CHAPTER SIX

Discussion and Conclusion

6.1 OVERVIEW

The purpose of Chapter Six is to discuss the overall research in order to determine what has been learned from the studies and the significance for children, families, and therapists who wish to use Neuro-Developmental Treatment (NDT). An overview of the research is first presented, reiterating the aims, methods and outcomes of each research phase. Next, the outcome of the intensive NDT treatment for the 12 children with cerebral palsy (CP), as measured by Goal Attainment Scaling (GAS) (Kiresuk, Smith, & Cardillo, 1994), video motion analysis and qualitative outcomes measures of parents' and therapists' perceptions of NDT, is discussed. Further discussion addresses the methodology that was developed to comprise an NDT measurement model, including the use of Goal Attainment Scaling (GAS) (Kiresuk, Smith, & Cardillo, 1994), and a clinic based 'filming protocol' that captured children's performance in targeted daily tasks, and which could be utilized to measure outcomes in future NDT efficacy studies. Finally, both the limitations of the study and its potential significance are outlined, as well as recommendations for future research.

6.2 INTRODUCTION

This research was guided by issues of service delivery for children with CP for which current literature on NDT provided few answers. First, although anecdotal support for NDT has existed for some time, there is little empirical evidence to support its use with children with CP. Second, although a relationship between improvements in everyday function and NDT is theorized, there is little data to support this proposition. Third, while there is a common expectation that therapists provide evidence of effectiveness of intervention for children with diverse CP typologies and functional goals, there is an absence of a common sound and relevant measurement model that can quantify outcomes of NDT. In response to these issues, the primary purpose of the research was, to investigate the impact of NDT on task performance, and how this impact could be best measured. The following research question arose from this overall purpose and guided this research:

> *"What is the impact of Neuro-Developmental Treatment on the functional outcomes of children with cerebral palsy as measured by their performance in selected daily living tasks?"*

A mixed-methods approach across three pilot studies was used to explore the research question. The first two pilot studies, documented in Chapters Three and Four in this thesis, utilized critical case study and small 'n' methods to develop an 'NDT Measurement Model' with the capacity to evaluate the relationship between intensive NDT and functional goal performance (such as in communication, self

care, mobility and play). In Pilot Study One, the Goal Attainment Scale (GAS; Kiresuk, Smith, & Cardillo, 1994) was trialed using DVD recordings of pre- and post-test NDT treatment sessions of two children with cerebral palsy, which were rated by experienced raters 'blinded' to the conditions of the study. In Pilot Study Two, Video Motion Analysis was trialed, in addition to GAS, to develop a filming protocol for six children with cerebral palsy (CP).

The third pilot study, documented in Chapter Five, used this NDT Measurement Model to document changes in functional performance following intensive NDT intervention in 12 children with cerebral palsy (CP). This pilot study utilized a quasi-experimental design, supported by qualitative data to determine the nature of functional changes observed. Specifically, a pre- and post-tested outcome study with follow-up and blinded rating was conducted, with the intervention given during the treatment practicums of an NDT certificate course. The NDT Measurement Model incorporated GAS and filming protocols developed in previous phases of the research, as well as The Measures of Processes of Care (MPOC) (King, Rosenbaum, & King, 1995), and NDT Course Questionnaires (Davis, 2008) to capture perceptions of the impact of NDT from families and therapists. The sequence of phases in the research is illustrated in Figure 6.1.

