The Manitoba Revision of the Luria-Nebraska Neurpsychological Battery for Children Standardized in Iceland

by

Jonas Gudmundur Halldorsson

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The undersigned certify that they have read a Master's thesis entitled: The Manitoba Revision of the Luria-Nebraska Neuropsychological Battery for Children Standardized in Iceland

submitted by Jonas G. Halldorsson

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Approved ☑ Not Approved ☐

Edward H. Schludermann

Advisor

Shirin Schludermann

....

....

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External Examiner

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ABSTRACT

The present study translated the Manitoba Revision of the Luria-Nebraska Neuropsychological Battery for Children into Icelandic. This translation was subsequently standardized on a sample of 261 "normal", "average" Icelandic school children aged 7-12 in Reykjavik, Kopavogur and Hafnarfjordur. Age levels were six, approximately 20 girls and 20 boys were tested at each age level. "Best performance norms" were established and an "absolute scoring system" developed. Profile sheets were made (one for each age-level, not aggregated across sex) where raw scale scores were transformed into T-scores. Tables were developed to make this task easier.

The present study examined the effectiveness of the battery to differentiate between normal (N), learning disabled (LD) and brain damaged (BD) children. For this purpose 53 LD children and 10 BD children were tested (aged 7-12). Diagnostic rules were developed. According to these rules, correctly classified were 99.6% of the N sample, 83% of the LD sample and 100% of the BD sample. Using diagnostic rules, the battery was able to differentiate between the clinical groups, to some extent, correctly classifying 60% of the LD children and 100% of the BD children.

The present study also examined national differences, sex differences and age differences. Overall Winnipeg children performed better than Icelandic children at ages 7-9, girls tended to perform better than boys and most items showed age trends.

LD children usually showed patterns of strengths and weaknesses, while BD children showed more overall poor performance.

Split-half and alpha coefficients for age-levels 7 and 12 were low, from .00 (e.g. visual scale) to .72 (reading) (mean of alpha coefficients .25). These low reliability coefficients, however, do not necessarily indicate that the scales are not reliable.

The present study indicates the test battery has construct validity in the sense that it differentiates successfully between N children and LD and BD children.

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Chapter I
INTRODUCTION

1.1 NEUROPSYCHOLOGY

Clinical neuropsychology or the scientific study of human brain-behavior relationships is one of the mewest branches of psychology although for thousands of years people have contemplated what is now called the mind-brain problem, i.e. what is the relationship between the mind and the body, is the human being only material or is there an immortal soul attached to the body. No solution has as yet been found to this problem although the materialistic view has been predominant among scientists the last decades.

During the last two hundred years probably the most debated issue in the study of brain-behavior relationships has been localization of functions, i.e. how and where are psychological functions localized in the brain and in the central nervous system (see e.g. Krech, 1964). Early in the 19th century Gall and Spurzheim forwarded the theory of phrenology one of the first theories of localization of functions. Since then there have been three major theoretical dispositions towards this problem.

First the localizationists have maintained that each complex psychological function is localized in one area of the brain, and the brain can be mapped according to the functions each area serves.

Secondly the holists have claimed that each psychological function is not located in one part of the brain, but represented all over the brain. This means that impairment of any function is directly associated with the amount of cerebral cortex destroyed (but not the site of the lesion). The holists also believe in the equipotentiality of the parts of the brain, i.e. an intact tissue can take over the functions of a damaged tissue.

Thirdly it is the functional view of the brain as forwarded by the Russian neuropsychologist A.R. Luria (1902-1977). Luria (1970) claims that simpler sensory and motor functions (e.g. vision, sight, receptive speech, expressive speech) are well localized in the human brain, but that more complicated psychological functions (e.g. reading out loud, writing as dictated by someone) form fuctional systems in the brain, i.e. the microfunctions are localized in different parts of the brain and different parts have to work together when a complex function is performed.

1.2 EAST AND WEST

A.R. Luria and L.V. Majovski (1977) have compared American and Soviet clinical neuropsychology. Luria and Majovski find that in some fundamental areas the Soviet approach and the American approach differ significantly. In the view of the authors American neuropsychology is basically quantitative test oriented and lacking in theoretical foundation. The American approach relies primarily on the use of standardized test batteries as a tool in diagnosing brain-behavior disturbances. Standardized tests are used both for experimental and clinical purposes in neuropsychology and the most widely used test battery is the Halstead-Reitan Neuropsychological Test Battery (HRNTB). This test battery, a standardized measure, has its norms and cut-off scores, consists of a number of subtests, and is designed to detect a wide range of deficits associated with brain lesions. Luria and Majovski see several limitations to the American approach using the Halstead-Reitan battery. Administration time is at least 6-8 hours. This approach is not based on a coherent theory of brain-behavior relationships and is therefore not helpful in providing suggestions for rehabilitation planning. Physical methods like Computerized Axial Tomography (the CAT scan) may soon be sophisticated enough to diagnose and localize brain lesions as well and faster than the neuropsychological batteries.

Luria and Majovski see Soviet clinical neuropsychology as fundamentally qualitative and based on a comprehensive, functional theory about brain-behavior relationships. This theory is able to provide directions as to restoration of functions following brain injury and to rehabilitation planning. Other advantages of the Soviet approach are its flexibility suitable for every individual case, it is quick (30-50 minutes), it only assesses the individual on the dimensions appropriate for his case, it integrates all available relevant information. Examination of each individual can be seen as a unique experiment "it can yield reliability assessed through the syndromes obtained and validity based on intersubject data" (Luria and Majovski, 1977).

Although the Soviet approach has been qualitative until now, Luria and Artimieva (1970) suggest that it would be useful at this point in time to analyze mathematically the vast amount of data that have been collected in the Soviet Union during the last forty years, observations that are the basis for syndrome analysis, and provide syndromes with their essential reliability.

It may be said that there are two different approaches or models in neuropsychology regarding brain damage. On one hand there is the medical model. Here the emphasis is on the cause, the symptoms and the remedial therapy. The emphasis is also on the diagnosis and localization of brain damage, comparing neuropsychological evidence with diagnosis made by physical methods such as the CAT scan. The HRNTB is based on the medical model, it is validated against localization of lesion. On the other hand there is the rehabilitation-education approach. Here the presence or localization of brain damage is not of primary importance. The emphasis is on the deficit profile, i.e. the pattern of strengths and weaknesses of neuropsychological functioning. The relative strengths and weaknesses are used as a guide for remediation and education planning. In this sense this model is more useful than the medical model. Test batteries based on Luria's theories are based on this model.

However at this point the present author would like to point out that it is unlikely that the physical diagnostic procedures like the CAT scan will replace neuropsychological test batteries like the HRNTB and batteries based on the theories of Luria. The reason for this is that physical diagnostic methods can only diagnose and localize brain lesions, they can not provide information as to which functions are impaired as a result of a particular brain lesion (see also Wedding and Gudeman, 1980). On the other hand neuropsychological test batteries can provide the teacher and other professionals with information as to the relative strengths and weaknesses of the individual, which functions are intact and which functions are impaired. The HRNTB is a very useful tool for this purpose, as it has now been used for more than thirty years and is supported by extensive research. Test results on the HRNTB may be explained in terms of the most recent findings and theories in neuropsychology supplementing for its lack of theoretical basis. It is also very useful to validate recent neuropsychological batteries (like batteries based on Luria's theories) against the HRNTB as research has shown the latter one to be highly valid and reliable (e.g. Boll, 1981).

As stated earlier Western neuropsychology is often viewed as quantitative, atheoretical and oriented toward psychometric testing (while Soviet neuropsychology is qualitative, theoretically based, and dislikes psychometric testing). However this may be an oversimplification. There are approaches in American neuropsychology that rely on theoretical models, e.g. the assessment of language disorders (Goodglass and Blumstein, 1973), and memory disorders (Butters and Cermak, 1980), as pointed out in a review by Satz and Fletcher (1981). American neuropsychology can be either individualized and quantitative, e.g. Goodglass and Kaplan (1979). The HRNTB is not representative for all aspects of American neuropsychology.

The advantages of the Luria assessment procedure over the HRNTB are that it breaks down complex neuropsychological functions into their microfunctions, while many of the items on the HRNTB, e.g. the Category Test, assess complex functions with many component skills. Results on the HRNTB usually do not indicate which of the microfunctions are impaired (Golden, Hammeke and Purisch, 1978; Luria, 1980). Because Luria's assessment procedure identifies specific deficits at the microfunction level it also provides valuable information relevant to diagnosis, localization and treatment planning (Hammeke, Golden and Purisch, 1978, Luria, 1980). Administration time is also short compared to the administration time of the HRNTB (3 hours vs 6-8 hours), no expensive or complicated equipment is needed and it may be administered at the bedside, administration can be divided into sections. The HRNTB requires expensive equipment and is preferably administered in a laboratory setting.

