco, Hagberg, Kadesjö, Westerlund, & Gillberg, 2007). A further investigation of the reading and spelling skills of the children in this thesis would therefore be preferable.

The limitations of the child self-report instrument used in Study IV are well known by the author. Still, the need to know more about the children's own opinions about their communicative ability is urgent and more studies of valid self-report instruments are warranted. In study IV, knowledge about the included children's language and communicative ability was obtained via CCC-2 (Bishop, 2003), a standardised questionnaire completed by the parents and teachers. This questionnaire was used to gain more understanding on how the children communicated at home and in school. The information obtained did not reflect the children's independent communication in all areas of daily life, but only their interaction with parents and teachers. There are some well-validated measures evaluating global participation in all types of situations (King, McDougall, DeWit, Petrenchik, Hurley, & Law, 2009; Jessen, Colver, Mackie, & Jarvis, 2003; Coster, Law, & Bedell, 2011), which

could be used to complement the measures in this thesis.

Furthermore, intelligible speech is important for succesful spoken communication. Reliable and valid assessment of speech intelligibility are challenging due to differences in how it is defined and all the multiple factors that can affect its measurement (Lagerberg, 2013; Miller, 2013). It is important to assess intelligibility in children with CP, yet intelligibility was not specifically focused upon in this thesis.

# 7  CLINICAL IMPLICATIONS

According to the results of this thesis, children with CP and speech impairment should receive comprehensive assessment of their speech, language and communicative abilities. For assessment of speech, the SLP should first gain an overall idea of the severity of the child's speech impairment, for example by rating severity of dysarthria in connected speech (spontaneous or repetition). As it has the highest impact on intelligibility, assessment of consonant articulation by means of a standardised test should then be used, and the same test can preferably be used for a phonological analysis. In the clinical assessment of language by the SLP, formal standardised tests of phonology, grammar, vocabulary (expressive and/or receptive) and receptive language comprehension should be used Information about the children's communicative abilities in daily life as perceived by important adults such as parents and teachers should be obtained and, since the communicative ability often is perceived differently by the child and by persons in their environment, as was shown in Study IV, children's own opinion should be requested. Although children with CP and speech impairment may lack the metacognitive skills to critique their communication performance accurately, it is valid information to obtain their opinions about how they perceive living with speech impairment.

Formal tests measuring children's opinions about their own speech and communication are lacking. Until formal tests arrive, the SLP should ask the children with CP and speech impairment, in informal ways, questions about their communicative ability and communication needs.

# 8 CONCLUSIONS

Based on the results of the four studies of the present thesis, it can be concluded that:

- By knowing the proportion of children with CP who also have speech impairment (21%), it will be easier to provide appropriate services and support for these children.


- Type of CP is an important factor to consider for the ability to speak. For example, a majority of the children with dyskinetic CP were nonverbal or had speech impairment, while a majority of the children with USCP did not have any speech impairment.


- Gross motor function in children with CP was significantly related with the ability to speak and is therefore important to take into account. For the children with speech impairment, there was no such relation.


- The children with speech impairment were generally rated to have severe difficulties with consonant production and dysarthria. Hypernasality was rare compared with earlier research.


- Non-verbal cognitive level was significantly related to consonant articulation and dysarthria and is an important factor to consider when for example planning assessments and management strategies for children with CP and speech impairment.

- The children with CP and speech impairment had severe problems with retelling ability. In relation to their chronlogical age, they used few subordinate clauses and had very limited sentence length.


- Expressive and receptive language skills and auditory memory functions proved to be important factors for children when retelling a story orally.

- New information was obtained when the children with CP and speech impairment themselves and key persons around them were involved in the assessment of the communicative ability. The children were mostly positive regarding their ability to communicate, while parents, teachers and SLPs were not. This is of importance in situations where children and key persons around them are to take an active part in for example selection of intervention options.


- In order to examine speech production in children with CP all the speech subsystems should be considered. Furthermore, assessments by means of standardised tests of articulation and expressive and receptive language should be included. Also information about the communicative ability from the children themselves and key persons around them is of great importance.

# ACKNOWLEDGEMENT

I would like to express my deepest gratitude to the following people:

All the children (and their families) who participated in this project.

Carmela Miniscalco, my principal supervisor and co-author, for your scientific guidance and special thanks to your invaluable advice – 'help the reader' – that you gave at the beginning of this work.

