OUTLINES - CRITICAL PRACTICE STUDIES

• No. 1 • 2010 • 3-23 •
http://www.outlines.dk

An Eye for Possibilities in the Development of Children with Cerebral Palsy: Neurobiology and Neuropsychology in a Cultural-Historical Dynamic Understanding

Louise Bøttcher

Department of Learning, The Danish School of Education, University of Aarhus

Copenhagen, Denmark

E-mail: boettcher@dpu.dk

Abstract

Taking children with Cerebral Palsy (CP) as an example, the article seeks an understanding of children with disabilities that connects neuropsychological theories of neural development with the situated cognition perspective and the child as an active participant in its social practices. The early brain lesion of CP is reconceptualised as a neurobiological constraint that exists in the relations between the neural, cognitive and social levels. Through a multi-method study of two children with CP, it is analysed how neurobiological constraints arise, evolve and sometimes are resolved through local matches between the child and its social practices. The result is discussed as support of a developmental science approach that includes processes at the social practice level along with knowledge of biological processes.

Keywords

Disability; Cerebral palsy; Neuropsychology; Child, Development; Cognitive functions; Learning; Brain lesions; Situated cognition

Introduction

Many types of disabilities are caused by defects to the neural system. Among these, children with cerebral palsy (CP) constitute a large and heterogeneous group, some are very disabled and cannot move around or speak without help from different types of remedies, others are nearly indistinguishable from children without CP and a large group

of them fall in between. As a disability, CP is associated with both cognitive and social impairments along with the motor impairments that are its main characteristic. However, most research in the development of children with CP and other developmental disabilities has focused on either neurobiology or social difficulties. Research in neurobiology advance our understanding of the biological differences between typical children and children with congenital or acquired neurological abnormalities, but the wider consequences of the differences are seldom explicated (E.g. Krägeloh-Mann et al. (2002) on CP, Korkman et al. (2003) on prenatal alcohol exposure and Anderson et al. (2004) on early-treated phenylketonuria). Research in social difficulties document differences in social functioning, but explanations of the differences found are often tentative and in the direction of ascribing them to the brain lesion and subsequent cognitive and behavioural difficulties (E.g. children with CP: Yude & Goodman, 1999; Schenker at al., 2005. Children with prenatal alcohol exposure: Schonfeld et al., 2006). Another line of research conducts qualitative or quantitative investigations of children with special needs and their participation in social practices, but without including the possible impact of the specific difficulties, the child might have due to its particular neurobiological disability (E.g. Mehan et al., 1986; Davis & Watson, 2001; Eriksson et al., 2007). Is it possible to approach and understand the development of children with disabilities in a way that includes biological, psychological, and cultural-historical contributions and the interactions between them?

In this article, the role of neurobiology and neuropsychology is approached through a study of children with CP. Focusing on the better functioning part of the children, who are able to move around by themselves with or without remedies, have a normal general level of cognitive functioning and complete normal school, only half are able to gain employment as adults (Michelsen et al., 2005). Several reasons for this low employment rate have been considered. One of these is the presence of specific cognitive impairments despite normal general cognitive functioning. For decades, CP has mainly been approached as a motor impairment, whereas cognitive impairments have received much less attention. If the cognitive impairments go unnoticed, they might impact on the learning ability and school performance of children with CP and later on the learning impairments might restrict the possibilities for secondary education and finally the employment rate of adults with CP (Michelsen et al., 2005). However, developmental trajectories of children with and without CP differ from each other not only because of the motor and cognitive impairments associated with CP, but because the physical world and the social institutions are first and foremost intended for children with normal psychophysical constitutions. Through the concept of disontogenesis, Vygotsky pointed to the particular problem of a fundamental incongruence between the psychological development of the child with a disability and the organisation of the social practices. The mismatch between the biological conditions and the cultural-historical conditions for development completely reorganizes the developmental trajectory of the child (Vygotsky, 1993) What emerge is the necessity of creating special cultural tools suitable to the psychological make-up of such a child, or help them mastering common cultural forms with the help of special pedagogical methods (Vygotsky, 1993).

If the remediation is to be effective, a thorough knowledge of the particular child's pattern of cognitive impairments is helpful in the creation of special tools or the organisation of pedagogical methods. Developmental neuropsychology offers concepts and methods to investigate and describe the cognitive problems, many children with CP face (e.g. Pirila et

al., 2004; Bottcher et al., in press). Moreover, neuropsychological research has specified the possibilities of plastic reorganisation in the immature brain (Stiles et al., 2005; Stiles, 2000) and how the plasticity might be limited for children with particular types of CP (Kuhnke et al., 2008; Juenger et al., 2007). The neurobiological angle seems necessary to understand the problems of learning and cognitive development, children with CP face, but is insufficient at its own, because it focuses mainly on the biological conditions for development (Although situational constraints are acknowledged within the clinical work on intervention and rehabilitation of individuals with neurobiological based problems). The developmental neuropsychological and the cultural-historical activity perspective supplements each other. Still, the divergence between the developmental neuropsychological and the cultural-historical activity approach keep challenging the union of biological and cultural approaches to the development and learning of children with CP. The aim of the article is to formulate a dynamic understanding of the child and the environment as dialectically interdependent that *includes* the neurobiological conditions of the child in the developmental dynamic. The particular focus will be on the learning and cognitive development of children with CP that takes place in school.

The article starts out by considering multilevel models as a valid approach to reconcile the developmental neuropsychological and cultural-historical activity approaches. Vygotsky's concept of disontogenesis is considered in relation to the cognitive development of children with cerebral palsy, supplemented by the situated cognition approach and the concept of cultural tools. Next, the development of children with cerebral palsy is specified in regard of both biological processes such as neural plasticity and gradual modularisation at the biological level and local age-graded norms for development and the child's motives at the psychological and social practice levels. To enable analyses of the dialectic between levels, the brain lesion is reconceptualised as a neurobiological constraint. In the following section, it is shown through empirical examples how neurobiological constraints can develop, move and in some cases resolve again. The article is ended by a discussion of the role of neurobiology in understanding children's development, both in regard of children with and without disabilities.

A multi-level framework

Multilevel approaches are often suggested in research that seeks to connect biological, cognitive and social aspects of development, although different authors accentuate different advantages of multilevel research approaches. The multilevel approach applied in this article is mainly inspired by Gottlieb (2007; 2002; Gottlieb et al., 1998) and Valsiner (2006). Gottlieb's (2007; 2002) multilevel model constitutes an alternative to a predeterministic approach to understand human development. His theory of development as probabilistic epigenesis emphasizes the reciprocity of influences within and between levels in the development of an organism. The main point of the approach by Gottlieb is that the whole system of multilevel processes becomes the general cause for development. His model has been taken up by Karmiloff-Smith (1998; 2007), who has used it to track how an early biological defect in the cerebral system affects the progressive localisation of neural circuits and the wider developmental trajectory of the child. Valsiner (2006) also adopted the model in order to describe the systemic rather than linear causality of human development.