Luria's theories have been criticized as having little empirical support (Adams, 1980b). How adequate Luria's theories and how efficient his investigation method is, has not been established by empirical research. Secondly Reitan (1976b) has criticized the individualized qualitative approach to neuropsychological assessment as a "disregard to standardized procedures and to the concept of cross validation" (p.199). Thirdly the Luria investigation procedure focuses on the patient's deficits rather than strengths. A neuropsychological battery like the HRNTB provides information both regarding the patient's strengths and weaknesses, which is useful for rehabilitation planning.

In the present author's view both the American, quantitative approach and the Soviet qualitative approach have made important contributions to clinical neuropsychology and should together form the basis for future growth of the subject in question.

1.3 LURIA'S THEORIES

In his article in Scientific American (1970) Luria claimed that sensory and motor areas of the brain had been carefully mapped but the rest of the brain, approximately three quarters of the cerebral cortex had still to be mapped. These areas are primarily associated with the higher behavioral processes which are very complex and according to Luria social in origin.

Higher behavioral processes consist of complex functional systems, and each process is based on a plan of operations that leads to a certain goal. Each functional system is self-regulating in the sense that the brain compares the results of actions with the plan and when the goal has been reached the brain stops the activity. This applies to all forms of behavior, simple and complex (Luria, 1970).

It seems to be that each complex behavioral process is directed by an apparatus consisting of several brain structures, where each brain structure is highly specialized in its role, and where there is a coordination and overall control of all the brain structures. If one brain structure is damaged this will disrupt the function of the complex behavioral processes but the nature of the disruption depends on which brain structure is destroyed, as each brain structure plays a highly specialized role (Luria, 1970).

In the view of Luria (1970) the objectives of neuropsychological investigation should be to "a) pinpoint brain lesions responsible for behavioral disorders and by that develop a means for early diagnosis and precise location of brain injuries so that they can be treated as soon as possible; and b) to provide a "factor andlysis" to help us understand the components of complex psychological functions for which the operation of the different parts of the brain are responsible" (p. 66). (By the term "factor analysis" Luria is not refering to the conventional statistical concept of factor analysis, but to the analysis of complex psychological functions into their microfunctions).

Luria (1970) considers the brain made up of three main blocks, each serving a basic function. The first block, the upper and lower part of the brain stem and particularly the reticular formation, regulates the energy level and tone of the cortex, providing it with a stable basis for the organization of its various processes. A damage to the first block results in disruption of the stability of the brain's dynamic processes, wakefulness deteriorates and memory traces become disorganized. Also the cortex may respond equally to significant and insignificant stimuli, or even respond more to the insignificant ones. The control of behavior becomes deranged.

The second block consists of the rear part of the cortex or the cortex posterior to the central sulcus. The second block includes highly specialized areas which on the whole analyze, code and store incoming information. These areas are organized in a hierarchical manner: the primary zones sort and record the sensory information; secondary zones organize the information further and code it; and the tertiary zones integrate data from different sense organs and form the basis for the organization of behavior (for a mapping of the primary, secondary and tertiary areas of the brain see Figure 1). Impaired primary area results in sensory defect but no changes appear in complex behavior. Damage to secondary area results in impaired analyzing and coding of incoming information and behavior processes that normally respond to these kinds of stimuli. Damage to tertiary area interferes with the integration of information from different sense organs and complex behavior based on such synthesis of information.

The third block, the cortex anterior to the central sulcus, especially the frontal lobes, is involved in the formation of intentions and programs for behavior. The third block is, like the second block, divided into primary, secondary and tertiary areas. The frontal lobes are connected to the brain stem, including the reticular formation. The frontal lobes serve primarily to activate the brain and regulate attention, concentration and behavior.

As stated earlier, according to Luria "every complex form of behavior depends on the joint operation of several faculties located in different zones of the brain. A disturbance in any one faculty will affect the behavior but each failure

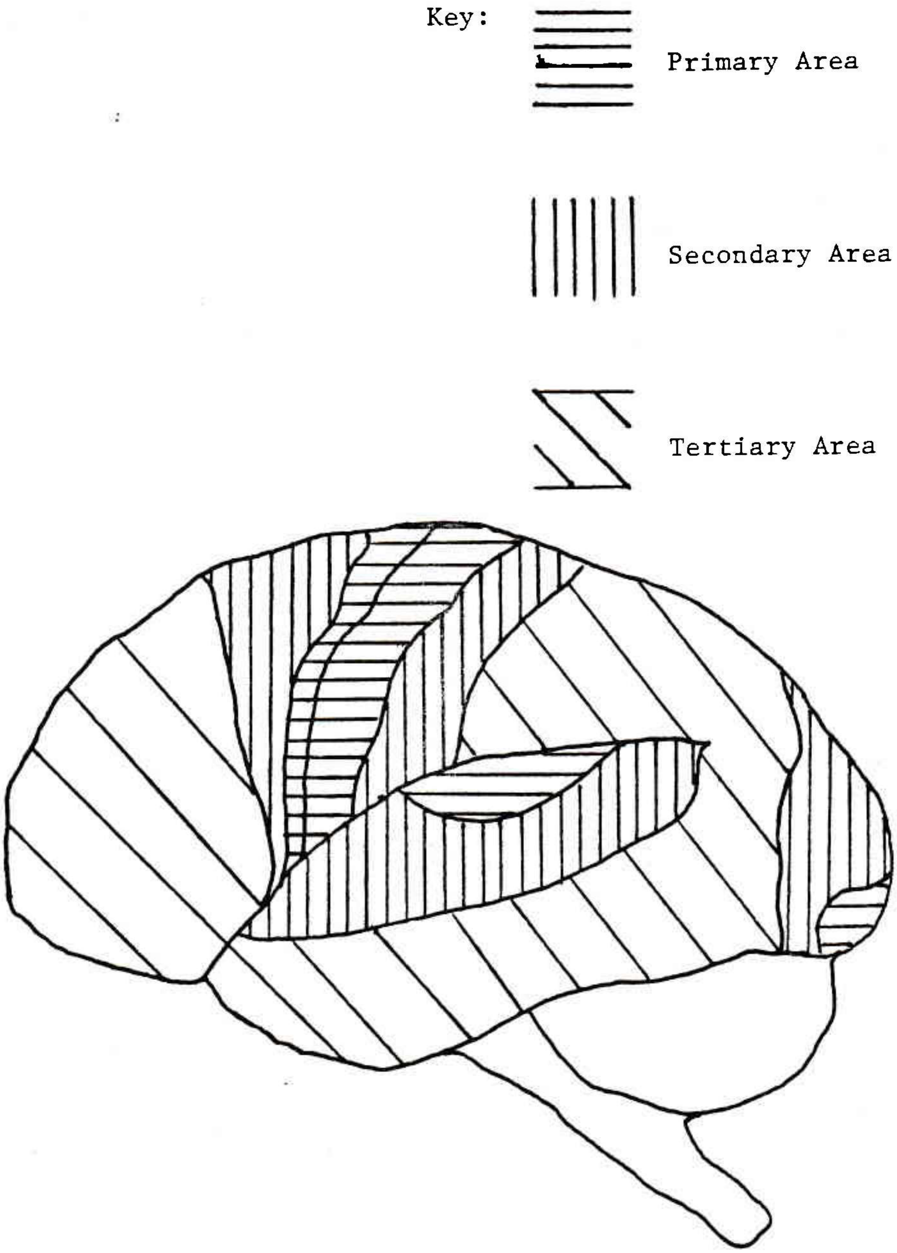


Figure 1. The Human Brain and Its Division into Primary, Secondary and Tertiary Areas. Adapted from Luria (1980, p. 57).

of a specific factor presumably will change the behavior in a different way" (Luria, 1970, p. 68). As an example, voluntary movement is not just the function of the motor cortex and its large pyramidal cells. Voluntary movement is the function of a system of subcortical and cortical zones interconnected in a complex way. Each zone is highly specialized in its functions within the functional system. That is why lesions of different parts of the brain can result in the disturbance of different voluntary movements. The first component of a voluntary movement is a precisely organized system of afferent (sensory) signals, i.e. feedback from muscles and joints necessary for corrections of actions. This involves the postcentral sensory cortex. Damage to this area of the cortex causes loss of sensation in limbs and inability to perform well organized voluntary movement. This condition is called afferent paresis. The second component of voluntary action is the spatial field, i.e. movement has to be oriented toward a certain point in space. This involves the tertiary parts of the parieto-occipital areas. Damage causes inability to evaluate spatial relations and a left/right confusion. The third component of voluntary movement is the kinetic melody factor, i.e. the the sequential interchanges of separate links of motor behavior. Here the premotor area of the cortex is involved. Damage to this area results in loss of skilled movement, an inability to stop one step of the movement and move to the next step smoothly. The fourth and last component of voluntary movement is the goal directedness, the stable program and meaning of movement. This is provided by the prefrontal lobes. Damage to the prefrontal lobes can lead to movements becoming meaningless repetitions, impulsiveness, and loss of purpose.