Anette Lohmander, my assistant-supervisor and co-author, who made this possible from the start and who has helped me to – 'help the reader' – in an outstanding scientific way.

Kate Himmelmann, my assistant-supervisor and co-author, for sharing your invaluable deep scientific knowledge about individuals with cerebral palsy and for helping me to 'help the reader'.

Annika Dahlgren Sandberg, my co-author and wise scientific advisor, for your educative and invaluable lessons in statistics; also many thanks for your help with 'helping the reader'.

Lena Hartelius for your kind advices during the work with this PhD project.

Göran Carlsson, for your wise advices and guidance at the very beginning of this project about children with cerebral palsy.

Åsa Mogren for our nice and friendly lunches and useful professional conversations over the years and for your help with assessments in Study II.

Emilia Carlsson for kind help with the assessments in Study III and IV.

Karin Eriksson (my role model!), Emma Forsgren, Maria Sundqvist, for all your invaluable and warm support, and for the pleasant and useful conversations over the years, you are the best office mates, ever.

My beloved Björn Israelsson for our useful and fruitful discussions on my thesis over these years and your never ending support and encouragement. You always believed in me and my ability to finish this thesis, even when I didn't. We have shared a lot you and I. My deepest and warmest love to you.

My son Erik Nordberg, for making your mother so warmly proud by just being you! Thank you for your supportive way of being. All my love from my heart to your heart, now and forever.

My sister Christina Nordberg Prah for sharing sorrows and cares about our dear parents during these years. Warm love to you, we are a good team!

My dear friend Eva Gredner for always being there for me and for just being yourself in such a warm and entertaining way. We have been friends for such a long time now!

My dear friend Eva Söderberg for being such a nice and wise friend in your own warm and impulsive way, which I appreciate so much. You have been important for me.

My dear friend Annika Rudqvist, I hope you know about the great importance that you have had in my life. And thanks for your warm support over the years and good luck to your Nils in New York, to your lovely Karolina and to all the others!

Lisbeth Nyman and the Bragefors familiy in Karlstad, I hope you are aware of the importance you have had for me in my life.

And to all you others, family and friends for being there and making my life more enjoyable.

# REFERENCES

Andersen, G.L., Irgens, L.M., Haagaas, I., Skranes, J.S., Meberg, A.E., & Vik, T. (2008). Cerebral palsy in Norway: prevalence, subtypes and severity. *European Journal of Paediatric Neurology, 12*, 4–13.

Allison K.M., & Hustad, C. (2014). Impact of sentence length and phonetic complexity on intelligibility of 5-year-old children with cerebral palsy. *International Journal of Speech-Language Pathology*, *16,* 396–407.

Baddeley, A. (1986). *Working Memory.* Oxford: Clarendon Press.

Baddeley, A., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (pp. 47–89). New York: Academic Press.

Baddeley, A.D., Thomson, N., & Buchanan, M. (1975). Word length and the structure of short-term memory. *Journal of Verbal Learning and Verbal Behavior*, *14*, 575–589.

Barty, E., & Caynes, K. (2009). Development of the Functional Communication Classification Scale. *Paper presented at the 3rd International Cerebral Palsy Conference*, Sydney, Australia.

Bishop, D.V.M. (2003). *The Children's Communication Checklist (CCC-2)*. Second Edition, CCC-2 Manual, Swedish version, 2011, Sweden: Pearson Education.

Bishop, D.V.M. (2003). *Test for Reception of Grammar Version 2 (TROG-2)* (Swedish version, 2009, Pearson Education). London: The Psychological Corporation.

Bishop, D. V. M. & Edmundsson, A. (1987). Language impaired 4-year-olds: distinguishing transient from persistent impairment. *Journal of Speech and Hearing Disorder*, *52*, 156–173.

Bishop, D. V. M., Brown, B., & Robson, J. (1990). A relationship between phoneme discrimination, speech production, and language comprehension in cerebral palsied individuals. *Journal of Speech and Hearing Research*, *33*, 210–219.

Bliss, L., Mc Cabe, A., & Miranda, E. (1998). Narrative assessment profile: Discourse analysis for school-age children. *Journal of Communication Disorders, 31*, 347–336.

Boliek, C. A., & Fox, C.M. (2014). Individual and environmental contributions to treatment outcomes following a neuroplasticity-principled speech treatment (LSVT LOUD) in children with dysarthria secondary to Cerebral Palsy. *International Journal of Speech-Language Pathology*, *16*, 372–385.