The idea of a multilevel approach is that the model functions as an organising device (Valsiner, 2006) in the analysis of how activity at one level affects activity at the other levels in a systemic causality. In this article (and elsewhere (Overton, 2003; Valsiner, 2006)) the model has been modified; a separate level of psychological functions has been added to serve the theoretical needs of a psychological approach. Also, the level of genetic activity has been left out to reduce the complexity.

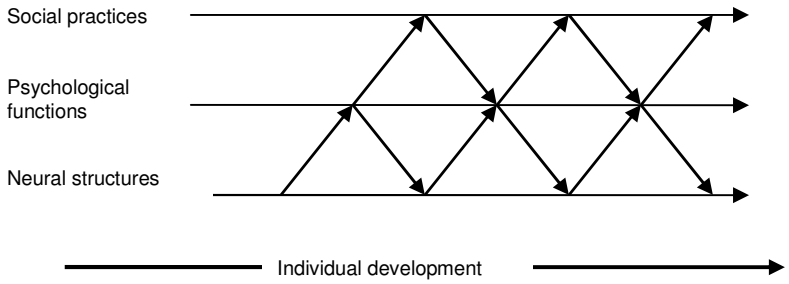

Figure 1: A multilevel model (Adapted from Gottlieb (2002)).

The inclusion of a separate level of psychological functions is necessary in order to understand the role of human agency in children's development. The particular activity of a child originates from motives that emerge and develop from changes in the relation between the child and its social practices (Leontiev, 1977). Hedegaard (2002) has elaborated further on the motive concept by supplementing it with Elkonin (1972) among others. In this approach, motives are understood as aspects of the child's personality building on earlier positive experiences of taking part in activities. Motives are both associated with the social practice and the previous motives associated with that practice. New motives arise when the child becomes aware of a disparity between its present situation and a desirable future one *and* real change in type of activity take place or is possible (Hedegaard, 2002). The point is to capture the dialectical relation between the child's activity and the social practice. Motives develop and change as the cognitive and emotional abilities of the child grows, leading the child to new forms of acting and participation in new institutional settings; thereby providing the child with new cognitive and emotional challenges. As such, motives and the activities, they give rise to, are an integrated part of development.

The Cultural-historical Approach to Development

Vygotsky (1993) made a distinction between natural and cultural development, where natural development is the physical development guarded by biological laws, while the cultural development covers the socialisation process, during which the child acquires cultural tools and develop new functional psychological systems that enable them to participate in still more complex socially shared interactions. During the development of a typical child, the socialisation process is usually fused with the process of biological maturation. Organic development of the brain, of the body and of the speech apparatus supports the cognitive and social development. In the typical child only one line of development is seen, because the two lines of development – natural and cultural – are fused with each other (Vygotsky, 1993; Scribner, 1997).

But this will not be the case for the child with a disability. Here the two lines of development often diverge, because the physical world and the social institutions; the social practice level, are first and foremost intended for children with normal psychophysical constitutions. The mismatch between the biological conditions and the cultural-historical conditions for development brings conflicts between different levels of development out in the open.

Even though Vygotsky's cultural-historical approach mentions two lines of development instead of three, his developmental logic has much in common with the multilevel approach as formulated by Gottlieb and Valsiner. The natural line of development can be placed at the biological level in the multilevel model. The cultural line of development is placed at both the psychological and the social practice level and their reciprocal interrelations. The dialectic between Vygotsky's two lines of development is analogous to the idea of the whole multilevel system as the general cause of development, because development entails the coordination of structures and processes at different levels (Valsiner, 2006).

Focusing on the development of cognitive functions and impairments, the multilevel perspective would agree with a broad approach to cognitive functions that includes activity at all three levels. Such a view would be in line with the particular position within the situated cognition perspective that maintains that individuals possess competencies and skill systems, which are acquired and developed through activities in social practices that afford particular distributed cognitions (Luria, 1971; Scribner, 1997; Salomon, 1993). Each individual engages in the social practice with his or hers specific qualities, interacts with the distributed cognitive system, and develops the social practice as well as their own competencies and skills.

The situated cognition approach is closely related with the concept of cultural tools (Daniels, 2008). Cultural tools are material and symbolic artefacts that regulate and transform both the psychological functions and the environment. Cultural tools are the knowledge and skills of the social practice traditions, individuals acquire through their participation in different cultural practices (Cole & Engeström, 1993). What makes tools particular interesting in relation to children with biological defects is the supposition that specialised cultural tools and pedagogical strategies within the distributed cognitive system can enable cognitive development of the child that was otherwise constrained (Vygotsky, 1993; Kozulin & Gindis, 2007). In the following, this assumption will be explored in relation to children with the developmental disorder cerebral palsy (CP).

Cerebral Palsy

Cerebral Palsy (CP) is a group of developmental disorders most recognizable by their disturbances of movement and posture. The disorders are due to an early non-progressive lesion of the central nervous system and the severity of the symptoms varies substantially. By tradition, CP is classified according to type of motor symptoms (*spastic*, *dyskinetic* or *ataxic)* and the location of impairment (*Hemiplegia*: arm and leg in one side of the body, *diplegia*: mainly the legs and to a lesser extent the arms or *tetraplegia*; all four extremities). The diagnosis of CP has been used since 1861 (at first as "Little's disease"), but the definition has been revised several times as more knowledge about the disorder has been gained. The main symptoms of CP are disorders of movement and posture, but other symptoms are often seen in addition; disturbances of sensation (vision or hearing) and perception (understood as the capacity to incorporate and interpret sensory information),

global or specific cognitive difficulties, communication disorders, and seizures (Bax et al., 2005). CP has a prevalence of 2-3 pr 1000 births which makes it the most common motor impairment in children (Uldall et al., 2001).

At the biological level, CP is first and foremost associated with two main types of cerebral lesion, even though many variations are seen both in the location and extent of the damage. The first type of lesion is damage to the white matter along the lateral ventricles of the brain, often in both hemispheres, and often specifically in the areas subserving motor functions and visual-perceptual functions (Krageloh-Mann et al., 1995; Guzzetta et al., 2001). This type of lesion might also affect other pathways of general information processing in the brain (Anderson, 2007) with potential consequences to the development of different cognitive functions (Fennell & Dikel, 2001; Pirila et al., 2004). The second type of lesion is cortical-subcortical lesions caused by an early ischemic incident. This type of lesion is often limited to one hemisphere, affecting motor and adjacent cerebral areas of one side only (Cioni et al., 1999).