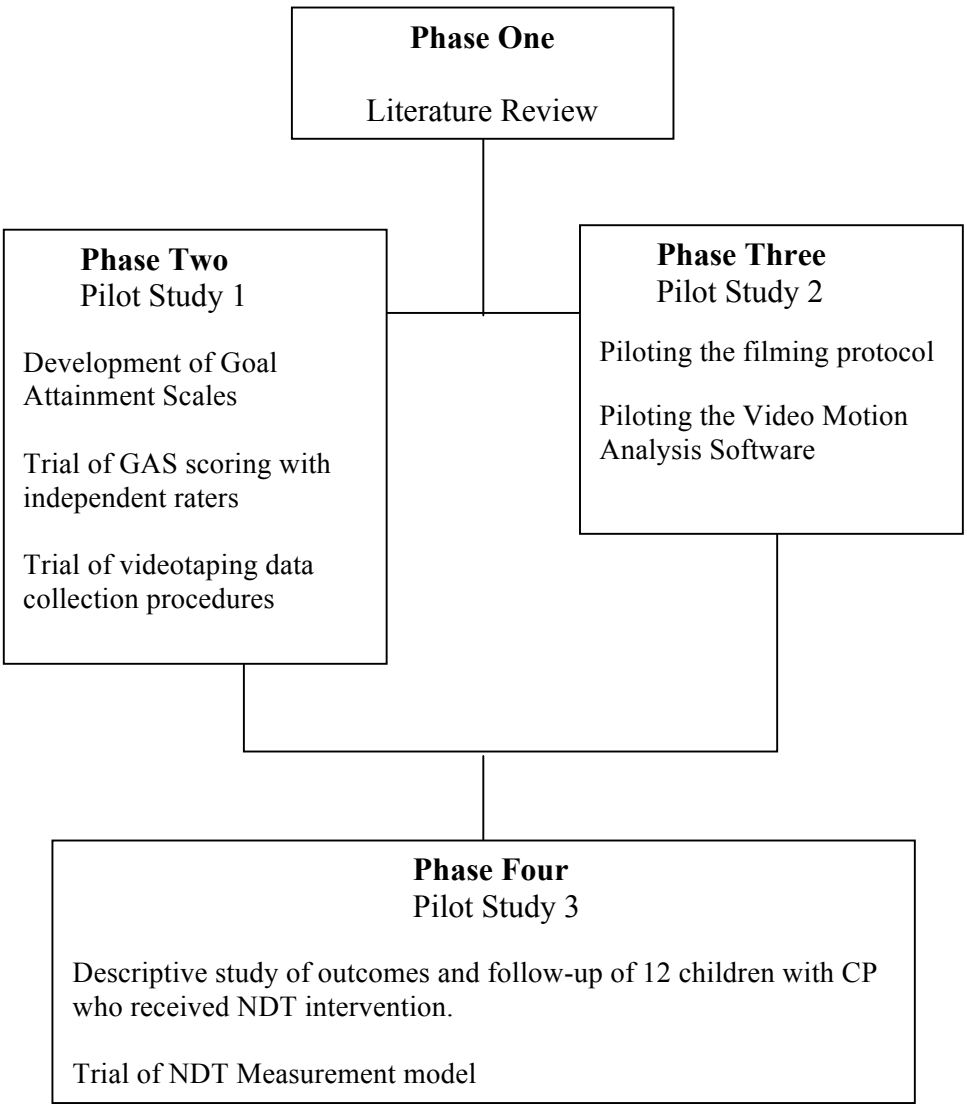

Figure 6.1: Visual representation of the four phases of the study.

6.3 DISCUSSION OF FINDINGS

This section draws together individual findings from all the research phases to present the primary findings in the context of the overall research project. These findings are listed below and form the basis of two main discussion points.

1. Outcomes as measured by GAS, motion analysis, and parent and therapist perceptions of outcomes
2. Efficacy of the NDT Measurement Model

6.3.1 Discussion of outcomes as measured by GAS, motion analysis and parent/therapists perceptions

The main purpose of the research was to investigate functional changes that occurred after an intensive course of NDT. Function and change were quantitatively measured using Goal Attainment Scaling and motion analysis. A major finding of the study was the positive change in the children's mean GAS scores from pre-test to post-test which was statistically significant for both the researcher and the CI raters (Figure 5.6 and Table 5.14). Moreover, the functional gains obtained during NDT were not lost after a period of withdrawal, as measured by stable mean GAS scores for the group of children between post-test and follow-up. These findings were supported by the results of motion analysis, which generated detailed information about the changes in the timing, distance and range of children's movements during task performance.

There are several reasons why improvements in function may have occurred between pre- and post-test performances in this study. First, it is thought that the NDT intervention as a whole led to improved function. While it is not possible to categorically attribute these functional gains to NDT in this quasi-experimental design, the fact that the gains made by children during the period of NDT were more dramatic than during the period of withdrawal from NDT is noteworthy, suggesting *an effect from the intervention* given. A similar outcome was found in another study where a group of infants who received 14 days of NDT were shown to have maintained significant gains three weeks after the intervention (Arndt, Chandler, Sweeney, Sharkey, & McElroy, 2008). While the results of this study

can suggest, with caution, that the improvement seen is associated with the intervention given in comparison to no other specialized intervention (NDT/no NDT), further research has to be carried out to determine whether NDT intervention achieves superior outcomes when compared to other modes of intervention.