Botting, N. (2002). Narrative as a tool for the assessment of linguistic and pragmatic impairments. *Child Language Teaching & Therapy*, *18,* 1–21.

Brutten, G.J., & Dunham, S.L. (1989). The communication attitude test. A normative study of grade school children. *Journal of Fluency Disorder*, *14*, 71–77.

Byrne, M. (1959). Speech and language development of athetoid and spastic children. *Journal of Speech and Hearing Research*, *24*, 231–240.

Clarke, M., Newton, C., Petrides, K., Griffiths, T., Lysley, A., & Price, K. (2012). An examination of relations between participation, communication and age in children with complex communication needs. *Augmentative and Alternative Communication*, *28*, 44–51.

Cockerill, H., Elbourne, D., Allen, E., Scrutton, D., Will, E., McNee , A., … Baird, G. (2014). Speech, communication and use of augmentative communication in young people with cerebral palsy: The SH & PE population study. *Child: Care, Health and Development*, *40*, 149–157.

Coster,W., Law, M., & Bedell, G. (2011). *Participation and Environment Measure for Children and Youth.* (PEM-CY). Toronto, ON: CanChild.

Dahlgren, S. O., Dahlgren Sandberg, A., & Larsson, M. (2010). Theory of mind in children with severe speech and physical impairments. *Research in Developmental Disabilities*, *31*, 617–624.

De Nil, L., & Brutten, G. J. (1990). Speech-associated attitudes: Stuttering, articulation disordered, and normal-speaking children. *Journal of Fluency Disorders*, *15*, 127–134.

Dickinson, H.O., Parkinson, K.N., Ravens-Sieberer, U., Giorgio, S., Thyen, U., Arnaud, C., … Colver, A. F. (2007). Self-reported quality of life of 8–12-year-old children with cerebral palsy: a cross-sectional European study. *Lancet, 369*, 2171–2178.

Dodwell, K., & Bavin, E.L. (2008). Children with specific language impairment: an investigation of their narratives and memory**.** *International Journal of Language and CommunicationDisorders*, *43,* 201–218.

Dunn, L., & Dunn, D. (2007). *Peabody Picture Vocabulary Test*. PPVT-IV. Fourth Edition, San Antonio: Pearson.

Eadie, T. L., Yorkston, K. M., Klasner, E. R., Dudgeon, B. J., Deitz, J.C., Baylor, C. R., … Amtmann, D. (2006). Measuring Communicative Participation: A Review of Self-Report Instruments in Speech-Language Pathology. *American Journal of Speech-Language Pathology*, *15*, 307–320. doi:10.1044/1058-0360(2006/030).

Egefors, E. (2012). Evidensbaserad barnlogopedi inom Habilitering och Hälsa - En kartläggning av barnlogopedens arbetssätt i förhållande till aktuell evidens [*Report on the evidence-based speech-language pathology at Habilitation and Health, Stockholm County Council & Karolinska Institutet. A survey of the SLP's work in relation to current evidence*]. Stockholm County Council & Karolinska Institutet, Stockholm, Sweden.

Enderby, P. (2014). Use of the extended therapy outcome measure for children with dysarthria. *International Journal of Speech-Language Pathology*, *16,* 436–444.

Enderby, P., John, A., & Petherham, B. (2006). Therapy Outcome Measures for Rehabilitation Professionals. Second Edition, London: Wiley.

European Study of Participation of Children With Cerebral Palsy Living in Europe

(SPARCLE; www.ncl.ac.uk/sparcle).

Gibbon, F. E., & Wood, S. E. (2003). Using electropalatography (EPG) to diagnose and treat articulation disorders associated with mild cerebral palsy: a case study. *Clinical Linguistics & Phonetics, 17*, 365–374.

Hagberg, B., Hagberg, G., & Olow, I. (1975). The changing panorama of cerebral palsy in Sweden 1954–1970. I. Analysis of the general changes. *Acta Paediatrica Scandinavia, 64*, 187–192.

Hansson, K & Nettelbladt U. (2007). Bedömning av språklig förmåga hos barn [Assessment of language ability in children]. In U. Nettelbladt, & E-K. Salameh (Eds.), *Språkutveckling och språkstörning hos barn. Del I – Fonologi, grammatik, lexikon [Language development and language impairment in children Part I – Phonology, grammar, lexicon](*pp 255-287). Lund, Sweden: Studentlitteratur AB.