At the psychological and social practice levels, empirical studies have associated CP with a higher prevalence of psychiatric disorders (Goodman & Graham, 1996), learning disorders (Frampton et al., 1998), problems in peer relations (Yude et al., 1998; Nadeau & Tessier, 2006) and restrictions in participation in day-to-day activities in childhood (Ostensjo et al., 2003).

The development of motor, cognitive, and social functioning of the child with CP will be affected by the brain lesion at the biological level. Supplementing this point of view with the perspective of situation cognition, a dialectical approach to the relation between biology, cognition and social practices needs to include all three levels.

The Biological Level: Possibilities and Constraints

Children's activity is dependent on possibilities within the neural basis. Simultaneously, the activity of the child impacts on the neurobiological possibilities through experience-dependent changes in the neural system (Greenough et al., 1987). The necessity of neurobiological development on cognitive and social development is similar in children with and without neurodevelopmental disorders. Children in general are more or less smart, talented for music, language, math… Looking at the biological level, why does the presence of a brain lesion completely alter the developmental trajectory and become a significant constraint on the child's cognitive development?

To answer this, it is necessary to include knowledge of neurobiological and neuropsychological development. As a start, the biological conditions are never stable. It is a fundamental property of the neural system to change, generally in an adaptive way, in response to external demands (Stiles, 2000). The changes are seen in both the structure and the functioning of the brain. During normal neural development, an abundance of neurons and connections are lost due to competition for resources. Some cells and connections are lost due to endogenous processes, but the major part of the elimination process in the system happens in response to the activity of the child, thereby sculpturing the cerebral system. This means that cognitive development and learning are active processes. It is the active use of psychological functions such as cognition and emotions in thinking and acting that in the end determines, which neural potentials that are turned into actual, lasting though changeable, neural pathways. The mature neuropsychological functioning, with relatively isolated modules for different cognitive functions, is the result

of a process of gradual modularisation accomplished through neurons biased for processing certain types of information and the child's employment of them (Bishop, 1997). This active fine-tuning of the neural system follows much the same process in children with CP. However, the trajectory of neural development might differ because of the impact of the early brain lesion. Bilateral, diffuse or widespread lesions are generally assumed to limit plasticity (Juenger et al., 2007; Kuhnke et al., 2008; Nass, 2002). The location of the lesion is also crucial. For example, lesions to areas typically serving language (Broca's and Wernicke's areas) set off language transfer to other areas, whereas lesions to areas serving visuo-spatial functions are associated with less extensive, intrahemispheric transfer of functions and ongoing difficulties in the cognitive area (Stiles et al., 2003). While the transfer of language is beneficial to the individual given the great importance of language in human social life, the overall effect might be a lower level of cognitive functioning, because the cognitive system as a whole is served by a reduced neural system. Even though the biological processes in many ways are similar in children with and without brain lesions, the biological development of children with brain lesions is constrained compared to children with intact brains.

The Psychological and Social Practice Levels: Motives and Expectations

The psychological functions and activity of a child take place in particular social practices. The child comes to understand more and becomes able of participating in still new practices. Children's developmental trajectories through nursery, kindergarten and school is a movement through different practices organised around our expectations of what a child is able to do and learn at certain ages and what we would like the children to do and learn at certain ages (Valsiner, 1997). The significance of the child's biological development is built-in in age-graded social and cultural practices. As such, the developmental trajectory of children is a complex interaction between biological development and the child's participation in social and cultural practices. The match between a practice and the child's ability to act in the practice is not naturally given, but can be seen as the result of an ongoing development of the organisation of the practice and the development of the children participating in the practice.

The child with CP act in a physical world and within social institutions that are first and foremost intended for children with normal psychophysical constitutions. Due to their brain lesion, many children with CP differs from their peer in ways, which cause a breakdown in the usual match between age and ways of organising different social practices. As an example; When the child begins day care in the nursery around the age of one, as many children in Denmark do, the social practice in the nursery is organised around the expectation that many of the children are not able to move themselves to the playground or on small trips. When moving to kindergarten around the age of three, this has changed. Now the practice is organised around a common expectation that each child is able to move around by itself. Due to their early brain lesion, many children with CP might differ in this aspect. At the age of three, many of them are not able to move around by themselves. This affects their participation in the daily activities such as free play or a trip to the forest.

The match between biological and social development is about readiness of the child to meet particular developmental challenges. New accomplishments and abilities are not

handed over to the child. Incongruities between the social practice and the abilities and potential abilities of the child are diminished through children's development of new abilities, development of the learning practice or both. The biological defect of the child with CP presents the child with constraints on its development not only at the biological level, but at the social practice level too, because it is much more difficult or even impossible for the child to develop to meet the built-in developmental challenges within the cultural-historical practices.

Cultural values of what constitutes a good life and appropriate development are reflected in institutional practices and through the participation of the child in social institutions, the cultural values become conditions for the development of child motives. Motives are related to the goals of children's activities in different practices over an extended period of time (Hedegaard, 2002). Because the motives of the child arise from both personal experiences and the social institutions the child is living in (Hedegaard, 2002), the child with CP can develop motives for activities that are or seem to be out of reach for that child from an adult perspective. For example the child with a walker, who wants to run and play soccer like the rest of the boys in his class. The developmental challenge creates a possible conflict between the motive for a particular activity and the ability of the child to carry out the activity, given its biological defect. To enable analyses of how such a conflict affects development and possibly moves the system as a whole, we need to analyse the connections between the different levels and describe the dialectical dynamic between them.

The Brain Lesion as a Neurobiological Constraint

Talking about a brain lesion stresses the damage to the neural tissue and as such an understanding confined to the biological level. In children with CP, the brain lesion can give rise to motor impairments, perceptual impairments and cognitive impairments. Departing in Vygotsky's concept of disontogenesis, each of the primary impairments needs to be understood in the practices, the child acts in, how the practices affects the development of motor functions, perception and cognition, how each practice is affected by the impairments of the child and which developmental restrictions or movement of constraints the impairments-in-practice give rise to. The presence of a defect or disability in a child reorganises the development of that particular child not only at the biological level, but at the psychological and social practice level too. In order to capture the multi-level nature of the impairment, the brain lesion is reconceptualised as a *neurobiological constraint*. The neurobiological constraint arises from the problematic mismatch and exists in the relations between the biological, the psychological and social practice level. The concept of neurobiological constraints includes both the biological reality of the brain lesion, the motor, perceptual and cognitive impairments as they are expressed in particular social practices and their dialectical relations with child motives and cultural-historical based built-in age-graded expectations to child development and child activity.

Another inspiration in the development of the concept has been Jaan Valsiner and his concept of constraints as developmental regulators. In his theoretical system, the particular activity of an individual is understood as originating from a structural system of outer and inner constraints. The inner constraints are described as multilayered semiotic constructions of internalised outer constraints (Valsiner, 1997). In contrast, neurobiological constraints are biological based, but in line with Valsiner's theoretical perspective always seen and analysed through their social moderation and mediation.