Another example of functional system is speech and writing. Luria describes the processes involved when a person is asked to write a given word (Luria, 1970).

The first component is the interpretation of the oral request. A word is a set of phonemes, each phoneme is coded by a letter or a combination of letters. Perception of words may depend on very slight differences between phonemes or even acoustic cues like pitch. The brain must analyze the phonemes on the basis of past language learning. Recognition of phonemes is performed by the secondary zones of the left temporal lobe, which are closely connected to other speech areas of the brain. Damage to these areas will make it difficult to distinguish between phonemes, e.g. between similar phonemes like the b in bull and the p in pull. The second component is that often people pronounce (internally or externally) unfamiliar words before writing them. The central (kinesthetic) region of the left hemisphere controls the the articulation of speech sounds. Damage to this area may lead to a confusion of sounds which are produced with similar tongue and lip movements, e.g. b and m. The third component is the coding of the phonemes into letters. Here the visual and spatial zones of the cortex are involved, i.e. the occipital and parietal lobes. Damage to these areas causes difficulties in recognizing and forming written letters, difficulty to visualize the required structure of the letter, to grasp the spatial relations between the parts of the letter, and to put these parts together and form a whole. The fourth component, when asked to write a given word, is putting the letters in their proper sequence to form the word in question. Sequential analysis involves the anterior region of the left hemisphere (the left prefrontal area). Lesion to this area results in an inability to carry out rhythmic movements (kinetic melody), difficulties in writing letters in their correct order. Patients with such lesions tend to substitute letters with meaningless stereotypes, and if the lesion is deep the patient may only repeat fragments of the letters. The fifth and final component of writing involves the whole third block. Its function is writing letters and words and at the same time expressing thoughts and ideas. If the third block is damaged we are not able to express our thoughts verbally or in writing.

Detailed investigation using items which test each microfunction of the complex behavioral process in question can be a guide to the exact location of the lesion, and also provide some idea what the strengths are and how the disrupted function can be repaired or compensated for.

Luria stresses the notion of "factor analysis" (which may also be called component analysis). By "factor analysis" Luria means that each individual subject can be factor analyzed in the sense that when a particular factor (microfunction) is impaired by a brain lesion all the complex behavioral functions that involve that factor are disturbed but all others, not involving that microfunction, remain intact. Behavioral processes that look very similar may turn out not to be related, - and on the other hand behavioral processes that do not seem to have much in common may be related by depending on the same factors, at least partly. Finally Luria points out that different parts of the brain may be involved when behaviors have become automatic through overlearning than when the analytic apparatus is needed to perform the behavior.

Luria in his theories was greatly influenced by Hughlings-Jackson, Pavlov and Vygotskii. Luria (1980) stresses that we must analyze each complex psychological human function. We must realize that each function is in fact a functional system, a set of interconnected microfunctions. Each complex function can be compared to a chain, the links make up the function. The links may not be fixed, some substitution may take place, which means that each functional system is a dynamic system. Each link may not be limited to one functional system, but be an essential part of many functional systems. Each link is situated in one part of the brain, and the links forming a functional system may be situated in different parts of the brain, forming a functional whole. The fact that the links making up a functional system may be interchangeable has significant implications for restoration of functions following brain damage, i.e. the disturbed function may be reorganized by using different links, forming a new functional system. The new functional system will not duplicate the performance of the disturbed functional system, but it will serve the same function. This theory does not maintain that there is equipotentiality between different areas of the brain, nor does it claim that a complex psychological function is strictly localized in one fixed part of the brain. Luria did not believe that there were innate centres for functions, but rather that the localization of functions in the brain was influenced by sociohistorical development to a significant degree (Luria, 1980).

Luria claimed that as each individual developed the same part of of the brain served different functions and that the deficit caused by the destruction of a certain part of the brain depended on the stage of the individual's development. Luria (1980) quotes Vigotskii's rule (Vigotskii, 1960) that:

> "In the early stages of ontogenesis, a lesion of a particular area of the cerebral cortex will predominantly affect a higher (i.e. developmentally dependent on it) center than that where the lesion is situated, whereas in the stage of fully formed functional systems, a lesion of the same area of the cortex will predominantly affect a lower center (i.e. regulated by it)" (p. 35).

According to Luria's model a complex functional system can be disrupted at any link, but the deficit pattern will differ depending on which link is damaged. In Luria's view functions must be qualitatively analyzed and so must symptoms, in order to find the primary defect responsible for the observed deficit. Often one circumscribed lesion will lead to a group of disturbances as the area affected may serve as a link in many functional systems. In Luria's view "the qualitative analysis of the syndrome as a whole is an essential step in the clinical analysis of disturbances of higher cortical functions from local brain lesions" (Luria, 1980, p. 84).

The general conceptions of Luria's theory, such as that the posterior block and the anterior block are both divided into primary area, secondary area and tertiary area, that all areas are interconnected, and that each complex psychological function is localized in different parts of the brain, has recently received independent support from the Scandinavian blood flow studies (Lassen, Ingvar and Skinhoj, 1978). When a specific area of the cortex is activated it needs increased amount of oxygen. For this purpose the blood flow to this particular area increases, bringing more oxygen. By injecting radioactive isotopes into the subject's bloodstream and with the help of radiation detectors around the subject's head and a computer, the researchers were able to generate a computer made image of the amount of blood flow to different areas of the cortex. They found that the pattern of blood flow to different areas of the cortex changed according to what tasks the subject was performing. The researchers were able to establish which areas of the cortex were activated (and provided with more blood and oxygen) while the subject was performing different tasks (moving, perceiving, reading, writing or resting). On the whole Luria's analysis of psychological and behavioral functions, and how and where they were localized in the cortex was supported by these blood flow studies.

Luria's claim that the localization of complex psychological functions is influenced by sociohistorical development to a significant degree has received support from human and animal studies on the critical period of the brain's development, emphasizing the need for environmental stimulation for "normal" brain development (e.g. Mussen, Conger and Kagan, 1979, p. 110; Hurley, 1969).

1.4 LURIA'S ASSESSMENT PROCEDURE

Luria (1980) has developed his own method of investigating the higher cortical functions in local brain lesions (syndrome analysis). This is a qualitative investigation starting with the preliminary conversation and then moving to a series of preliminary tasks. On the basis of the results obtained an individualized investigation is carried out. The tasks chosen depend on the investigator's view of the nature of the deficit (e.g. verbal, perceptual) and on the patient's performance on earlier tasks. Thus different patients with different deficits are given different sets of tasks. The administration of a given task (e.g. the word to be read, the design to be copied) is not standardized. No norms or standardization procedures are included in Luria's method, and Luria strongly discourages such procedures be applied to syndrome analysis. On the other hand great emphasis is on the ability of the examiner to make accurate clinical judgements and to choose the appropriate tasks. When the investigation has been carried out the clinician formulates his neuropsychological conclusions and may recommend procedures for rehabilitation planning.

Luria's neuropsychological investigation method is in practice an extension of the neurological examination. It relies heavily on the ability of Luria's theory to analyze complex neuropsychological functions into their microfunctions, which can be localized in specific areas of the cortex. Constant revision of the analysis of the factors that make up complex functions is necessary as knowledge about the functional organization of the brain increases.

Functions investigated by Luria's tasks are: motor functions; acoustico-motor coordination; higher cutaneous and kinesthetic functions; higher visual functions; mnestic processes; receptive speech; expressive speech; writing; reading; arithmetical skills; and intellectual processes.

1.5 CHRISTENSEN'S VULGARIZATION

In 1975 a Danish clinical psychologist Anne-Lise Christensen published Luria's Neuropsychological Investigation, Text, Manual and Cards, in an attempt to structure Luria's assessment procedure, to build up a framework so the investigation would be thorough and exhaustive. Christensen like Luria stressed that the quantification and standardization of neuropsychological investigation methods would not be useful because of the variability and flexibility necessary (Christensen, 1975).