Hansson, K., & Nettelbladt, U. (2004). Gramba. Grammatiktest för barn [Grammatical Assessment for Children]. Malmö, Sweden: Pedagogisk Design.

Hardy, J.C. (1983). *Cerebral palsy*. Englewood Cliffs, NJ: Prentice Hall.

Havstam, C., Dahlgren Sandberg, A, & Lohmander, A. (2011). Communiaction attitude and speech in 10-year-old children with cleft (lip and) palate: An ICF perspective. *International Journal of Speech-Language Pathology*, *13*, 156–164.

Heselwood, B., & Howard, S. (2008). Clinical phonetic transcription. In M. J. Ball, M. R. Perkins, N. Mueller, & S. Howard (Eds.), The handbook of clinical linguistics (pp.381–399 ). Malden, MA: Blackwell Publishing.

Hellquist, B. (2013). Fonemtest. [Phoneme Test]. Malmö, Sweden: Pedagogisk design.

Hidecker, M.J.C. (2010). Building the evidence for communication interventions. *Developmental Medicine & Child Neurology*, *52*, 316–317.

Hidecker, M. J. C., Paneth, N., Rosenbaum, P. L., Kent, R.D., Lillie , J., Eulenberg, J. B., … Taylor, K. (2011). Developing and validating the Communication Function Classification System for individuals with cerebral palsy. *Developmental Medicine and Child Neurology*, *53*, 704–710.

Himmelmann, K., Beckung, E., Hagberg, G., & Uvebrant, P. (2006). Gross and fine motor function and accompanying impairments in cerebral palsy. *Developmental Medicine & Child Neurology*, *48*, 417–423.

Himmelmann, K., Hagberg, G., & Uvebrant, P. (2010). The changing panorama of cerebral palsy in Sweden. X. Prevalence and origin in the birth-year period 1999–2002. *Acta Paediatrica*, *99*, 1337–1343.

Himmelmann, K., Hagberg, G., Wiklund, L.M., Eek, M.N., & Uvebrant, P. (2007). Dyskinetic cerebral palsy: a population-based study of children born between 1991 and 1998. *Developmental Medicine & Child Neurology*, *49*, 246–251.

Himmelmann K, Uvebrant P. (2011). Function and neuroimaging in cerebral palsy: a population-based study. *Developmental Medicine & Child Neurology*, *53*, 516–521.

Himmelmann, K., Lindh, K., & Hidecker, M.J.C. (2013). Communication ability in cerebral palsy: A study from the CP register of western Sweden. *European Journal of Paediatric Neurology*, *xxx*, 1–7.

Holck, P., Dahlgren Sandberg, A., & Nettelbladt, U. (2010). Inferential ability in children with cerebral palsy, spina bifida and pragmatic language impairment. *Research in Developmental Disabilities*, *31*, 140–150.

Holck, P., Dahlgren Sandberg, A., & Nettelbladt, U. (2011). Narrative ability in children with cerebral palsy. *Research in Developmental Disabilities*, *32*, 262–270.

Holmberg, E., & Stenkvist, H. (1983). Nya Lundamaterialet. Kartläggning och bedömning av barns språkliga förmåga [The Lund test of phonology and grammar. Description, and assessment of children's linguistic abilities]. Malmö: Utbildningsproduktion AB.

Hustad, K.C. (2010). Childhood dysarthria: cerebral palsy. In: K.M. Yorkston, D.R. Beukelman, E.A. Strand, & M. Hakel (Eds.). *Management of motor speech disorders in children and adults.* 3rd ed. Austin (pp.376-378). TX: Pro-Ed.

Hustad, K. C., Gorton, K., & Lee, J. (2010). Classification of speech and language profiles in 4- year-old children with cerebral palsy: A prospective preliminary study. *Journal of Speech, Language and Hearing Research, 53,* 1496–1513. doi:10.1044/1092-4388(2010/09-0176)

Håkansson, G., & Hansson, K. (2007). Grammatiska problem hos barn med språkstörning [Grammatical problems in children with language impairment]. In U. Nettelbladt, & E-K. Salameh (Eds.), *Språkutveckling och språkstörning hos barn. Del I – Fonologi, grammatik, lexikon [Language development and language impairment in children Part I – Phonology, grammar, lexicon](*pp. 171–198). Lund, Sweden: Studentlitteratur AB.

International Phonetic Association (IPA). (1999). *The Handbook of the International Phonetic Association.* Cambridge: Cambridge University Press.