They act as regulators of the development in and through activity in practice in a dialectical relation. The neurobiological constraint is an analytical concept that accentuates the contextuality of the biological defect; how the child with a brain lesion is always acting situated in particular practices. The point is to enable analyses of how neurobiologically based problems emerge and move within the dynamic developmental system.

Conflicts between Levels in the Multilevel Developmental System

During development, the biological constitution of a child provides new opportunities or places constraints on the development of cognitive functions, and through this, on the activity of the child. At the same time, the activity of the child feeds into the neural and cognitive development of the child through learning and plasticity. This process of ongoing constraining and emerging activity is potentially conflictual. Within the cultural-historical understanding of development, conflicts are defined as processes that arise in the interaction between the maturing biological capacities and changes in the institutional practices and result in changes in the social situation of the child. Conflicts consist of three parts; deconstruction, where the present relation between the child and the social practice is brought out of balance, construction where a new relation between the child and the social practice is emerging and mastering, where the new competencies, strategies and motives reorganises the child and its activity as a whole towards a new synchrony with the social practices (Vygotsky, 1998). Conflicts are generally thought of as a common and necessary condition for development. They are constructive in as much as they function as the fuel of development that pushes both child and social practice towards a new synchrony. If the child with CP who wants to play soccer is able to accept his imperfect activity in the beginning, the soccer activity might push the biological constraint and gradually improve in quality. At the same time, the child with CP must be granted the opportunity to play despite his poorer performance, not just once, but on a regular basis. A developmental conflict can only promote development in so far as a new synchrony is attainable within the present situation of the multilevel developmental system of the child with CP. However, the mismatch between the biological and social line of development of a child with a biological defect can give rise to conflicts, where development through a new synchrony is not attainable at the level of the child's activity or immediate social setting.

Empirical study

Empirical studies of groups of children with CP have either focused on types of brain lesions (e.g. Krageloh-Mann et al., 1995; Goto et al., 1994), cognitive impairments (e.g. Pirila et al., 2004; Sigurdardottir et al., 2008) or social difficulties (e.g. Nadeau & Tessier, 2006; Yude et al., 1998), but never on the interactions between activity at all three levels. However, to approach a dialectical understanding of the relation between cognitive functions and the activity of the child, it is necessary to consider the institutional practices children with CP live their lives in and in which their neurobiological constraints emerge and evolve. Central among these are schools and their aim of teaching children the cultural-historical practices for thinking and acting, which are considered necessary in order to participate in our society. This applies to children with CP as well, whether they

are placed in mainstream classes, special classes or special schools. The way the learning practices and eventual cognitive remediation are organised might differ between different schools and between mainstream and special education classes, but with the same general aim of independent adult functioning in the present society and according to dominant cultural values. In order to explore the dialectical dynamic between development at the neurobiological level, the psychological level and the level of social practices of a disability such as CP, a small number of children, who had all participated in my quantitative study of cognitive impairments associated with CP (Bottcher et al., in press), were chosen to participate in multi-method case studies combining neuropsychological assessments with qualitative observations or interviews. Knowledge about lesions is inferred from the CP diagnosis and the neuropsychological assessment. Two cases have been chosen for this article.

First, the emergence and development of neurobiological constraints is analysed from the dialectical dynamic between the biological, psychological and institutional levels. Secondly, it is explored how a neurobiological constraint can be resolved.

Even though the cases represent unique examples of children in their everyday practices, the similarity of social institutions such as schools and the learning practices in them and the high incidence of biologically based cognitive and motor impairments of children with spastic CP gives reason to suspect that the situations of the two children are not exceptional, but represent patterns that can be found in other children with CP as well.

Method

All children in the quantitative study were tested with a neuropsychological test battery (*N*= 33). In addition, the primary teacher completed a questionnaire about executive functions (Behaviour Rating Inventory of Executive Function (BRIEF)(Gioia et al., 1996)). In this article, the test results are included as background knowledge and used as guidelines in the interpretation of the capacities of the two children

The case study method was chosen to capture the subjective relations between particular children, their cognitive impairments and the practices, they live in. This method is useful under research conditions over which the researcher has little or no control (Yin, 1994). It allows the examination of children's development in their everyday settings including the relations between different biological and institutional developmental conditions. It allows the inclusion of the perspective of the child along with the perspective of the teachers, and enables documentation of how the participating children contribute to their own social practices under certain biological and social conditions. Furthermore, a multiple cases design was chosen to allow the examination of contrasting patterns along different dimensions; gender, type of CP, motor impairment, class arrangement, social participation in class, cognitive impairments, social impairments. Each case was carefully selected and the selection of cases was theoretically grounded rather than based in sampling logic (Yin, 1994). In the case studies (N= 4), participant observation was chosen as the preferred method to gain knowledge about the child's everyday life at school (Hedegaard & Fleer, 2009). Each child was observed for one week during school.

Two children would not allow class observations and separate interviews with the children and their teachers were done as an alternative. Both children were chosen because I had gained the impression that problematic/challenging conflicts were present in their

everyday functioning in school. As I regarded the inclusion of children with this type of conflicts important, I had to compromise with regard to the specific method.

Both observations and interviews were analysed by identification of repeated sequences of interactions, defined as shared activity in a practice involving two or more persons. Children's intentions were identified as engagements and intentional focus in particular situations. Children's capacities were identified as knowledge and abilities apparent in situations, both in the class room and in the neuropsychological assessment.

During the second level of interpretation, the identified sequences of interactions were used to characterise the learning practices of each of the children. Because motives are related to the goals of children's activities in different practices over an extended period of time, as earlier mentioned, often repeated intentions were assumed to characterise child motives. Neurobiological constraints were traced in conflicts between the capacities of the child, motives and the activity going on in the school practice.

The analysis of the interview differed mostly in the fact that the interviews provided me with *the interviewee's descriptions of* recurring sequences of activities.

Two boys with Cerebral Palsy

The following two cases were chosen for analysis because the contrast between them illustrates how the dynamic between neurobiological and social processes might create neurobiological constraints and eventually dissipate them. The analyses of the two cases are discussed in relation to the incongruence between the biological and social development and the role of neurobiology in understanding child development.

Case 1: Marcus. Marcus is a boy at 10 with cerebral palsy. All his four limbs are affected and to move around, he must either crawl, use his walker or his electric wheelchair. In addition he has a severe visual impairment caused by his brain lesion. Marcus has been placed in a public school with expertise in the education of children with motor disabilities and learning disabilities. The school has both mainstream classes and special classes and from the beginning Marcus was placed in a special class. In the second half of first grade, he began having some of his lessons in the mainstream first grade class. This dual class arrangement continued in second grade, but with increasing problems, and from the beginning of third grade, Marcus' participation in the mainstream class was discontinued. Marcus does not have a helper but the low number of children in Marcus' special class makes it possible for him to receive one-to-one teaching when necessary.