Second, it is not possible to determine from this study whether one particular aspect of the NDT intervention led to functional improvement, or whether the changes were the cumulative effect of all aspects of the intervention given. The changes seen in children's functional performance in this study are assumed to reflect several central parameters of NDT intervention outlined in Chapter Two, with the most notable NDT parameters being the use of specific physical guidance prompts (physical handling) to control and facilitate children's motor actions and engagement in relevant task performance, as well as intensity and repetition (Bain, 2005; Howle, 2002; Bierman, 2012).

The assumption suggested in this discussion point is that the therapy strategies used in the NDT program may have prompted children to *learn to apply functional movement strategies to a particular task*. From a learning perspective, NDT handling strategies that were utilized in this study (examples outlined in Table 2.1) are classified as physical prompts, used to increase the probability that children will respond in a more functional way during task performance (Berry & Ryan, 2002; Bly, 1991, 2000; Breslin & Ryan, 2002; Halfens, 2004; Howle, 2002; Jonsdottir, Fetters, & Kluzik, 1997; Kaplan, 2002). These physical prompts are thought to contribute to "errorless" learning because their use results in few motor

performance mistakes. The goal of physical response prompting through NDT is to transfer motor control from the therapist to the child during the desired activity. This is done by using a 'most to least' prompt hierarchy, beginning with as much physical guidance as the child requires to engage successfully in the desired motor task, and then gradually fading the physical support when the child begins to succeed in controlling postures and actions (Howle 2002). Studies have shown that response prompting in this way is effective for learning task performance from preschool through adulthood, in a variety of instructional contexts, and with a variety of physical impairments, including children with CP who may also have other sensory and intellectual disabilities (Horner, Carr, Halle, McGee, Odom & Wolery, 2005; Wolery, Ault, & Doyle, 1992). It is probable that the application of an overall systematic approach to teaching motor tasks, that is inherent in contemporary NDT philosophy and practice, contributed to successful outcomes in this study, rather than any one particular physical handling strategy per se. Further research is required to determine which aspects of NDT are central requisites to improvements in functional capacity in children with CP, or whether there is a 'critical cumulative mass' of intervention parameters that must all be 'in place' in order to predict successful outcomes.

Third, it is possible that the *intensity of the intervention* administered may have contributed to improvement over a relatively short period of time. The children all received NDT intervention twice weekly, totaling 23 hours per child during the course practicum treatment block. This was more individual treatment than most of the children would have experienced in their 'regular' therapy programmes. Evidence from other modes of intervention for children and families show factors

such as the setting, format, dose and length of treatment play an important role in outcomes (Webster-Stratton & Hammond, 1997). In particular, treatment intensity (the number, frequency and regularity of sessions) has been described as a central aspect (Kordy, Rad, & Senf, 1998), with positive correlation between the amount of treatment and the amount of therapeutic benefit highlighted. Parent training programs of less than 10 hours in duration, for example, are less likely to be effective (Kazdin, 1987), and families who attend more sessions and greater than 50% of a program are likely to have more successful outcomes than families with poor attendance (Strain, Steele, Ellis, & Timm, 1982). Treatment intensity has been found to have a predictive relationship to functional outcome, and the amount of treatment children and families participate in is likely to also be related to positive outcomes at follow-up. Findings similar to those in this study have been reported in relation to psychosocial interventions (Medalia & Richardson, 2005) and adult brain injury rehabilitation (Byl, Pitsch & Abrams, 2008), and for children with cerebral palsy (Arndt, Chandler, Sweeney, Sharkey, & McElroy, 2008; Bar-Haim et al., 2006; Eliasson et al., 2005). Although intensive opportunities to engage in therapy appear to play an important role in inducing and maintaining change, the outcomes are not uniform across participants (Teasell, Bitensky, Salter, & Bayona, 2005). That research outcome resonates with the findings of this study which showed each of the 12 children made different amounts of progress in response to a similar intensity of treatment. Further research is required to determine the intensity required at different ages in children with CP to enable parents and therapists to predict the outcome of NDT.