International Phonetic Association (IPA). (2005). The International Phonetic Alphabet (revised to 2005). Cambridge:Cambridge University Press. http://www.langsci.ucl.ac.uk/ ipa/IPA_chart_© 2005.pdf

Jessen, E. C., Colver, A., Mackie, P. C., & Jarvis, S. (2003). Development and validation of a tool to measure the impact of childhood disabilities on the lives of children and their families. *Child: Care, Health and Development*, *29*, 21–34.

Johannisson, T.B., Wennerfeldt, S., Havstam, C., Naeslund, M., Jacobson, K., & Lohmander A. (2009). The Communication Attitude Test (CAT-S): Normative values for 220 Swedish children. *International Journal of Language and Communication Disorders*, *44,* 813–825.

Kent, R. D. (1996). Hearing and believing: some limits to the auditory-perceptual assessment of speech and voice disorders. *American Journal Speech Language Pathology*, *5*, 7–23

Kim, H., Martin, K., Hasegawa-Johnson, M., & Perlman, A. (2010). Frequency of consonant articulation errors in dysarthric speech. *Clinical Linguistics and Phonetics*, *24* , 759–770 .

King, G., McDougall, J., DeWit, D., Petrenchik, T., Hurley, P., & Law, M. (2009). Predictors of change over time in the activity participation of children and youth with physical disabilities. *Child Health Care*, *38*, 321–351.

Krägeloh-Mann, I. (2004). Imaging of early brain injury and cortical plasticity. *Experimental Neurology*, *190,* 84–90.

Lagerberg,T.B., Åsberg, J., Hartelius, L., & Persson C. (2014). Assessment of intelligibility using children's spontaneous speech: methodological aspects. *International Journal of Language & communication Disorders*, *49*, 228–239. doi: 10.1111/1460-6984.1206

Larsson, M., & Dahlgren Sandberg, A. (2008). Memory ability in children with complex communication needs. *Augmentative and Alternative Communication*, *24*, 139–148.

Law, M., Haight, M., Milroy, B., Willms, D., Stewart, D., & Rosenbaum, P. (1999). Environmental factors affecting the occupations of children with physical disabilities. *Journal of Occupational Science*, *6,* 102–110.

Lee, J., Hustad, K.C., & Weismer, G. (2014). Predicting speech intelligibility with a multiple speech subsystems approach in children with cerebral palsy. *Journal of Speech, Language, and Hearing   Research. 57*, 1666–1678. doi: 10.1044/2014_JSLHR-S-13-0292

Lewis, C. (1994). Episodes, events and narratives in the child's understanding of mind. In C. Lewis, & P. Mitchell (Eds.). *Children's early understanding of mind: Origins and development.* (pp. 457–488). Hove, UK: Lawrence Erlbaum Associations Ltd.

Liégeois, F. Mayes, A., &  Morgan, A. (2014). Neural Correlates of Developmental Speech and Language Disorders: Evidence from Neuroimaging. *Current Developmental Disorder Report*, *1*, 215–227. doi: 10.1007/s40474-014-0019-1

Liégeois, F. J., & Morgan, A.T. (2012). Neural bases of childhood speech disorders: lateralization and plasticity for speech functions during development. *Neuroscience & Biobehavioral Reviews, 36,* 439–458.

Lohmander, A., Borell, E., Henningsson, G., Havstam, C., Lundeborg, I., & Persson, C. (2005). SVANTE – Svenskt artikulations- och Nasalitets Test [Swedish Articulation and Nasality Test], Lund, Sweden: Studentlitteratur.

Lohmander, A., Borell, E., Henningsson , G., Havstam, C., Lundeborg , I., & Persson, C. (2014). SVANTE Svenskt artikulations- och Nasalitets Test [Swedish Articulation and Nasality Test] (2nd Ed.), Lund, Sweden: Studentlitteratur.

Martinez-Biarge M., Diez-Sebastian, J., Wusthoff, C.J., Lawrence, S., Aloysius, A., Rutherford, M.A., Cowan, F.M. (2012). Feeding and communication impairments in infants with central grey matter lesions following perinatal hypoxic-ischaemic injury. *European Journal of Paediatric Neurology,16,* 688–696.

McCormack, J., McLeod, S., McAllister, L., & Harrison, L. J. (2010). My speech problem, your listening problem, and my frustration: The experience of living with childhood speech impairment. *Language, Speech, and Hearing Services in Schools, 41,* 379–392. doi:10.1044/0161-1461 (2009/08-0129).