Separate interviews were done with Marcus and his main teacher.

Case 2: Angus. Angus is a boy at 12 with cerebral palsy affecting all four limbs. He is able to walk without any remedies, but uses his three-wheeled scooter for longer distances. Angus' motor impairment includes dysarthria characterised by a weak, high-pitched voice.

Angus attends a mainstream sixth grade class at a small private school, which has a tradition for inclusion of children with disabilities or behavioural problems. Angus was evaluated in kindergarten and the school did express some concern as to whether he was too disabled to be included in their classes. At that time, Angus couldn't walk on his own

and spoke with an almost non-detectable voice. Now he participates in the lessons at much the same conditions as his peers, the only exception being that Angus has his personal laptop and, in some classes, a person that helps him with practicalities such as taking notes from the blackboard.

Angus was observed for one week in school.

Neurobiological Constraints on Learning

At the biological level, Marcus' type of CP is associated with lesions to the white matter in both hemispheres as described earlier, affecting both motor pathways and visual tracts. In addition, the neuropsychological examination point to lesions affecting cerebral areas that serve the development of several specific cognitive functions at the psychological level. Overall, Marcus has a normal level of verbal cognitive functioning, measured with the verbal comprehension index from the Wechsler Intelligence Scale for Children, third version (WISC-III). However, he shows severe problems with visual perceptual analysis such as discrimination between similar shapes or detecting differences in spatial directions. His score in a test of sustained attention is below the normal area. In the BRIEF questionnaire the teacher of Marcus had marked the presence of behaviour that pointed to problems in several areas of executive functions. Executive functions are defined as several related functions that together allow the individual to direct its attention, act flexible and goal-directed (Alexander & Stuss, 2000; Welsh & Pennington, 1988; Powell & Voeller, 2004).

The perceptual and cognitive impairments are mentioned by Marcus' teacher as obstacles to the organisation of Marcus' learning practice. Marcus' perceptual and cognitive impairments impede his ability to learn, first of all because he cannot read ordinary print in a book, secondly because he requires the support of an adult to devise a strategy for solving an exercise and keep focused on the exercise at hand. The teacher finds it difficult continually to find adequate teaching material for Marcus:

> *Teacher: He likes to sit and do math exercises, calculations, on the computer. But, of course, they have to be simple, those on the screen have to be very simple, because otherwise he won't do it. He cannot do it with a lot of different things on the screen, because then he cannot take the picture in. So it is a bit difficult to find programs with variation for him.…*

Marcus' brain lesion has impeded his development of cognitive functions and a neurobiological constraint has emerged. The neurobiological constraint is not stable, but is diminished through the adaptations of teaching material by Marcus' teacher, through Marcus' placement in a special class where one-to-one teaching is an option and through the introduction of a personal computer to Marcus, where teaching material can be scanned into and magnified on the screen. Marcus' learning practice is organised around his need for remedies that diminish the neurobiological constraints arising from his motor and visual difficulties. In the interview, Marcus describes the computer as a learning aid:

> *Marcus: Because I… I get the pages of the book scanned, then you can get it up.*
> *Interviewer: But what does the computer do? Why is it easier to get the pages on the computer than in the book?*
> *Marcus: Because then it becomes bigger.*

In the excerpt, Marcus expresses a very concrete understanding of how one of his neurobiological constraints is moved in a particular situation. However, Marcus' need for remedies has given rise to a new, psychological constraint; his dependence on his teacher. The new goal in the social practice becomes to diminish Marcus' dependence on his teacher. He needs to learn to move the neurobiological constraints on his own:

> *Teacher: And this is one of the things we work on with Marcus. That he, because of his poor vision, he must learn to familiarize himself with asking for those remedies, which are necessary in order for him to see things.*

In order to reach this goal, Marcus needs to generalize from his current, concrete level of understanding; letters can be magnified, to a more general level; What remedies can ease this activity? This mental operation requires the ability to detach oneself from the problem as it presents itself and consider it at a meta-cognitive level; an operation which is considered to belong to the area of executive functions. More specifically, this kind of mental operation requires a flexible approach, in which the child considers and compares the different activity options, monitors it's own progress and alter it's activity if necessary. According to the neuropsychological assessment, this type of mental operation might be particular difficult for Marcus due to his problems with flexible thinking and use of working memory at the psychological level. Still, through repeated, concrete experiences of using aid's at the social practice level, Marcus might reach a more general understanding of his need of different aid's at the psychological level, possibly circumventing his defects at the biological level.

Sometimes neurobiological constraints appear to be immobile from the perspective of the child or the adults working with the child. During Marcus' spring term in second grade, he experiences to become quickly exhausted and when he is tired, his performance level deteriorates substantially. Fatigue is typically seen in relation to brain lesions. The lack of energy becomes an obstacle in his learning activity:

> *Teacher: In math, it became "now you just do what you would like to do, Marcus", because I couldn't get anything out of him. I couldn't get him concentrated about anything. If I tried to show him anything new, he laid himself down across the table at once.*

However, Marcus' fatigue acquires a new meaning if we include activity at the other levels besides the biological. Both Marcus and his teacher relates how playing with friends during recess is important to Marcus. The repeated intention of being part of a friendship group points to social inclusion as a leading motives of Marcus'. In the mainstream class, Marcus experienced to be different from his class mates both during classes; for example he was the only one using a computer, and during recess, when the class mates were engaged in activities that was difficult for Marcus to join due to his motor impairments. So Marcus began to spend a lot of energy walking back and forth between the mainstream class and the special class to ensure he had friends to spend recess with. He also made an effort to hide his difficulties and still does:

Teacher: Yesterday, I was reading with Marcus. He always reads from the computer and I magnified the letters to size 48, which we normally use, and ask him; can you see it, Marcus? Yes, he says and starts to read. But he can only read it, because he had read it at home and then he reaches a word that is difficult for him and he cannot tell the letters apart. […] We would really like him to say that he needs the letters to be made bigger.

Marcus tries to hide his visual-perceptual difficulties and earlier in the mainstream class he refused to use his computer. His experience of social exclusion has shaped his motive for social inclusion and interweaved it with an avoidance of being different. However, his efforts hiding his difficulties and his refusal to use remedies exhaust him and make learning harder for him. Exhaustion as a neurobiological constraint has emerged from the conflict between Marcus' motive of social inclusion at the psychological level and the organisation of the social practice; Marcus' dual class arrangement and his experience of social exclusion in the mainstream class. The finding of a solution to the conflict becomes important, because the inability of Marcus to engage in the learning of anything new is putting him further behind his peers. However, a solution was not reachable within the current organisation of the learning practice. From the perspective of Marcus, the conflict appeared immobile and in that period he often broken down crying in the mainstream class. The movement of the neurobiological constraint was only possible through a reorganisation at the social practice level, in which the dual class arrangement was discontinued.