Fourth, it is possible that the process of specific and collaborative *goal setting* which was negotiated by the researcher, the therapists, parents and the children may have largely contributed to children attaining the desired goal. As described in Section 2.4, therapists who utilize NDT are compelled to collaborate with clients in a goal setting process. Goal setting alone has been found to have an intervention effect (Locke & Latham, 1990, 2002). A growing body of therapy literature suggests multiple benefits of a collaborative goal setting approach to therapy, including improved outcomes in comparison to therapy that does not include this process (Gagne & Hoppes, 2003; Webb & Glueckauf, 1994).

In this study, time and capacity limits were placed on the goals set, with outcomes linked to a positive conclusion. Furthermore, as outlined in Section 5.3.2, goals nominated by therapists and parents for each of the children were further broken down into sub-goals, which reflected 'small step' achievements that were addressed in intervention. It is possible that this collaborative, transparent, stepwise approach to goal attainment among therapists, parents and children may have resulted in a discrete, systematic approach to intervention that itself, made outcomes achievable.

A second important finding of the study was the *maintenance of functional gains* as measured by GAS scores between post-test and follow-up task performances, a period of time that involved no NDT, and that was *longer* than the intervention period. This may indicate several factors apart from effective learning described above. First, although parents were not 'taught' how to apply specific NDT strategies, all parents had visual access to the child's therapy sessions and

frequent opportunities to talk to their child's therapists about treatment and progress. It is possible that they were able to apply the same physical prompting systems during functional tasks at home, hence maintaining intervention effects. Parents of children participating in this study were motivated enough to volunteer to support their children to attend additional, intensive intervention, and could therefore be assumed to be parents who *may* therefore have been prepared to follow through with any intervention suggestions given. The initial intervention goals that were set for each child, and which were the bases for the GAS, were derived from the desires of the parents and children themselves, rather than being set by therapists alone. It is possible that the motivation to, not only achieve the goals set, but also to maintain performance over time without further therapy, was a major contributing factor to the maintenance of therapy effect.

Remarks in the parent surveys which were discussed in Section 5.6, indicated that some children not only maintained performance levels in the tasks learned, but were able to apply the relevant motor skills to other tasks. This may indicate that children not only learned specific motor skills, but also the ability to apply the skill strategically, prompting generalization. This finding suggests an important area of focus for future NDT research regarding the way children with CP can be assisted to learn to apply movement strategically to task performance. Contemporary research into how children learn (Granott & Parziale, 2002; Siegler & Svetina, 2006) indicates that children as young as 18 months use a variety of motor strategies for solving a given motor problem at any one time (e.g. walking up and down a ramp). With everyday experience, some motor strategies become less frequent, others become more frequent. As new motor strategies are

discovered, older strategies cease to be used. Children choose adaptively among motor strategies, with choice being determined by a judgment about which strategies best fit the demands of the task being performed. Children make this choice from their repertoire of known and experienced strategies (Siegler, 2005). In applying this information to the results of this study, several hypotheses could be made. If children learned 'new' motor skills from the NDT, they may have developed a broader skill repertoire from which they could choose to do other tasks at home. The strategies that were learned in NDT sessions were learned within the context of a functional task. Perhaps this contemporary and functional NDT approach allowed them to learn not only the motor skill itself, but the conditions under which the motor skill could be used, hence prompting generalization to similar functional conditions. The implication for future NDT research is not only in measuring the impact of NDT on task performance per se, but also in discovering the capacity of NDT to build a repertoire of motor strategies and the capacity to use motor function strategically.

The results from separate parent and therapist surveys suggested positive perceptions about the children's goal outcomes and their experiences with NDT. Results from the Measures of Processes of Care (King, Rosenbaum, & King, 1995a) and Course Survey Questionnaires (Davis, 2008) yielded a positive approval rating by parents and therapists of the NDT received, and the extent to which goals were achieved during the course treatment practicums, a finding replicated in other similar research (De Mauro, 2010). As outlined in Section 2.4, NDT is focused on the needs of (and driven by), both parents and children. Parent responses from the MPOC, which is purported to generate "a validated and

reliable self-report measure of parents' perceptions of the extent to which the health services they and their child(ren) receive is family-centred" (McMaster University, 2011), indicated that NDT intervention was given in consideration of parent and children's needs. These results were in line with many years of anecdotal evidence from parents and therapists undertaking NDT courses. This study focused on obtaining the perceptions of the outcomes from a short, intensive course of NDT only, and from a very supportive group of parents. These goals were child-focused, and problem oriented. Further research is suggested which investigates the place, timing and focus of similar goals generated for NDT intervention, within the broader context of family centred goals over time.