Mc Fadd, E., & Hustad, K. C. (2013). Assessment of social function in four-year-old children with cerebral palsy. *Developmental Neurorehabilitation*, *16,* 102–112.

Mc Tear, M.F. (1985). Developing conversation in young children. *Child Language Teaching and Therapy, 1,* 162–171.

Mei, C. Reilly, S. Reddihough, D. Mensah, F., & Morgan, A. (2014). Motor speech impairment, activity, and participation in children with cerebral palsy. *International Journal of Speech-Language Pathology*, *16*, 427–435.

Mei, C., Reilly, S., Reddihough D., Mensah, F., Green, J., … Morgan, A.T. (2015). Activities and participation of children with cerebral palsy: parent perspectives. *Disability and Rehabilitation, Jan14*, 1-10. [Epub ahead of print].

Miller, C. A. (2004). Developmental Relationships Between Language and Theory of Mind. *American Journal of Speech-Language Pathology*, *15*, 142–154.

Miller, N. (2013). Measuring up to speech intelligibility. *International Journal of Language and Communication Disorders, 48*, 601–612.

Milner, B. (1971). Interhemispheric differences in the localization of psychological processes in man. *British Medical Bulletin, 27*, 272–277.

Miniscalco, C., Hagberg, B., Kadesjö, B., Westerlund, M., & Gillberg, C. (2007). Narrative skills, cognitive profiles and neuropsychiatric disorders in 7 and 8-year-old children with late developing language. *International Journal of Language and Communication Disorders*, *42,* 665–681.

Morgan, A.T. (2015). Innovative assessment reveals speech production and language comprehension are dissociable skills in severe cerebral palsy. *Developmental Medicine & Child Neurology*, *57*, 209–216

Morgan, A.T., Liégeois, F., Liederkerke, C., Vogel, A.P., Hayward. R., Harkness, … , Vargha-Khadem, F. (2011). Role of cerebellum in fine speech control in childhood: persistent dysarthria after surgical treatment for posterior fossa tumour. *Brain and Language 117*, 69–76.

Netsell, R. (1969). Evaluation of velopharyngeal function in dysarthria. *Journal of Speech and Hearing Disorders, 34*, 111–122.

Nettelbladt U., Håkansson G., & Salameh E-H. (2007). Specifik intervention av fonologi, grammatik och lexicon. [Specific intervention of phonology, grammar and lexicon]. In U. Nettelbladt, & E-K. Salameh (Eds.), *Språkutveckling och språkstörning hos barn. Del I – Fonologi, grammatik, lexikon [Language development and language impairment in children Part I – Phonology, grammar, lexicon](*pp 289-309). Lund, Sweden: Studentlitteratur AB.

Norbury, F.C., & Bishop, D. (2003). Narrative skills of children with communication impairments. *International Journal of Language and Communication Disorders 38*: 287–313.

Nordberg, A., Carlsson, G. & Lohmander, A. (2011). Electropalatography in the description and treatment of speech disorders in five children with cerebral palsy. *Clinical Linguistics & Phonetics*, *25*, 831–852.

Oliver, M. (1986). Social policy and disability: Some theoretical issues. *Disability, Handicap and Society, 1*, 5–18.

Parkes, J., Hill, N., Platt, M.J. & Donnelly,C. (2010). Oromotor dysfunction and communication impairments in children with cerebral palsy: a register study. *Developmental Medicine & Child Neurology, 52*, 1113–1119.

Pennington, L. (1999). Assessing the communication skills of children with cerebral palsy: does speech intelligibility make a difference? *Child Language Teaching and Therapy*, 15, 159–169.

Pennington, L., Goldbart, J., & Marshall, J. (2005). Direct speech and language therapy for children with cerebral palsy: findings from a systematic review. *Developmental Medicine & Child Neurology, 47*, 57–63.

Pennington, L., Miller, N., Robson, S., & Steen, N. (2010). Intensive speech and language therapy for older children with cerebral palsy: a systems approach. *Developmental Medicine & Child Neurology*, 52, 337–344.

Pennington, L., Roelant, E., Thompson, V., Robson, S., Steen, N., & Miller, N. (2013). Intensive dysarthria therapy for younger children with cerebral palsy. *Developmental Medicine & Child Neurology, 55*, 464–571.