Dissipation of Neurobiological Constraints

Angus has the same type of CP as Marcus, but the neuropsychological assessment did not reveal any cognitive impairments. The observations confirmed the picture of Angus as a boy with a level of cognitive functioning and learning similar to his peers. Probably his cerebral lesions are less extensive than Marcus' and more confined to motor areas. In the observations, motives for learning and for social participation seemed present across situations.

Like Marcus, Angus differs from his peers in the mainstream class. At school start, his motor and speech difficulties made the school hesitate in admitting Angus and as such can be interpreted as constituting neurobiological constraints at that time. Both motor and speech difficulties are still readily observed in Angus' activities in the school practice:

(From observation, day 3, English lesson).
Angus has raised his hand, wants help from the teacher. The teacher helps the boy next to Angus, but fails to notice Angus' hand. Angus calls the teacher's name but his voice is too low to be heard, he tries to snap with his fingers to get her attention, but resigns when she turns and leaves his table. Strenuously, he gets up from his chair and walks over to her, gets her attention and asks her a question about the exercise, he's working on.

Surprisingly, Angus' significant motor and speech difficulties no longer seem to generate neurobiological constraints. Through the organisation of the social practice, a local match between Angus' capacities and the demand in the social practice has been accomplished. At the level of the social practice, many examples are seen: Angus has a special chair, he is placed next to a column with a power supply for his lap top and he has a set of drawers

for his books and papers to ease access. In addition, Angus' motor impairments are often compensated in and through the activity of Angus and his peers together without any need for explicit arrangements. For example when working in pairs or in a group, the other children always move over next to Angus, where he has his special chair and his computer.

At the psychological level, the resolution of the neurobiological constraints can be associated with Angus' motive for social inclusion and his ability to use remedies or otherwise compensate. Angus' compensating activity is supplemented by his class mates' acceptance of him as an equal participant in their activities at the social practice level, both in the lessons and during recess:

> *(From observation, day 2, recess):*
> *A game of throwing leaves is going on. Many children are running around outside throwing leaves at each other. Angus bends down and picks up leaves slowly. He has developed a technique of bending down and slowly raking leaves together with his hands, then picking up the pile and walking as fast as he can to throw the leaves at some other child, preferably someone standing still.*

In the excerpt, Angus is very good at compensating and his activity is supported by the other children who act towards him as a participant in the game by throwing leaves at him too. The positive dynamic between Angus' activity and the activity of his teachers and peers may be further enabled by the nature of Angus' biological defect, which has probably spared the areas supporting his development of metacognitive functions. The conflicts between Angus' difficulties due to his cerebral palsy and the demands in the learning practice can be solved without major changes of the learning practice.

Discussion

The concept neurobiological constraint has been used to analyse the dialectical dynamics between the developing neural system and the child's activity in social practices. Following Valsiner (1997), neurobiological constraints are biologically based regulators of child development from the present to the future. Reconceptualising the brain lesion into a neurobiological constraint has emphasized that the consequences of a brain lesion are never static. It changes the focus to conflicts between biological defects, cognitive difficulties and learning demands at the social practice level and highlights that neurobiological constraints such as learning impairments are movable in and through activity in the social practice. Following Vygotsky (1993) and the cultural-historical activity approach (e.g. Luria (1971), Scribner (1997), Cole & Engeström (1993)), the neurobiological constraints are mediated in and through the activity of the child, the introduction of specific cultural tools for remediation, and the organisation of the social practice connected to cultural-historical institutions such as schools, hospitals, centres for special education and so forth. The conflictual mismatch between the biological endowment of children with an early brain lesion and the social practice has exposed developmental dynamics between biology, psychology and the social practice, which often remains more hidden in the development of children without disabilities. The mismatch between the biological, psychological and social practice level of development of a child with a biological defect can give rise to conflicts, where development through a

new synchrony is not attainable at the level of the child's activity or immediate social setting. Instead, a reorganisation of the practice at a higher level is required; the organisation of special teaching at the school, the organisation of school placement at a municipal level or even educational acts at a national, political level. This draws attention to the fact that the concept of social practice used in the analyses is a methodical reduction. In further analyses, it might be useful to expand the social practice concept to include several layers, for example as done by Bronfenbrenner & Morris (1998) or Hedegaard (2009). The solution of a conflict through reorganisation of the social practice is part of the dialectic understanding that individuals can affect and change their own conditions for development. However, the different levels in the developmental system might be associated with different functional time scales. The solution to a conflict that requires reorganisations of the activities in the learning practice through negotiations and reorganisations in other practices such as a school board or municipal organ might come about at a much slower pace than if the solution could be found directly in the learning activity. The necessary, but slower reorganisations may make the conflict appear immobile from the perspective of the child or the child's family. The analysis of Marcus and his learning illustrated this very well. The conflict created between Marcus' need for cognitive remediation on one hand and the amount of energy he spent striving for social inclusion at the other created a situation in which his learning was slowed down, thereby furthering the distance between him and his peers. Furthermore, the conflict constrained Marcus' acceptance of tools for cognitive remediation, whose purpose is to move the neurobiological constraints and minimize the gap between Marcus's neurobiologically constrained activity and the cultural-historical demands for learning and child development within the learning practice. Marcus' repeated breakdowns in class did affect the system and change the organisation of his learning practice, but only after several months, during which Marcus experienced his situation as ceaseless and intolerable at the same time.

In contrast, the case of Angus illustrates how the incongruence between biological and social development can be resolved within the learning practice despite a substantial motor impairment. Angus' neurobiological constraint at the time of his school start has been moved and resolved through the dynamic interaction between Angus' motives for social inclusion that makes him join motor demanding activities despite his difficulties, Angus' acceptance and competent use of tools for cognitive remediation such as a lap top, and the considerations shown towards him by peers and teachers and incorporated as part of the social practice in the school.

The empirical analyses also highlighted how different social practices afford different use of tools for cognitive remediation with consequences for the possibilities for cognitive development within the practice. A tool such as a lap top is by no mean an objective remedy, but acquires its meaning and use only through the activity of the user, the child, in particular practices. In understanding the affordances of the social practices of Marcus and Angus, their motives came to constitute an integrated part. Only when the tool is integrated by the child as a possible mean to a desired end can it contribute to the necessary learning and cognitive development.

Marcus and Angus represent unique examples of children in their everyday practices. However, due to the great similarity of social institutions such as schools and the learning practices in them and the high incidence of biologically based cognitive and motor impairments of children with spastic CP, there is reason to suspect that the developmental

patterns described in the analyses are not exceptional, but could be common conditions for development for many children with spastic CP, at least in Denmark and possibly in other countries with highly similar schooling systems.