6.4 MEASUREMENT MODEL

6.4.1 Use of Goal Attainment Scaling (GAS)

The second series of findings in this research related to the effectiveness of an NDT Measurement Model that was developed for use in the final phase of the study. The components of the model were effective in capturing reliable data with the capacity to measure change made by children in everyday task performance. Several components comprised the NDT Measurement Model: GAS, motion analysis, MPOC and NDT Course Surveys. The use of each of these in this study will now be addressed.

Overall, GAS was found to be an effective choice of outcome measure and foundation to the development of an 'NDT Measurement Model' based on the following parameters. First, GAS offered standard procedures for measurement of functional performance that were common to a number of children with

disparate ages, CP typologies and target outcomes. Second, GAS was found to be, with training, a measure that demonstrated good to excellent reliability among raters. Third, the ability to set GAS subscale scores offered the opportunity to measure small changes, an important validation to parents and children who have severe disability due to CP. Fourth, and perhaps most importantly, GAS was able to be utilized to measure salient functional change that was unique to, desired by, and important to parents and children. This finding is similar to the findings of other researchers who have utilized GAS as a sensitive outcome measure for children with CP (Cardillo & Smith, 1994; Maloney, Mirrett, Brooks, & Johannes, 1978; McLaren & Rodger, 2003; Ottenbacher & Cusick, 1989; Sakzewski, Boyd, & Ziviani, 2007; Wallen, O'Flaherty, & Waugh, 2004).

There were, however, some difficulties experienced with the use of GAS. The results of the first two pilot studies indicated that even experienced therapists require considerable training to establish and utilize GAS. In this study, the amount of agreement between the researcher's GAS scores and those of the blinded CI raters increased between Pilot Study One and Pilot Study Three. There may have been several reasons for this. First, with increased exposure to the process of scoring the GAS against videotaped performances, CIs may have become more adept at identifying the small onscreen parameters that identified performance expectations at each GAS level from -2 to +2. Second, the researcher had the luxury of observing children 'in the flesh', in comparison to CI visual observations that were constrained by two dimensional DVD performance. This may have resulted in some of the discrepancies between researcher and CI scoring in all phases of the study. Third, the researcher established the GAS

scales and subscales, and thereby had access to detailed and implicit understanding of scoring parameters at each level that was not available to the CI raters. Fourth, there is an obvious question concerning researcher bias, particularly in the researcher assignment of changes in GAS scores in the final phase of the research.

Despite these possible issues, results indicated that, when controlling for researcher bias through the use of blinded raters, the considerable agreement between the research and CI GAS scoring supports its use to measure functional outcomes in an unbiased manner. Last, improvement in GAS agreement between researcher and CIs may have been related, in part, to the improved clarity of the video footage which was generated by changes to the filming protocol over time. A number of authors have used video recording to document changes in task performance following other interventions (Chakerian & Larson, 1993; Mitchell & Cusick, 1998). The few studies which utilized video recording in measuring outcomes from NDT suggested the inclusion and development of filming as central to the development of any measurement model (DeGangi & Royeen, 1994; Jonsdottir, Fetters, & Kluzik, 1997; Lilly & Powell, 1990).

The process of generating GAS in the final pilot study began with the goals set by the therapists who treated the children. They were novice 'goal setters', who did not have detailed knowledge about the children's abilities at the time they set their original goals. In addition, they were encouraged by course instructors to 'set the bar high' in goal setting, in an attempt to encourage children to 'progress to their optimum potential'. It would have been preferable to encourage the therapists to

set the functional goals to the level they 'reasonably expected' the child would achieve. It is possible that for some of the children, the goals contained some unrealistic expectations, which, in conversion by the researcher to GAS, resulted in an unattainable 0 goal level.

Future research utilizing GAS will need to consider the time needed for rater training to achieve consistency and stability in rating when using raters who are novices to the GAS procedures.