Pennington, L., Virella, D., Mjoen, T., da Graca Andrada, M., Murray, J., Colver, A., … de la Cruz J. (2013). Development of The Viking Speech Scale to classify the speech of children with cerebral palsy. *Research in Developmental Disabilities*, *34,* 3202–3210.

Platt, L. J., Andrews, G., & Howie, P. (1980). Dysarthria of adult cerebral palsy: II. Phonemic analysis of articulation errors. *Journal of Speech and Hearing Research*, 23, 41–55.

Raven, J. C., Court, J. H., & Raven, J. (1986). *Raven's progressive matrices and Raven's coloured matrices*. London: HK Lewis.

Regionalt vårdprogram. (2014). [regional care program cerebral palsy]. In Tedroff, K., & Wide K. (Eds.) Stockholm: Stockholm County Council.

Renfrew, C. (1997). *Bus Story Test – A Test of Narrative Speech*, 4th edition, Bicester, Oxon: Winslow Press.

Ronen, G.M., Streiner, D.L., & Rosenbaum, P. (2003). Health-related quality of life in children with epilepsy: development and validation of self-report and parent proxy measures. *Epilepsia*, *44*, 598–612

Rosenbaum, P., Paneth, N., Leviton, A., Goldstein, M., Bax, M., Damiano, D., … Jacobsson, B. (2007). A report: the definition and classification of cerebral palsy April 2006. *Developmental Medicine & Child Neurology, Supplement, 49*, 480.

Salame, P., & Baddeley, A. (1982). Disruption of short term memory by unattended speech: Implications for the structure of working memory. *Journal of Verbal Learning and Verbal Behavior*, *21*, 150–164.

Seme, E., Wiig, E. H., & Secord, W. A. (2004*). Clinical Evaluation of Language Fundamentals (CELF)*. San Antonio, TX: Pearson.

Schiariti, V., Sauve, K., Klassen, A.F., O'Donnell, M., Cieza, A., & Masse, L.C. (2014). 'He does not see himself as being different': the perspectives of children and caregivers on relevant areas of functioning in cerebral palsy. *Developmental Medicine & Child Neurology*, 56, 853-861.

Shriberg, L.D., Austin, D., Lewis, B.A., McSweeny, J. L., & Wilson, D. L. (1997). The percentage of consonants correct (PCC) metric: Extensions and reliability data. *Journal of Speech, Language and Hearing Research*, *40*, 708–722.

Shriberg, L.D., & Kwiatkowski, J. (1982). Phonological disorders III: A procedure for assessing severity of involvement. *Journal of Speech and Hearing Disorders*, *47*, 242–256.

Sigurdardottir, S., & Vik, T. (2011). Speech, expressive language, and verbal cognition of preschool children with cerebral palsy in Iceland. *Developmental Medicine & Child Neurology*, *53*, 74–80.

Smith, M., Dahlgren Sandberg, A., & Larsson, M. (2009). Reading and spelling in children with severe speech and physical impairments: a comparative study. *International Journal of Language & Communication Disorders*, 44, 864–882.

Smith, A., & Goffman, L. (2004). Interaction of language and motor factors in speech production. In B. Maasen, R. D. Kent, H. F. M. Peters, P. H. H. M. van Lieshout, & W. Hulstijn (Eds.). *Speech Motor Control in Normal and Disordered Speech* (pp. 225–252) Oxford: University Press.

Slaughter, V., & Repacholi, B. (2003). Introduction: Individual differences in theory of mind. What are we investigating? In B. Repacholi, & V. Slaughter (Eds.), *Individual differences in theory of mind. Implications for typical and atypical development* (p.1). Hove: Psychology Press.

Stanley, F. J., & Watson, L. (1992). Trends in perinatal mortality and cerebral palsy in Western Australia, 1967–1985. *British Medical Journal, 304***,** 1658–1663.

Stothard, S. Snowling, M. Bishop, D.V.M., Chipcase, B., & Kaplan, C. (1998). Language-impaired preschoolers. A follow-up into adolescence. *Journal of Speech, Language and Hearing Research, 41*, 407–418.

Stubbs, M. (1983). *Discourse analysis: The sociolinguistic analysis of natural Language*. Chicago, IL: University of Chicago Press.

Sullivan, K., Zaitchik, D., & Tager-Flusberg, H. (1994). Preschoolers can attribute second order beliefs. *Developmental Psychology, 30*, 395–402.