Christensen (1975) standardized items and the administration procedure of Luria's investigation method "to ensure the process of investigation would be as thorough and exhaustive as it was designed to be" (Christensen, 1975, p. 9).

Christensen like Luria relies on the functional systems and the qualification of symptom approach in her neuropsychological investigation.

A.-L. Christensen in her book Luria's Neuropsychological Investigation (1975), quotes Luria as commenting when she showed him her outline of Luria's Neuropsychological Investigation: "Of course it is a vulgarization - but I have always wanted someone to do what you have done" (p. 9).

Christensen's Neuropsychological Investigation follows the same pattern as Luria described in his book Higher Cortical Functions in Man (Luria, 1980). Christensen's adaptation includes 253 items divided into 10 areas, i.e. motor functions, acoustico-motor organization, higher cutaneous and kinesthetic functions, higher visual functions, impressive (receptive) speech, expressive speech, writing and reading, arithmetical skills, mnestic (memory) processes, and intellectual processes (Christensen, 1975).

Christensen mentions that the investigation primarily evaluates the functions of the left dominant hemisphere (Christensen, 1975).

Christensen (1975) standardized questions and assessment procedures, but used the positive-negative sign approach, i.e. patient's performance on a task was either adequate or inadequate. The strengths of Christensen's "vulgarization" over Luria's assessment procedure are that everyone is asked the same questions and therefore displays strengths as well as weaknesses. The weak points of Christensen's "vulgarization" are the lack of norms (especially for children, where maturation is fast and there are great individual differences in the rate of maturation) and there is little psychometric information available on it, it is not known how useful it is in differentiating between adequate and inadequate performance.

1.6 THE LURIA-NEBRASKA NEUROPSYCHOLOGICAL BATTERY (LNNB)

In spite of Luria's recommendations and warnings Charles J. Golden, Associate Professor at The University of Nebraska Medical Center, has standardized Luria's tasks. Already considerable research has been carried out to establish the reliability of this standardization and its validity. In short Golden and his collaborators have found the test battery to be of high reliability and validity, and highly useful as a diagnostic tool and of great importance in rehabilitation planning.

By standardizing Luria's investigation procedure the goal was to create a battery that would combine the advantages of qualitative and quantitative neuropsychological assessment (Golden, 1981a, 1981b; Golden, Ariel, McKay et al., 1982; Golden, Hammeke and Purisch, 1978; Hammeke et al., 1978). The aim was to design a battery that would assess brain dysfunction quickly and reliably and that would include qualitative assessment in accordance with Luria's assessment procedure (Golden, Ariel, Moses, Wilkening, McKay, MacInnes, 1982, pp. 40-41).

Item selection: Items in the Luria-Nebraska Neuropsychological Battery (LNNB) were originally obtained from Christensen's version of Luria's investigation procedure (Golden, Hammeke and Purisch, 1978). A few of Christensen's items were excluded on the basis either that normal people had difficulties passing them or it was difficult to score and standardize them. A few items were added to the test battery, namely items that were supposed to measure the motor and tactile functions of the right hemisphere (Golden, Hammeke and Purisch, 1978; Hammeke et al., 1978). Then 282 items were (Hammeke, Note 1) administered to 50 neurologically intact medical patients and 50 patients with mixed neurological diagnosis (Golden, Hammeke and Purisch, 1978; Hammeke, Note 1). Here 13 items that were not able to discriminate effectively between the two groups were dropped, leaving 269 items making up the LNNB. Golden (Golden, Hammeke and Purisch, 1978, 1980) organized these items the same way as Christensen did (Christensen, 1975) into 11 scales: motor functions, rhythm, tactile functions, visual functions, receptive speech, expressive speech, writing, reading, arithmetic, memory, and intellectual processes. Besides these 11 scales there are three other important scales, developed by recombining some of the 269 items in different ways, i.e. the left hemisphere and right hemisphere scales (assessing primarily the motor and tactile functions of the respective hemispheres) and the pathognomic scale which is made up of items that were found to best discriminate between the two groups of patients (Golden, Hammeke and Purisch, 1980).

Administration: It has been claimed (Adams,1980a) that the administration instructions (Golden, Hammeke and Purisch, 1980) are a strange mixture: on one hand there are standardized instructions for each item, but on the other hand the diagnostician is encouraged to individualize the administration and to test the limits so far as the intent of the item is preserved. The authors (Golden, Hammeke and Purisch, 1980) state that: "standardized instructions are flexible" (p. 13). However it is unclear how this flexibility (which is good in itself) affects the scoring of items. More clearcut advice for administration possibilities is now being developed (Golden, 1981a; Golden, Ariel, Moses et al., 1982).

In the view of the present author the test battery should first be administered according to standardized procedures to establish item and scale scores. However when standardized testing has been completed more information can be collected about the patient by individualizing the assessment method and testing the limits.

Adams (1980b) claims that a standardized test battery based on Luria's investigation procedure and theories: "seems to be a logical impossibility ... the need to be consistent, rigorous and public in the application and development of protocols seems antithetical to the approach that Luria described" (p. 514).

The administration of the battery takes 1,5 to 2,5 hours (Golden, Hammeke and Purisch, 1980), may be given at the bedside and at different sections, designed for patients 15 years of age or older.

Scoring: Items are scored in several ways, such as number of errors, time it takes to perform a task, etc. according to the instructions of the manual (Golden, Hammeke and Purisch, 1980). Raw scores of each item are transformed according to norms into 0, 1 or 2 scores. Normal performance receives a score of 0, a clearly impaired performance is scored as 2, and a borderline performance a score of 1.

Norms were established by finding cutoff points that showed maximum effectiveness in discriminating between 75 persons as brain damaged or normal. How scale scores were derived is not clear, as this information has not been published in detail or in its entirety (Golden, 1981a, 1981b; Golden, Hammeke and Purisch, 1978, 1980). This has been very unfortunate as subsequent research, conclusions and clinical interpretations are based on the scale score system (Golden, Ariel, Moses et al., 1982).

Scores of all items on each of the 14 scales are summed to get the 14 raw summary scale scores. High scores are indicative of brain impairment. Raw scale scores are then transformed into T-scores (standardized scores with a mean of 50 and a standard deviation of 10). These transformation values are based on means and standard deviations from a normal standardization sample of 50 medical patients who were not hospitalized because of conditions affecting the brain (Hammeke et al. 1978). The representativeness and size of the standardization sample may be criticized. It is not known what are the limitations to using the norms. Golden (1981a) has accepted this criticism and the need to "fully expand the test's normative base"(p. 231). However this should have been done before the test was marketed.

1.7 GOLDEN CRITIQUED

The present author would like to stress at this point that, as can be seen in the following section, the research on the Luria batteries has been ambiguous and open to criticism. This does not imply that the test batteries themselves are useless. However the usefulness and applicability of these test batteries has still to be established by more, empirically sound research.

General critique: The LNNB has already been marketed and advertized as a test of outstanding quality and usefulness. However some researchers (e.g. Adams, 1980; Spiers, 1981) have pointed to serious methodological flaws in the research of Golden and his collaborators, and have suggested that the test battery should neither be advertized nor marketed until sufficient, valid research is available to support it. Critics claim that the research on the LNNB has numerous substantial statistical and methodological flaws and that Golden has not been successful in combining Luria's qualification of the symptom approach with a standardized quantitative approach of the West. Critics claim that the battery has been marketed and advertized too early. However

Golden and his associates claim that the LNNB evaluates all major neuropsychological functions and that it is an effective tool for the diagnosis of brain damage and for rehabilitation planning.

Adams (1980b) and Spiers (1981) claim that the 0,1,2 scoring system is not sensitive enough in the assessment of neuropsychological functions and that more precision is possible with regard to present neuropsychological knowledge. However Golden (1980) maintains that other scoring systems have been tried out (e.g. 0,1,2,3 and 0,1,2,3,4) but they had not been found to be superior in discriminating normal individuals from brain damaged ones. Here however Golden misses the point that the main goal of the LNNB is not to diagnose and localize brain damage but to carefully assess the individual's strengths and weaknesses and to collect in that way valuable information for rehabilitation and education planning.

Golden, Ariel, McKay et al. (1982) claimed that each scale assessed a general skill area. However as the items on each scale are heterogenous, i.e. assess different functions, Golden, Hammeke and Purisch (1980) stress the importance of noting which items are passed and which items failed on a particular scale, when interpreting and defining the nature of the deficit.

Russell (1980) claims that items on each scale are so heterogenous that summing item scores on a scale is practically meaningless.