6.4.2 Use of Logger Pro with conversion of data to Excel

The use of Logger Pro with Excel resulted in 'home computer' based measurements of a number of parameters of targeted goal behaviours.
A limitation of using GAS scales based on the video footage edited with Final Cut Pro (Final Cut Pro, 2007), is that the scales were based *only* on visual observations that were distributed on the ordinal GAS scales. The use of Logger Pro as a video motion analysis tool resulted in *ratio* scaled measurements of changes in task-related behaviours by tracking computer generated dots overlaid 'onscreen' on to the 'anatomically' placed ink dots on each child's body. This subsequently enabled measurements to be made in dimensions of time, distance and joint angles.

While this measurement method generated helpful quantitative information, there were some difficulties that would need to be considered in future research using this part of the NDT Measurement Model. First, while in most instances the dots on the children's anatomical landmarks could be seen clearly enough to track their

movement (with the computer generated dot and the floor gird as measurement references), occasionally dots were partially rubbed off or obscured by clothing. Second, the process of conversion of visual input to computer-generated output data was straightforward for brief segments of video footage (one minute or so), but more complex for longer segments (e.g. four minutes). In this study, video clips were kept brief for easier scoring by the CI expert raters and for the generation of computer data. While this suited the tasks that were attempted by the children in the study, further research would need to be done on longer task performances to assess the usefulness of motion analysis to measure functional change. Third, it was found that when images were 'zoomed and cropped' for closer viewing of body segments (for example, of hand or oral function), the images were not completely clear. Measurements had to be generated from the 'un zoomed' footage to ensure correctly referenced measurements.

Use of more recent technology may overcome these issues in future research. For example, Canon high definition digital SLR cameras have approximately five times the clarity of the cameras used in Pilot Studies Two and Four (Canon MD160). Though considerably more expensive compared with the three cameras used, measurement reliability could be enhanced by the increased clarity of images. For example, 'lip rounding' could not be measured for one child, for whom this outcome was a targeted part of his goal, due to reduced clarity in visual performance data. Small steps towards goals, as illustrated by this example, are important clinical indications that guide therapists in planning and building on small achievements towards functional goal attainment. This study has

contributed towards development of an 'NDT Measurement Model' capable of measuring such small steps in a clinic environment.

There are a number of further ways in which use of 'low tech', portable motion analysis software can be used to measure outcome in performance of a variety of daily tasks in children's own 'familiar' clinics or home/school situations. Suggestions include 'extra checking' that dots are clear of clothing such as bathers and crop tops, to enable a clear view for measurement, and ensuring people and equipment don't block the camera's view of the dots on the children's bodies.

In summary, the use of Logger Pro software with conversion of data to Excel resulted in fast and accurate measurements of a number of parameters of targeted goal behaviours, Logger Pro is a low cost, easy to use, video motion analysis software package that has the potential for immediate application to the clinic/home/school environment. The technique can also be used to measure other improvements in goal related behaviours seen at post-testing, but which may not be included in written goals.

6.5 LIMITATIONS OF THE STUDY

Limitations of the research relate to the characteristics and sample size in each of the pilot studies, and to the data collection and analysis techniques. In designing each phase of the research, attempts were made to minimize the effects of these limitations.

6.5.1 Methodological limitations.

There are several limitations to this study. First, as described in Chapter Five, the methodology employed in the final pilot study was a quasi-experimental pre- and post-tested outcome study, with follow-up and blinded rating, rather than the planned randomized controlled trial (RCT). Examples and merits of randomized controlled trials (RCTs) were discussed in the literature review, as the appropriate methodology for determining outcomes following intervention (Howle, 2006; Lannin, Scheinberg, & Clarke, 2006; Sackett, Strauss, Richardson, Rosenberg, & Haynes, 2000). This study lacked a control group (either no intervention or an alternate intervention) against which experimental NDT outcomes group could be compared. Furthermore, 'outside therapies' occurring simultaneously to NDT were noted and their impact considered in interpretation of the results obtained, but random assignment to intervention groups, or further controlling for therapy input occurring outside of therapy was not done. While the results of this study suggest an intervention effect on functional outcome after NDT, this conclusion should be drawn with caution and followed up with replicated studies and research that incorporates more robust experimental design.