Reflecting on the role of neurobiology, it becomes clear that even in cases of obvious biological constraining of some development possibilities, it is essential to avoid both pre-determinism and reductionism. The knowledge of neurobiological processes is essential to ensure a thorough understanding of the specific neurobiological constraints that might arise in relation to particular disabilities. However, the biological approach needs to be supplemented with a situated understanding of the child's cognitive difficulties as created by the gab between biological and social conditions to make sure we have an eye for their possible movability.

Extending to the development of children without disabilities, there is no reason to assume that Angus is the only child that develops within a local match between his biological conditions and the social practices. The local match of a child with a disability might call for extra and ongoing negotiations in the local practice, which are not necessary in children without. But if a typical Danish child is moved to a school in another country, a mismatch might arise between the child and the local age-graded norms for children's development and negotiations called for. Supposing all children function and develop within local matches between their biological conditions and social practice, it would support a developmental science approach that includes processes both at the biological and the social practice level as suggested by others, for example Bronfenbrenner & Evans (2000). Developmental science as an interdisciplinary field, in which knowledge domains such as developmental neuroscience and cultural-historical developmental theory could meet in a developmental approach encompassing at least three levels of analysis; a biological level, a level of psychological functions and a level of social practices. The knowledge flow between different traditions for studying development could stimulate the different fields and lead to new lines of inquiry and, through this, new insights. Knowledge about neurobiological processes such as plasticity and gradual modularisation might potentially inform cultural-historical theories of children's development in regard of studying how local matches between biological and social conditions arise and evolve. Cultural-historical developmental theory could provide concepts to analyse the reciprocal relationship between levels and ensure a dialectical understanding of the crucial interdependence between children and their social practices that fuels the development of both.

References

Alexander, M. P. & Stuss, D. T. (2000). Disorders of frontal lobe functioning. *Seminars in Neurology, 20,* 427-437.

Anderson, P.J., Wood, S.J., Francis, D.E., Coleman, L., Warwick, L., Casanelia, S., Anderson, V.A., Boneh, A. (2004). Neuropsychological functioning in children with early-treated phenylketonuria: impact of white matter abnormalities. *Developmental Medicine and Child Neurology, 46*, 230-238.

Anderson, V. (2007). Childhood white matter injuries: What are the issues? *Developmental Neuropsychology, 32,* 619-623.

Bax, M., Goldstein, M., Rosenbaum, P., Leviton, A., & Paneth, N. (2005). Proposed definition and classification of cerebral palsy, April 2005 - Introduction. *Developmental medicine and child neurology, 47,* 571-576.

Bishop, D. V. M. (1997). Cognitive neuropsychology and developmental disorders: Uncomfortable bedfellows. *Quarterly Journal of Experimental Psychology Section A-Human Experimental Psychology, 50,* 899-923.

Bottcher, L., Meulengracht, E. F., & Uldall, P. (In press). Attentional and executive impairments in children with spastic cerebral palsy. *Developmental medicine and child neurology*.

Bronfenbrenner, U. & Evans, G. W. (2000). Developmental science in the 21st century: Emerging questions, theoretical models, research designs and empirical findings. *Social Development, 9,* 115-125.

Bronfenbrenner, U. & Morris, P. A. (1998). The Ecology of Developmental Processes. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology* (5th ed., pp. 993-1025). New York: John Wiley and sons.

Cioni, G., Sales, B., Paolicelli, P. B., Petacchi, E., Scusa, M. F., & Canapicchi, R. (1999). MRI and clinical characteristics of children with hemiplegic cerebral palsy. *Neuropediatrics, 30,* 249-255.

Cole, M. & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognitions. Psychological and educational considerations* (pp. 1-46). New York: Cambridge University Press.

Elkonin, D. B. (1972). Toward the problem of stages in the mental development of the child. *Soviet Psychology, 10*, 538-653.

Eriksson, L., Welander, J., Granlund, M. (2007). Participation in everyday school activities for children with and without disabilities. *Journal of Developmental and Physical Disabilities, 19*, 485-502.

Daniels, H. (2008). *Vygotsky and Research*. New York: Routledge.

Davies, J.M., Watson, N. (2001). Where are the children's experiences? Analysing social and cultural exclusion in 'special' and 'mainstream' schools. *Disability and Society, 16,* 671-687.

Fennell, E. B. & Dikel, T. N. (2001). Cognitive and Neuropsychological Functioning in Children With Cerebral Palsy. *Journal of Child Neurology, 16,* 58-63.

Frampton, I., Yude, C., & Goodman, R. (1998). The prevalence and correlates of specific learning difficulties in a representative sample of children with hemiplegia. *British Journal of Educational Psychology, 68,* 39-51.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kensworthy, L. (1996). *BRIEF Professional Manual.* Psychological Assessment Resources.

Goodman, R. & Graham, P. (1996). Psychiatric problems in children with hemiplegia: Cross sectional epidemiological survey. *British Medical Journal, 312,* 1065-1069.

Goto, M., Ota, R., Iai, M., Sugita, K., & Tanabe, Y. (1994). MRI Changes and Deficits of Higher Brain Functions in Preterm Diplegia. *Acta Paediatrica, 83,* 506-511.

Gottlieb, G. (2002). Probabilistic Epigenesis of Development. In J. Valsiner & K. J. Connolly (Eds.), *Handbook of developmental psychology* (pp. 3-17). London: Sage.

Gottlieb, G. (2007). Probabilistic epigenesis. *Developmental Science, 10,* 1-11.

Gottlieb, G., Wahlsten, D., & Lickliter, R. (1998). The significance of biology for human development: A developmental psychobiological systems view. In Ed-in-chief William Damon (Ed.), *Handbook of child psychology* (5th ed., pp. 233-273). New York: Wiley.

Greenough, W. T., Black, J. E., & Wallace, C. S. (1987). Experience and Brain-Development. *Child Development, 58,* 539-559.

Guzzetta, A., Mercuri, E., & Cioni, G. (2001). Visual disorders in children with brain lesions. 2. Visual impairment associated with cerebral palsy. *European Paediatric Neurology Society, 5,* 115-119.

Hedegaard, M. (2009). Children's development from a Cultural-Historical Approach: Children's activity in Everyday Local Settings as a Foundation for their Development. *Mind, Culture and Activity, 16*.

Hedegaard, M. (2002). *Learning and Child Development*. Aarhus: Aarhus University Press.

Hedegaard, M. & Fleer, M. (2009). *Studying Children. A cultural-historical approach*. London: Open University Press.

Juenger, H., Linder-Lucht, M., Walther, M., Berweck, S., Mall, V., & Staudt, M. (2007). Cortical neuromodulation by constraint-induced movement therapy in congenital hemiparesis: An fMRI study. *Neuropediatrics, 38,* 130-136.