Scorer reliability: Five subjects were randomly selected for testing from a sample of 50 neurological patients and 50 medical control patients (Hammeke, Note 1; Golden, Hammeke and Purisch, 1978, 1980). The test battery was then administered by one examiner in the presense of a second examiner, both scoring performance independently. On 282 items agreement in scoring ranged from 92% to 98% (mean=95%). Correlations between scores for each examiner ranged from .97 to .99 for the five subjects. However composition of sample is unclear (scoring is probably easier when normal individuals are tested). As sample is small variability may be too small to test the limits of the scoring criteria. More research is needed before Golden's (1980) claim that "the scoring criteria are highly reliable" (p. 517) can be substantiated.

Test-retest reliability: On a sample of chronic, static, neurological patients Golden, Berg and Graber (1980) found test-retest reliability correlation coefficients to range from .77 (right hemisphere scale) to .96 (arithmetic). Test interval ranged from 10-489 days. These findings have not been replicated. The length of the time interval was not found to have significant effects, which is not usual.

Split-half reliability: Odd-even split was used by Golden, Fross and Graber (1981). Correlations on scales ranged from .89 (memory) to .95 (reading). As previously mentioned in this section, items of each scale are heterogenous. The reason for high correlations is probably caused by the design of the test that similar items tend to go together in twos (e.g. first the right hand is tested and then the left hand). Some other form of split-half reliability would give better infomation (e.g. splitting each scale in half and comparing the first item of the first half with the first item of the second half; or alpha coefficient), but this has not been performed yet.

It should be mentioned here however that if a neuropsychological test battery has adequate validity then it is reasonable to assume it has also adequate reliability (Boll, 1981).

Content validity: Golden and his associates (Chmielewski and Golden, 1980; Golden, Hammeke and Purisch, 1980; Moses and Golden, 1979; Purisch et al., 1978) claim that the LNNB provides a comprehensive and extensive assessment method for all neuropsychological functions. However some researchers (Crosson and Warren, 1982; Delis and Kaplan, 1982) question the ability of the battery to assess comprehensively neuropsychological functions. Spiers (1981) even claims that the LNNB is not able to assess any major neuropsychological function in an adequate or comprehensive manner.

Regarding content validity two major issues are raised, one concerning the selection of items and the other regarding the contamination of items. As mentioned earlier Golden and his colleagues (Hammeke, Note 1; Golden, Hammeke and

Purisch, 1978) deleted items from the item pool if they were not able to discriminate effectively statistically between normal and neurological patients. Crosson and Warren (1982) and Delis and Kaplan (1982) have suggested that items should have been included on the basis of current knowledge of brain behavior relationships as the goal is not primarily to diagnose and localize brain damage but to establish the individual's strengths and weaknesses, by assessing the intactness of a representative sample of microfunctions. Secondly, Crosson and Warren (1982), Delis and Kaplan (1982) and Spiers (1981, Note 4) have pointed out the contamination of items, i.e. the individual's performance on items relies heavily on the intactness of receptive and expressive language functions. This criticism also applies to many items of the HRNTB. Crosson and Warren (1982) suggest that the battery is not suitable for patients with language disorders. Lewis, Golden, Moses, Osman, Purisch and Hammeke (1979) have admitted that severely aphasic patients had problems taking the test and were therefore excluded from their research (p.1007).

Golden, Ariel, Moses et al. (1982) have suggested that instructions may be individualized to suit the needs of the patient and that responses on many items (e.g. tactile) need not be verbal. However it is not clear how this would affect results, if the results would be comparable to norms.

Another and related criticism refers to that items on each scale are too few to satisfactorily assess the micro-functions of a particular skill, e.g. the reading scale does not assess reading comprehension (Crosson and Warren, 1982) and the memory scale does not measure recent or remote memory (Spiers, 1981).

However Golden, Ariel, Moses, et al. (1982) have provided convincing evidence that the LNNB may be used to assess neuropsychological functions adequately and exhaustively, but satisfactory assessment relies heavily on the clinician's knowledge of brain behavior relationships, and how this appears on the battery, as well as information from other sources and instruments.

Construct validity: The internal consistency of each scale (does each scale tap one general construct) has been found to be high (Golden, Fross and Graber, 1981). However the statistical methods (factor analysis and item intercorrelations) used in this research has been criticized, not leading to reliable conclusions. Correlation with other instruments has found the LNNB and the HRNTB to overlap significantly in skills assessed (Golden et al., 1981).

Golden and his associates have carried out investigations to assess the ability of the battery to differentiate between normal and neurological patients (Hammeke, Note 1; Golden, Hammeke and Purisch, 1978; Hammeke et al., 1978). However the results of these investigations are unclear as the procedures (samples not adequately described, samples not controlled for education, etc.) were questionable. It was found that 89% of items were able to discriminate between patient groups. This was found by performing 282 t -tests, which is a questionable procedure (Adams, 1980a, 1980b). Although the LNNB shows promise in distinguishing between normal and neurological patients, more methodologically sound research is needed. The LNNB also shows promise in localizing and lateralizing brain damage but resarch regarding this has the same statistical and methodological problems as described above.

In conclusion, the LNNB shows promise but much more methodologically and statistically sound research is needed to establish how well the battery does the job it is designed for, and how useful it is as a tool for deciding rehabilitation and education procedures.

1.8 THE NEUROPSYCHOLOGICAL DEVELOPMENT OF CHILDREN

1.8.1 The Effects of Brain Injury on Children

There are two major theories regarding the effects of brain injury on children (see Springer and Deutsch, 1981). The first theory stresses the "plasticity" of a child's brain, i.e. intact cortical areas may take over the functions of a damaged area to a greater extent among brain damaged children than among brain damaged adults. This implies that brain damage may have less severe consequences in childhood than in adulthood. This theory also implies that during early childhood the brain functions according to mass action theory, but as the brain matures functions become more and more localized and lateralized. This relates to the view of intellectual processes being general in nature during early childhood but becoming progressively more specialized with age.

The second theory claims that besides the direct effects of brain damage among children, such brain damage will also negatively affect the development of higher cognitive skills, as this development is dependent on the lower impaired processes. This means that brain impairment may have more severe effects among children than adults. Golden (1981) cites research supporting that takeover of functions following brain injury mainly appears among very young children with large lesions, lesions that may involve a substantial part or the most of one hemisphere, but the other hemisphere is left intact (DeRenzi and Piercy, 1969; Reed and Reitan, 1969). These cases are relatively rare in the clinical population (Strich,1969, in DeRenzi & Piercy). Other research cited by Golden (1981) indicates that early childhood injuries (2-4 years) cause more impairment than injuries occuring later, e.g. at ages 5-7 (Boll,1976). These findings are in line with Luria's theory, stated earlier, that early damage of lower functional system will negatively affect the development of higher functional systems. It follows that a child is more likely to show a generalized deficit following a brain injury than a brain damaged adult (Golden,1981). Golden (1981) stresses the importance of taking into account the neurodevelopmental stage of a child's brain at the time of injury, to be able to evaluate the effects of that particular injury.

Research on the sex differences in the lateralization of complex psychological functions suggests that on the average males are better at spatial abilities than females but females are superior on language functions (e.g. Coltheart, et al., 1975). Also this evidence suggests that spatial abilities are lateralized early in life (before age 6) and that these abilities are more lateralized (usually in the right hemisphere) in boys than in girls (Witelson, 1976). Verbal abilities also seem to be more lateralized among boys than among girls (Springer and Deutsch, 1981, p. 127).

Waber (1976) found evidence supporting that early maturers tend to have better verbal than spatial abilities but the reverse is true for late maturers. Waber also found that early maturers tended to have less speech lateralization than late maturers, indicating that lateralization differences between boys and girls may not be directly due to sex but to the fact that girls tend to mature earlier than boys.

Levy (1978) suggests there might be an evolutionary basis for sex differences of spatial and verbal abilities. Man as a hunter had to rely on visual-spatial abilities, but females usually have had to bring up children which requires verbal abilities. However greater degree of lateralization does not necessarily mean greater ability.

Lenneberg (1967) in his literature review concluded that lateralization started at the time of language acquisition but was not fully completed until puberty. Others (e.g. Basser, 1962) claim that lateralization is completed at age 5 or earlier. To what extent lateralization is present at birth is not known, and the plasticity of the brain at that age makes it difficult to investigate (Springer and Deutsch, 1981). Also it has not yet been empirically established if lateralization increases with age.

In conclusion, the diagnosis of brain damage and its localization and lateralization is more difficult among children than among adults. This may be because of the plasticity of the brain or because of the lack of localization and lateralization of functions in the child's brain. Mass action may be the case in early childhood, associated with general intellectual processes. Gradually functions may become more localized and lateralized. However early brain damage may affect later brain organization in different and unknown ways, making localization and lateralization of brain damage very difficult. However for the planning of rehabilitation and special education methods such information is not a prerequisite, it is sufficient to know the child's strengths and weaknesses. It is however useful to know if brain damage is present or not in a child, as if it is not other causes must be identified as responsible for poor school performance, etc.