Second, the pilot studies included small samples of children with cerebral palsy. Pilot Study One studied two children, and Pilot Study Two, six children. VideoPoint™ was only piloted with one child (Videopoint™, 2005). However, the intention of first two pilot studies was not to measure outcome, but to develop a measurement model and practice in using the measures, evaluating their potential usefulness for further use. In Pilot Study Three, the 'convenience sample' of 12 children is considered too small to be able to generalise results to a

wider population. A small cohort also increased the chance of a Type 1 or Type 11 error, where a causative relationship between NDT and daily task performance improvements could be falsely identified, or 'missed'. In addition, the children did not comprise a homogenous sample, but rather, had diverse classifications of type and severity of cerebral palsy, and co-morbidities such as epilepsy, visual impairment, and intellectual disability, and a variety of sensory processing, emotional, and behavioural issues.

Finally, clinical studies within the context of improving children's performance in any area of therapy are vulnerable to the confounding effect of natural development. The pre-test, post-test, follow-up design adopted in this research enable some assessment of the relative effect of the experimental intervention (NDT), and natural development (withdrawal of NDT). Further randomized controlled designs will be able to address this issue with increased rigor.

Some questions remain concerning the use of 'low tech' video motion analysis software packages, versus 'high tech', valid, and reliable alternatives, such as measurements in kinematics labs. Unlike the GAS scores utilized in this study, analysis and calculations of pre- to post- and follow-up task related 'onscreen behaviours' as measured with Logger Pro / Excel, were not independently verified (Vernier, 2010). Although this measurement system did not use a standardized procedure, clear operational filming steps were developed and utilized the same way in pre-test, post-test and follow-up data collection. Due to time, neither reliability nor validity of this filming protocol was established for use in this study. Further research is required to validate the use of this potentially valuable

outcome measure for use in an 'NDT Measurement Model', and to assess its reliability.

6.6 SIGNIFICANCE OF THE RESEARCH

The current research makes a significant contribution to NDT theory and practice for children with CP.

6.6.1 Theoretical contribution

As outlined in Chapter Two, a theory of NDT is emerging. Central to this emerging theory is the concept that task performance is dependent upon motor control of the task being distributed among interactive neural and body systems, which are spontaneously organized by task parameters and context. This concept implies the assumption of a relationship between NDT that is directed towards specific task motor behaviours, and improvement in function that is addressed within the context of learning how to engage in a desired and relevant task. The findings of this study contribute evidence to demonstrate how this might happen. The NDT Measurement Model that was developed for this research demonstrated the capacity to measure functional outcome (GAS) that was linked to improvements in specific motor steps of task performance (GAS subscales and motion analysis). These results also reinforced propositions within the Occupational Performance Model (Australia) (Chapparo & Ranka, 1997) which suppose a functional link between motor capacity and effective task performance in work, play and self-care areas of occupational performance.

Another central concept within the NDT Enablement Model (Figure 2.3) is the assumption that NDT is able to contribute to moving the child along the continuum towards function and participation. The results of this research provide preliminary indications of the potential for NDT to be used to improve children's functional performance in nominated tasks, and that the newly learned improvements may generalize to participation in other home and school tasks.

6.6.2 Methodological contribution

While the methods utilized in this research do not generate conclusive evidence of the impact of NDT on functional performance, they contribute to the growing body of evidence that supports its use. It can be argued that small foundational studies are required at this stage of NDT research. Powell (2010) for example stressed the importance of small NDT studies, such as pre- and post-treatment trials, and cited these as: "milestones along the developmental research trajectory" (Whyte, Gordon, & Rothi, 2009). Stamer (2010) similarly emphasised the importance of exploratory trialing of sensitive outcome measures such as GAS and filming to discover NDT treatment effects in the clinic. This is seen as part of an NDT research pathway progressing towards incorporating larger scale RCT efficacy studies into a variety of research methodologies that may contribute towards clinical decision making for children with CP (Ligthelm et al., 2007; Rosenbaum, 2010).

6.6.3 Empirical contribution

Data generated in the course of this research adds to the empirical evidence supporting the use of NDT. While further validation of the findings of this

research are needed, the results can be used with other smaller studies to demonstrate convergent evidence to support its use and provide an empirical platform upon which replication studies can be built.