Surveillance of Cerebral Palsy in Europe. (2000). Surveillance of cerebral palsy in Europe: A collaboration of cerebral palsy surveys and registers (SCPE). *Developmental Medicine & Child Neurology*, *42*, 816–824.

Svensson, Y., & Tuominen-Eriksson, A-M. (2002). Bussagan [Bus Story]. Gothenburg, Sweden: Specialpedagogiska institutet Läromedel.

Theunissen, N.C.M., Vogels, T.G.C., Koopman, H.M., Verrips, G.H.W., Zwinderman, … Wit J.M. (1998). The proxy problem: child report versus parent report in health-related quality of life research. *Quality of Life Research, 7*, 387–397.

Thirumanickam, A., Raghavendra, P., & Olsson C. (2011). Participation and social networks of school-aged children with complex communication needs: a descriptive study. *AAC: Augmentative and Alternative Communication, 27*, 195–204.

UN GENERAL ASSEMBLY (UN), 1989, Convention on the Rights of the Child (20 November 1989, United Nations, Treaty Series, vol. 1577, p. 3) (available at: http://www.refworld.org/docid/3ae6b38f0.html) (accessed 7 July 2014).

Van Dijk, T. (1981). *Studies in the pragmatics of discourse*. The Hague: Mouton.

Ward, R. Leitão, S., & Strauss, G. (2014). An evaluation of the effectiveness of PROMPT therapy in improving speech production accuracy in six children with cerebral palsy. *International Journal of Speech-Language Pathology*, *16,* 355–371.

Watson, L., Blair, E., & Stanley, F. (2006). *Report of the Western Australian Cerebral Palsy Register to birth year 1999*. Perth: TVW Telethon Institute for Child Health.

Wechsler, D. (1999). *Wechsler Intelligence Scale for Children, Swedish standardization*. Stockholm, Sweden: Psykologiförlaget.

White, D. A., Craft, S., Hale, S., & Park, T. S. (1994). Working memory and articulation rate in children with spastic diplegic cerebral palsy. *Neuropsychology*, *8*, 180–186.

White-Koning M., Arnaud, C., Dickinson, H.O., Thyen, U., Beckung, E., Fauconnier, J., … Colver, A. (2007). Determinants of Child-Parent Agreement in Quality-of-Life Reports: A European Study of Children With Cerebral Palsy. *Pediatrics, 120*, 804–814.

Wilcox, J.M., & Woods, J. (2011). Participation as a basis for developing early intervention outcomes. *Language, Speech, and Hearing Services in Schools*, *42,* 365–378.

Woolfson, L. (2004). Family well-being and disabled children: A psychosocial model of disability-related child behaviour problems. *British Journal of Health Psychology, 9,* 1–13

World Health Organization. (1993). Measurement of Quality of Life in Children. Geneva, Switzerland: Division of Mental Health, World Health Organization.

World Health Organisation. (2001). *The International Classification of Function, Disability and Health (ICF)*. Geneva, Switzerland: http://who.int/classifications/icf/en/

World Health Organisation. (2001). *The International Classification of Function, Disability and Health Version for Children and Youth (ICF-CY)*. Geneva, Switzerland:

Workinger, M.S., & Kent, R.D. (1991). Perceptual analysis of the dysarthrias in children with athetoid and spastic cerebral palsy. In C. A. Moore, K.M. Yorkston &, D.R. Beukelman (Eds.), *Dysarthria and Apraxia of Speech: Perspectives on Management* (pp.109-126). Baltimore, Maryland: Paul Brookes.

Yorkston, K.M., Beukelman, D.R., Strand, E.A., & Hakel, M. (2010). Perspectives on Motor Speech Disorders. A Clinical Point of View. In *Management of motor speech disorders in children and adults* (p. 4) 3rd ed. Austin, TX: Pro-Ed.

Åsberg Johnels, J., Hagberg, B., Gillberg, C., & Miniscalco, C. (2013). Narrative retelling in children with neurodevelopmental disorders. Is there a role for nonverbal temporal sequencing skills? *Scandinavian Journal of Psychology, 54,* 376–385.

Öhrvall, A.M., Eliasson, A.C., Löwing, K., Ödman, P., Krumlinde-Sundholm, L. (2010). Self-care and mobility skills in children with cerebral palsy, related to their manual ability and gross motor function classifications. *Developmental Medicine & Child Neurology*, *52*, 1048–1055. doi: 10.1111/j.1469-8749.2010.03764