1.8.2 Neurodevelopmental Stages

Although at birth virtually all the neurons of the brain have been generated (Kandel and Schwartz, 1981) the brain weight is only approximately one fourth of the weight of an adult's brain. At age two however the weight of the brain is three times that at birth and close to the adult size. At age two also higher mental functions have started to appear (Springer and Deutsch, 1981). After birth several aspects of neurological development continue or appear, e.g. myelinization, dendritic growth, growth of cell bodies and establishment of pathways among neurons (Golden, 1981). These processes depend on genetic mechanisms, nutrition and general health and are a necessary prerequisite for the development of psychological and behavioral functions. For a successful psychological and behavioral development physiological maturation is not sufficient, environmental stimulation is also required. This environmental stimulation will also affect the physiological maturation process, e.g. the establishment of neuronal pathways (Mussen, Conger and Kagan, 1979).

Golden (1981) suggests there are five major stages of neurodevelopment which is in line with Luria's theories. These stages also tie in with the stages of cognitive development as forwarded by Piaget.

Stage one: This stage refers to the development of the most basic parts of the brain, unit one, or the reticular formation and related structures. The development of unit one is usually completed at birth (in cases of premature birth this may not be so), or not later than 12 months from conception. While this system has not yet fully developed, children can be expected to show arousal/attention deficits. If this system is damaged during its development it usually leads to hyperactivity and attention/filtering disorders. The child may either find it hard to concentrate and be easily distracted by irrelevant stimuli (too much cortical stimulation), or the child may get too little cortical stimulation and be hyperactive in order to provide extra cortical stimulation.

Stage two: This stage involves the development of the primary motor and sensory areas (motor, tactile, auditory, visual) and takes place during the same time period as stage one. The development of stage two is genetically determined and not influenced by the environment. The motor reflexes present at birth are typical stage two behavior. As the secondary areas of the brain develop stage two behavior usually disappears. Injury to primary areas of the cortex may lead to the loss of primary functions (e.g. cortical blindness), however through the brain's plasticity the intact opposite hemisphere may take over the functions of the damaged area to some degree.

Stage three: During this stage the secondary areas of the cortex develop. This development usually starts around birth and is not fully developed until age 5. The secondary areas of the cortex organize and code information from the sense organs, and the development of these areas is obviously influenced by environmental stimulation. Behavior associated with this stage is e.g. learning to speak and learning to walk.

Stage four: This stage refers to the development of the tertiary areas of the second block, mainly localized in the parietal lobes. This stage is thought to last from age 5 to 8. These tertiary areas integrate information from different sense organs and are associated with very complex behavior. The functioning of these areas is necessary for learning to read and write and for simple arithmetic.

Stage five: This is the last stage of neurodevelopment and only starts at adolescence and it may not be fully completed until age 24, according to Golden (1981). This stage includes the development of the tertiary areas of the third block, the prefrontal lobes. These areas are associated with the highest forms of human thinking and intentional behavior.

1.8.3 Diagnosis of Brain Injury in Children

Golden (1981) claims that it is more difficult to diagnose brain damage among children than among adults. Poor performance may be caused by several factors besides brain damage, such as low intelligence, developmental delays, cultural differences, motivational and behavioral problems. However, in the present author's opinion patterns of performance or relative strengths and weaknesses are more important than the knowledge of presence or absence of brain damage. It would be interesting to investigate to what extent neuropsychological batteries are able to differentiate between learning disabled children and children of low intelligence, culturally disadvantaged children, etc.

In neuropsychology the same method is used to localize and lateralize brain damage among children as among adults. However Golden (1981) points out several important factors that should especially be considered when childred are diagnosed: a) Neuropsychological disorders in childhood are usually diffuse and the effects of a lesion in one area of the cortex differ according to the neurological stage the child was at, at the time of injury; b) Deficits are affected by later training, which is usually cognitive in nature. Motor and sensory deficits may be less affected by training and therefore be better localizers than cognitive functions; c) Pattern of the deficit depends on the age of the child when the injury occurred; d) It is important to have appropriate age norms because children develop fast and there are considerable individual differences in the rate of development; e) It is important to differentiate between primary and secondary effects of brain damage (secondary effects like behavioral and emotional problems that often appear among brain damaged children).

In the present author's view, when developing a test battery for children age norms are especially important. There are, as mentioned earlier, fast cognitive changes in childhood which makes developing a test for children a challenge. On the whole it is more difficult to make a test for children than for adults because of the rapid developmental changes. When developing tests for children we need age norms for a more valid assessment, and we also need to relate items to children's style of cognitive functioning. It is also important to adapt tests and to standardize tests to different populations, cultures and early educational experiences, for cross-cultural comparisons. By establishing age norms we increase the diagnostic effectiveness of the test in different cultural settings. Studies have shown the importance to establish sex norms, as girls mature faster than boys (Mussen, Conger and Kagan, 1979, p. 112).

1.8.4 Learning Disabilities

The concept "learning disabled child" refers to a child that has specific learning difficulties at school, but is doing well on other subjects. A learning disabled child is usually defined as being of average or above average intelligence. (For reference see Gaddes, 1980). The learning disasbled child does not have the overall poor school performance associated with diffuse brain damage and very low intelligence. Golden (1981) cites evidence supporting that learning disabled children tend to show a number of specific neurological and neuropsychological deficits. A significant percentage of learning disabled children has a pattern of deficits that would be expected from a localized brain injury. It is suggested that neuropsychological investigation may be able to identify such children and that these children may benefit from special teaching programs based on their performance (pattern of strengths and weaknesses) on neuropsychological tests (Golden, 1981).

There seems to be different patterns of deficits learning disabled children show, however Golden (1981) points out a few factors these children tend to have in common: a) Overall, all learning disabled children perform well, there is no generalized loss of functions; b) Patterns of deficits usually indicate a focal lesion, usually in the left hemisphere, not because the left hemisphere is a more often damaged but because the deficits associated with left hemisphere lesion cause more disruption with school work; c) Usually the cognitive deficits are accompanied by motor/sensory deficits; d) Not all deficits may be neurological in nature. It is important to concentrate on the strengths and weaknesses of the individual.

1.9 LURIA BATTERIES FOR CHILDREN

1.9.1 The LNNB for Children (LNNBC)

Unaffected by the severe critique the LNNB received Golden and his associates have gone on to develop a standardized children's version of the Luria-Nebraska Battery (LNNBC).

Golden (1981) states that now The LNNTB has been adapted for children and that some initial normative data has been established for this adaptation on a sample of 120 children aged 8-12. Golden claims that this adaptation has some value as being able to discriminate between normal and brain injured children, but as research has just started the full value of this battery has still to be established. The children's version of the Battery is shorter than the adult version, includes 149 items (Tramontana, Sherrets and Wolf, 1983), and many items have been modified for children. However it is divided into the same subareas as the adult version. The adaptation is intended for children 8-12 years of age and is supposed to test the functions of all areas of the brain except those of the prefrontal areas (a tertiary area which according to Golden is not fully developed until around age 24) (Golden, 1981).

When developing the LNNBC Golden and his associates followed the viewpoint that children move through succeeding stages of brain maturation (and intellectual functioning), each stage qualitatively different from the others. The view was, in other words, not that children were only less skilled adults, and the same basic test could be used for both children and adults. The tests were not only made easier for children (like what was done when the WISC-R and the HRNTBC were developed), items were changed and adapted, some deleted and new items added.

As mentioned above the LNNBC was designed for children aged 8-12, i.e. for children at stage 3 of neuropsychological development according to Golden (1981). Stage 3 refers to the development of the tertiary parietal areas. The tertiary frontal areas of the brain are not fully developed at this age, according to Golden (1981) (not fully mature until early adulthood) and therefore items measuring the functions of this area in the LNNB were eliminated in the LNNBC.

Age appropriateness of item instructions and material was assessed and adapted. The test was administered to a small group of above-average children in order to identify inappropriate items and to see which other adaptations might be necessary. Two revisions were made and tested on a small group of children. Then a third version was tested on a group of 60 children. From these results the fourth version was created and norms established on a group of 120 normal children aged 8-12; 24 at each age level. Golden (1981) claims that the results are supporting the dvelopmental stages view, i.e. items that rely on second stage functioning or less show little age trends, but items assessing tertiary parietal functions show significant improvement with age. Norms for each age group show age trends for 50% of items. Separate norms for girls and boys are not reported.