6.6.4 Practical contribution

A major focus in developing the measurement protocols in this research has been the clinical utility of both the procedure and the instruments. Focus has always been on developing relevant and achievable measures to enable 'small study' measurement of NDT treatment outcomes that could be carried out in community and clinic contexts. The methodological significance of this study lies in its ability to be replicated within other clinical situations, with other samples of children and tasks. It offers a measurement model which may meet a range of outcome measurement needs of therapists, from those who wish to use a common way to measure functional outcomes of therapy, to those who wish to engage in more formal research into service provision and outcomes for children with CP. The measurement model developed represents a significant addition to the assessment options available to therapists who utilize NDT and other forms of intervention to improve function of children with CP. At present, therapists are limited by assessment tools that provide limited ecological validity (for example, tests of motor function per se), as administration is typically removed from any functional context.

6.7 RECOMMENDATIONS FOR FUTURE RESEARCH AND PRACTICE

First, replication of this research may consider using a larger cohort of children with CP, which would provide a greater opportunity to measure the effects of NDT on a range of CP typologies. Alternatively, Sharkey et al. (2002) suggested that smaller NDT studies could be strengthened through the recruitment of participants who represented 'homogenous populations' in order to better predict the effect of NDT on functional outcomes of children who displayed different types of CP (such as, for example, children with hemiplegia). The intervention measured in this research was short term and intensive. Future studies might compare short term, intensive intervention outcomes with longer term, less intensive intervention. Similarly, future studies might compare therapist administered interventions with parent generated interventions and the associated impact on children's functional outcome in a number of their life contexts.

Second, considering that the likelihood of other therapies occurring simultaneously with NDT is high, the impact of a *combined* therapy approach for children with cerebral palsy could be further investigated: for example, the effects of botox and spasticity medications.

Third, the film set as developed for this research, can be easily adapted to be a permanent component of a treatment room of approximately 10m x 5m. For fast set up, markers can be left on skirting boards and small tape marks on the floor. A permanent set-up might enable frequent use of motion analysis as not only an assessment mode, but also a feedback system that directly contributes to

intervention. Similarly, the filming protocol together with 'film set in a suitcase' (Plate 5.3, Chapter Five) developed for this research could be available for any therapist to use in any context as it allows sufficient flexibility to film diverse daily task performances and motor accommodations during the process of learning.

Fourth, for future research involving GAS, the treating NDT therapists should learn to write their own GAS goals. This process should involve intense practice during the early phase of the study, as reliability of the GAS measure increases with experience (Kiresuk, Smith, & Cardillo, 1994). Similarly, considerable training of 'raters' is required. In this study, training of expert raters included three training periods through Pilot Studies One, Two and Three. Furthermore, if video footage is used to generate data, camera technology that will produce the clearest video footage should be used. This, along with specific outcome measures (such as 'number of times performed'), may improve reliability in further research.

Fifth, future research could further investigate the link between the assessment process, goal setting and intervention. In discussing the results of this research, it was proposed that the generation of GAS served to focus NDT intervention towards functional change.

Sixth, Royeen and de Gangi (1992) raise a number of questions about how research involving examination of the impact of intervention should be conducted, including by whom. This research utilized experienced practitioners who

administered NDT under the guidance of NDT instructors, thereby controlling for treatment fidelity. Future studies examining the impact of NDT should continue to consider the fidelity of intervention given.

6.8 CONCLUSION

This study addressed the question: 'What is the impact of Neuro-Developmental Treatment on the functional outcomes of children with cerebral palsy as measured by their performance in selected daily living tasks'. Three pilot studies trialed methodology to measure potential change in performance in targeted daily living tasks by children with cerebral palsy in response to NDT intervention, and to develop an 'NDT Measurement Model'. Daily tasks included self care, mobility, hands skills, communication, educational and vocational skills, leisure pursuits and play (Howle, 2002; World Health Organization, 2001).

The aim of these pilot studies was to focus on the relationship between intensive NDT and functional goal performance and whether observed, meaningful clinical changes in performance could be empirically measured. In particular, a multi-methods approach to the research generated evidence to support the use of intensive, short term NDT to improve specific functional performance of twelve children with CP.

A measurement model with the potential for clinical and community use was developed. The components of this model are GAS, a standard filming procedure, motion analysis software and descriptions of parent and therapist perceptions of outcomes. This measurement model demonstrated the ability to measure small 'one step' achievements towards functional goal improvements with acceptable inter rater reliability (GAS) and face validity (GAS and Motion Analysis). Refinements of the model to improve reliability of use in clinical settings are suggested.