Karmiloff-Smith, A. (1998). Development itself is the key to understanding developmental disorders. *Trends in Cognitive Sciences, 2,* 389-398.

Karmiloff-Smith, A. (2007). Atypical epigenesis. *Developmental Science, 10,* 84-88.

Korkman, M., Kettunen, S., Autti-Rämö, I. (2003). Neurocognitive impairment in early adolescence following prenatal alkohol exposure of varying duration. *Child Neuropsychology, 9(2)*, 117-128.

Kozulin, A. & Gindis, B. (2007). Sociocultural thinking and education of children with special needs. From defectology to remedial pedagogy. In H. Daniels, M. Cole, & J. V. Wertsch (Eds.), *The Cambridge companion to Vygotsky* (pp. 332-362). New York: Cambridge University Press.

Krageloh-Mann, I., Petersen, D., Hagberg, G., Vollmer, B., Hagberg, B., & Michaelis, R. (1995). Bilateral Spastic Cerebral-Palsy - MRI Pathology and Origin - Analysis from A Representative Series of 56 Cases. *Developmental medicine and child neurology, 37,* 379-397.

Krägeloh-Mann, I., Helber, A., Mader, I., Staudt, M., Wolff, M., Groenendaal, F., DeVries, L. (2002). Bilateral lesions of thalamus and basal ganglia: origin and outcome. *Developmental Medicine and Child Neurology, 44*, 477-484.

Kuhnke, N., Juenger, H., Walther, M., Berweck, S., Mall, V., & Taudt, M. (2008). Do patients with congenital hemiparesis and ipsilateral corticospinal projections respond differently to constraint-induced movement therapy? *Developmental Medicine and Child Neurology, 50,* 898-903.

Leontiev, A. N. (1977). *Problemer i det psykiskes udvikling. I-III [Problems in the development of the psychic. Volume I-III]*. Copenhagen: Rhodos.

Luria, A. R. (1971). Towards the problem of the historical nature of psychological processes. *International journal of psychology, 6*, 259-272.

Mehan, H.; Hertweck, A. & Meihls, J. (1986). *Handicapping the handicapped? Decision making in students' educational careers.* Stanford: Stanford University Press.

Michelsen, S. I., Uldall, P., Kejs, A. M. T., & Madsen, M. (2005). Education and employment prospects in cerebral palsy. *Developmental medicine and child neurology, 47,* 511-517.

Nadeau, L. & Tessier, R. (2006). Social adjustment of children with cerebral palsy in mainstream classes: peer perception. *Developmental medicine and child neurology, 48,* 331-336.

Nass, R. (2002). Plasticity; mechanisms, extent and limits. In S. J. Segalowitz & I. Rapin (Eds.), *Handbook of Neuropsychology Vol 8, part I* (2nd ed., pp. 29-68). B. V.: Elsevier Science.

Ostensjo, S., Carlberg, E. B., & Vollestad, N. K. (2003). Everyday functioning in young children with cerebral palsy: functional skills, caregiver assistance, and modifications of the environment. *Developmental medicine and child neurology, 45,* 603-612.

Overton, W. F. (2003). Metatheoretical features of behavior genetics and development. *Human Development, 46,* 356-361.

Pirila, S., van der, M. J., Korhonen, P., Ruusu-Niemi, P., Kyntaja, M., Nieminen, P. et al. (2004). A retrospective neurocognitive study in children with spastic diplegia. *Developmental Neuropsychology, 26,* 679-690.

Powell, K. B. & Voeller, K. K. S. (2004). Prefrontal executive function syndromes in children. *Journal of Child Neurology, 19,* 785-797.

Salomon, G. (1993). No distribution without individuals' cognition: a dynamic interactional view. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 111-138). New York: Cambridge University Press.

Schenker, R., Coster, W.J., Parush, S. (2005). Neuroimpairments, activity performance and participation in children with cerebral palsy mainstreamed in elementary schools. *Developmental Medicine and Child Neurology, 47*, 808-814.

Schonfeld, A. M., Paley, B., Frankel, F., O'Connor, M.J. (2006). Executive functioning predicts social skills following prenatal alcohol exposure. Child Neuropsychology, 12, 439-452.

Scribner, S. (1997). *Mind and social practice. Selected writings of Sylvia Scribner.* New York: Cambridge University Press.

Sigurdardottir, S., Eiriksdottir, A., Gunnarsdottir, E., Meintema, M., Arnadottir, U., & Vik, T. (2008). Cognitive profile in young Icelandic children with cerebral palsy. *Developmental medicine and child neurology, 50,* 357-362.

Stiles, J. (2000). Neural plasticity and cognitive development. *Developmental Neuropsychology, 18,* 237-272.

Stiles, J., Moses, P., Passarotti, A., Dick, F. K., & Buxton, R. (2003). Exploring developmental change in the neural bases of higher cognitive functions: The promise of functional magnetic resonance imaging. *Developmental Neuropsychology, 24,* 641-668.

Stiles, J., Reilly, J., Paul, B., & Moses, P. (2005). Cognitive development following early brain injury: evidence for neural adaptation. *Trends in Cognitive Sciences, 9,* 136-143.

Uldall, P., Michelsen, S. I., Topp, M., & Madsen, M. (2001). The Danish Cerebral Palsy Registry - A registry on a specific impairment. *Danish Medical Bulletin, 48,* 161-163.

Valsiner, J. (2006). Developmental Epistemology and Implications for Methodology. In R. M. Lerner (Ed.), *Handbook of child psychology. Vol 1. Theoretical models of human development* (6th ed., pp. 166-209). Hoboken, N J: John Wiley and sons.

Valsiner, J. (1997). *Culture and the Development of Children's Action. A Theory of Human Development*. (2nd ed.) New York: John Wiley and sons.

Vygotsky, L. S. (1993). *The collected works of L.S. Vygotsky. Vol 2: The fundamentals of defectology (Abnormal psychology and learning disabilities)*. New York: Plenum Press.

Vygotsky, L. S. (1998). *The collected work of L.S. Vygotsky. Vol 5: Child Psychology*. New York: Plenum Press.

Welsh, M. C. & Pennington, B. F. (1988). Assessing frontal lobe functioning in children: Views from developmental psychology. *Developmental Neuropsychology, 4,* 199-230.

Yin, R.K. (1994). *Case Study Research. Design and methods.* (2nd ed.). Thousand Oaks, Ca: Sage.

Yude, C. & Goodman, R. (1999). Peer problems of 9- 10-year-old children with hemiplegia in mainstream schools. Can these be predicted? *Developmental Medicine and Children Neurology, vol 41*, 4-8.

Yude, C., Goodman, R., & McConachie, H. (1998). Peer problems of children with hemiplegia in mainstream primary schools. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 39,* 533-54