The LNNBC includes the same basic scales as the adult version. Items are scored the same way, and raw scores converted into 0,1,2 scores. Item scores (0,1,2) are added up for each scale and these scale scores are then transformed to T-scores (standardized scores with a mean of 50 and a standard deviation of 10) tables are provided for this purpose (Golden, 1980).

Research on the LNNBC only started in 1980. Golden reports that 50 children were tested with the LNNBC and the battery effectively predicted both IQ and Wide Range Achievement Test (WRAT) reading levels with multiple correlations across the 11 Luria scales of values ranging from .75 to .85 (Golden 1981). It was also found (Golden, 1981) that 50 brain damaged children (lesions were not in the tertiary frontal area) performed significantly worse than 50 normal children on the LNNBC. Research has still to be extended to larger samples and learning disabled children (Golden, 1981).

Golden has done more research on the adult version than on the children's version and therefore the criticisms of the adult version also apply to the children's version and even more. This is one more reason to standardize carefully and do research using the children's version, especially as Luria's work shows promise for educational institutions.

To what extent do cultural factors influence neuropsychological functions? To answer this question we must cross-validate neuropsychological batteries in two or more different societies.

1.9.2 The LNNBC Revised Manitoba Edition (LNNBC-RL)

Rune Lundin, a school psychologist at The Child Guidance Clinic in Winnipeg (Rune S. Lundin, c/o The Child Guidance Clinic of Greater Winnipeg, 700 Elgin, Winnipeg, Manitoba, Canada) is presently working at revising Golden's LNNBC, and standardizing this revision for school aged children in Manitoba, as well as for preschool children. (For the Manitoba Revision of the LNNBC see Appendix A).

Lundin has made some changes to the LNNBC, deleted, added and changed some of the items, and developed a revision of 149 items which are divided into scales and scored the same way as the LNNBC. This version is called the Manitoba Revision of the Luria-Nebraska Neuropsychological Battery for Children (LNNBC-RL).

Lundin, in an unpublished pilot study (Lundin, Note 2) has administered his revision to a group of normal children aged 5 to 12. For children aged 5-7 some items have been changed or deleted, especially items that rely on academic abilities such as reading, writing and mathematics, and also items assessing intellectual processes. Here Lundin has actually developed two versions of his revision, one version for children aged 5-7 and another version for children aged 8-12. Preliminary norms have been developed for children aged 5-7 and for children aged 8-10. Children in the standardization sample were of average intelligence, and were plus or minus 6 months from their birthday at the time of testing. The Manitoba norms as established by Lundin do not show much age trends, probably because there are actually two batteries, and because children are plus or minus 6 months from their birthday at the time of testing (overlap likely). In Lundin's pilot study separate norms have not been developed for boys and girls, boys and girls are aggregated. Items are scored in the same way as the items of the LNNB, item scores are transformed to 0,1 or 2 according to established age norms (each child is compared to his/her age peers), the transformed item scores are added up for each scale and these scale scores are transformed to T-scores on a profile sheet developed in Manitoba (Lundin, Note 2; Appendix A).

Lundin has also tested several learning disabled and brain damaged children, in order to diagnose and localize brain damage, and to assess their strengths and weaknesses and on the basis of this information (together with other available information) to plan remedial and special education programs. In Winnipeg a program has been set up to detect learning disabilities among 5 year old children with the aid of the LNNBC-RL (for 5-7 year old children), and to treat the learning disabled children found, on the basis of test results.

Lundin has written a preliminary manual for the LNNBC-RL which includes the interview and the history taking questions, and all the test items and instructions for administration followed by the Manitoba norms (Lundin, Note 2). Secondly Lundin has written Clinical Interpretation and Item Analysis of the LNNBC-RL, as a help for the clinician in assessing test results (Lundin, Note 3). Furthermore Lundin is presently preparing Approaches to Remediation, a guide on how to use test results for remediation and education planning.

1.9.3 Clinical Interpretation of the LNNBC-RL

In an unpublished paper Lundin (Lundin, Note 3) has described the clinical interpretation and the item analysis of the LNNBC-RL. With the permission of the author the following information has been abstracted from his unpublished paper:

To be able to understand performance on the LNNBC-RL one must understand how the performance on each item reflects brain functions and dysfunctions. Each item is designed to assess one specific ability (microfunction) or a combination of abilities. Each specific ability or microfunction can be related to a specific part of the cortex. The battery is not designed to assess all neuropsychological functions, rather the functions that are the prerequisites for academic progress, identifying specific impairments as well as relative strengths and weaknesses. The nature of the present battery, built on the theories of Luria, means that a child with a specific brain impairment can do well on many items but will fail on those items related to the particular microfunctions that are impaired. This gives the clinician specific information about the child's brain functioning. This can be contrasted to test items on other tests, such as the WISC-R Coding Subtest and the Halstead Category Test. These items do not give specific information about brain functioning as they involve so many microfunctions or functional systems. These items are not so valuable in determining specific strengths and weaknesses and deciding remedial measures.

Very high scale scores (90T or more) usually indicate "cases of severe brain dysfunction involving vascular accidents, extensive scar tissue, severe convulsive disorders or severe chronic degenerative disease" (Lundin, 1982, p.

1). Moderately high scale scores (60-70T) usually indicate brain dysfunction or recovery from injury, if cooperation is good.

On this battery all items are important as each one is designed to assess a specific microfunction. This means that although a scale score is normal, 5 items missed in a sequence on that particular scale can be indicative of a specific brain impairment and providing important information. If a scale score exceeds the cutoff point closer analysis of items missed will provide a more precise identification of the child's impairment within that area. If a child's scale score is normal but he/she fails a few items on that particular scale, the items missed are usually related to some other major functional area than that measured by the scale. For example, items 4 to 7 on the motor scale are related to the tactile scale. Evaluation of items missed is therefore very important to understand the impairment and to decide rehabilitation. This evaluation can also help to identify emotional and behavioral problems that often accompany brain impairment in the school-age child. Through the careful analysis of deficits and strengths remedial programs may be designed and information gained to advice parents and teachers on the problems the child might be expected to have in the future.

The scale scores provide a quick evaluation whether the child is brain impaired or not and the severity of that disorder. It is claimed that each scale is 85% effective at discriminating between brain damaged and normal children (Gustavson et al., 1982, Note 5). A scale score of 70-80T is usually indicative of congenital or pre-partum small injuies. A scale score above 80T suggests severe disorder usually a more recent one and presently interfering with brain functioning.

Left and right hemisphere scales are designed to lateralize the impairment. These two scales are primarily based on items from the motor scale and the tactile scale.

The qualitative approach should be combined with the quantitative approach. When testing a child using the LNNBC-RL the qualitative aspects of the child's performance should be noted, e.g. how the child approaches the task. An inability to perform a task may have different causes (a child may find it difficult to write letters because of a motor problem or because of a visual-spatial problem, etc.), here qualitative assessment is necessary to distinguish between possible causes. "Testing the limits" procedure may be used when it may provide extra information, however usually this is not necessary as the same problem is presented in different ways throughout the battery.

It is possible to forward hypotheses about the child's brain dysfunctioning, and to test these hypotheses, and arrive at the hypothesis that best explains the child's test results, using the three approaches, qualitative assessment, scale scores and item analysis.

1.9.4 Interpretation of Individual Scales

This subsection is also based on Lundin's (Lundin, 1982, Note 3) unpublished paper on the clinical interpretation and item analysis of the LNNBC-RL.

The motor scale: This scale includes the greatest number of items of all the scales (34 items). It assesses a variety of motor functions, both functions of the right and the left hemisphere.

Items 1-3 assess simple movements of the hands and the fingers. Impaired performance on these items is associated with brain impairment in or near the posterior frontal lobe.

Items 4-7 require the child to be blindfolded and involve simple motor movements associated with kinesthetic and tactile feedback. Therefore these items if failed usually suggest impairment of the parietal lobe.

Items 8-14 involve simple motor movements together with spatial organization (right-left). These items are especially sensitive to disorders of the frontal lobe and also disorders of areas of the right hemisphere that are associated with optic-spatial organization.

Items 15-18 involve both simple and complex movements and the organization of behavior. Poor performance is associated with impairment of the motor area of the frontal lobes and also prefrontal areas and premotor region.

Items 19 and 20 involve oral movements. Failure may indicate frontal lobe or parietal lobe impairment, but also disorder of some of the cranial nerves, reflecting disruption in the brain stem or generalized brain dysfunction.

Items 21-32 measure construction dyspraxis. If drawings are very poor this may be caused by severe spatial disorganization associated with impairment of the right or the left parietal area. If the qality of drawings is normal but drawing is slow this may reflect motor dysfunction or in some cases be due to compulsiveness.

Items 33 and 34 assess the child's ability to respond to a speech regulation of the motor act. The child has to understand the instructions, keep them in mind for some time and respond appropriately. The understanding involves the temporal-parietal areas of the left hemisphere and the speech regulation of the motor movements involves the frontal lobes. A frontal lobe disorder makes it hard for the child to move in response to a verbal command although understanding may be good.

As can be seen from above the motor scale items are sensitive to different types of brain impairment besides that of the posterior frontal lobes, e.g. impairment of the temporal and parietal lobes, and disorders of the anterior frontal lobes. However if scale score exceeds 80T this usually indicates lesion of the frontal lobes. The motor scale is useful for the localization and lateralization of brain impairment. By looking at the right and left hemisphere scales along with the motor scale, valuable information can be gained. A high score on the motor scale but low scores on the left and right hemisphere scales usually indicates the intactness of simple motor movements but poor functioning of the more complex movements caused by a lesion in the right hemisphere or in the frontal lobe of either hemisphere. The Motor scale can be used to localize brain damage along the anterior posterior dimension. In the case of pure parietal lobe dysfunction, motor scale score will usually not exceed 60T but items 4-7 are often failed. However it must be kept in mind that localization is not the main goal of the battery, rather to establish areas of strength (scale scores below 50T) on which alternate teaching strategies can be based.

Rhythm: Item 35 involves the analysis of groups of tones (two tones are presented, which one is higher?). Perception of tonal qualities is directly associated with the temporal lobe of the right hemisphere.

Items 36-38 involve the reproduction of tones or the expression of tonal relationships, by some associated with the frontal lobe of the right hemisphere. Children with expressive aphasia resulted by injury to the left hemisphere may pass these items easily and this strength may be used for alternate teaching strategies, e.g. learning to read using the sing-song technique or using rhyming instead of letters.

Items 39-40 involve the evaluation of acoustic signals (the child must say how many beeps he/she hears).

Items 41-42 assess the child's ability to reproduce rhythmic patterns which is associated with the right temporal area and the ability to reproduce sounds using the dominant hand (right hand usually) involving the left hemisphere. Reproducing rhythms from verbal commands also involves the left hemisphere areas associated with comprehension. The items of the rhythm scale are also sensitive to disorders of attention and concentration (hyperactivity). If the child has attentional problems (it is useful to assess this before the test is administered) it is important to ensure at the beginning of each item that he/she is paying attention. Psychiatric children may do worse on these items than neurological children, because of their attentional problems. In the case when attention and cooperation is good and there is no speech problem poor scale score here is usually due to right hemisphere impairment. If there are speech problems the cause can be either of the left or the right hemisphere.

Tactile functions: This scale mainly assesses the functions of the anterior parietal lobe of either hemisphere.

Items 43-56 involve cutaneous sensation. Both the primary and secondary tactile areas of the posterior block may be involved and items 53-56 measure partly impairment around the angular gyrus.

Items 57-58 involve muscle and joint sensation, associated with both anterior and posterior part of the parietal lobe. If the child only fails on these two items of the tactile scale the clinician should look for errors on items 4-7 of the motor scale. Items 57 and 58 assess stereognostic perception and these items are especially sensitive to the residual effects of old brain injury.

The left and right hemisphere scales are made from items of the motor and tactile scales. Research has shown that lateralization according to these scale scores is accurate in 85% of cases (Gustavson et al., 1982, Note 5). Usually the performance of the left hand should be at least equal to or even slightly better than the performance of the right hand due to practice effects.

Visual functions: Items 59-60 involve naming of objects and naming objects from pictures. These items are sensitive to left hemisphere disorder. These items are very simple but if they are not passed, performance on subsequent items will be extremely poor.

Items 61 and 62 involve more visual-spatial perception.

Item 64 involves visual memory, a right hemisphere function usually.

Item 65 assesses the ability for spatial rotation, is sensitive to the impairment of visual-spatial skills. If the child does not have expressive or receptive speech deficits elevated scores on this scale indicate right hemisphere dysfunction.

Receptive speech: This scale assesses the ability of the child to analyze and understand receptive speech.

Items 66-71 measure phonetic hearing and understanding, repeating and writing phonemes. Item 71 assesses the ability to understand phonemes spoken at different levels of pitch, related to the right temporal area.

Items 72-77 involve the understanding of simple words and sentences, to ensure the child is hearing correctly.

Items 78-83 test the ability to understand complicated instructions and to answer them.

All items on this scale can be affected by left hemisphere impairment, but a right hemisphere dysfunction can also elevate this scale score (e.g. items 79 and 80 involve spatial orientation). Items that include comparison (81-83) are sensitive to impairment of the parietal-occipital areas of the left hemisphere, but may also be failed simply because of lack of understanding, associated with injuries of the temporal lobe or angular gyrus. The items on the receptive scale are not dependent on reading readiness, reading ability or the level of education. If the child performs well on this scale but poorly on the reading scale this is indicative of impairment of the occipital or temporal-occipital areas of the left hemisphere. The receptive scale is especially sensitive to left hemisphere damage but its score may also be elevated by right anterior damage, playing a role in the understanding of basic English phonemes, analysis of pitch and the rhythm of speech.

Expressive speech: This scale assesses the ability of the child to express phonemes, simple words and sentences and to repeat complex sentences and express automatic and more complex speech.

Items 84-88 assess the ability to repeat phonemes and words from dictation.

Items 89-92 assess the ability to read the same material. If the child is able to pass either sequence, significant expressive difficulties are not present. If items 84-92 are passed but the child has difficulties with items 93-104 low IQ may be expected or frontal lobe damage of the left hemisphere. Higher forms of speech are especially associated with frontal lobe functions. In most cases high scale scores here (70T or more) are caused by left hemisphere dysfunctions, invoving the temporal frontal area, especially the posterior two thirds of the frontal lobe. If the problem is basically to change sounds or the slurring of speech kinesthetic damage may be expected (associated with parietal damage and tactile deficits, e.g. items 4-7).

Writing: This scale involves analyzing words phonetically, copying and writing what the examiner dictates. Children under 8 years of age may not have sufficient educational background so a writing readiness test would be more appropriate here. Disorders of writing are often associated with temporal, parietal, occipital impairment, especially in and around the angular gyrus of the left hemisphere. There are however some exceptions to this. Being able to write from written material but not from auditory material indicates specific damage in the temporal lobe. Being able to write from dictation but not from written material however indicates impairment of the occipital- parietal areas of the brain. If the problem is in forming letters and changing from one letter to the next this may be due to impairment of kinesthetic feedback, confusing letters that are drawn by similar motor movements. If a child is not able to draw because of paralysis, this is due to a lesion of the motor strip area of the posterior frontal lobe. Writing at an unusual angle to the page may be indicative of right hemisphere impairment. Inability to read or write own name may indicate childhood dementia or diffuse brain damage.

Reading: This scale assesses the ability to integrate letters into words, to recognize letters, to read words and sentences. Failure here is associated with impairment of the temporal-occipital area of the brain, or the temporal-parietal area of the left hemisphere. If a child knows the letters and is able to read words but not sentences and paragraphs this may be due to impairment of the tertiary parietal areas (areas which are involved in the analysis of grammatical structures) or the impairment of the secondary visual areas of the occipital lobe (visual scanning).

Mathematics: This scale of all the scales is most sensitive to educational deficits among children, a scale score of 90T may be reached without any indication of brain dysfunction. Poor performance may be due to emotional reaction to mathematics, by gently encouraging the child, he/she may be able to perform better. Because of the nature of these items, performance here may be used to assess task orientation.

The first items on this scale involve the writing of numbers from dictation, and to read same numbers. Here the clinician looks for reversals and spatial deficits, possibly caused by right hemisphere or left hemisphere occipital-parietal dysfunction.

Next the child is asked to compare numbers (which is larger?) a function associated with the left occipital-parietal area.

Then simple arithmetical problems are presented, the child should be able to perform from memory. If the child fails these simple items this may mean a serious inability to understand or a severe left hemisphere damage (especially involving parietal areas).

Item 126 (more complex arithmetical problems) indicates if failed by older children left parietal dysfunction. Item 127 (classic serial three's) is difficult even for normal children, however very poor performance here is associated with brain damage, especially if the child is doing well on other items of the scale, and is then associated with a left frontal lobe dysfunction.

The memory scale: This scale assesses short-term and intermediate memory functions.

Item 128 involves memorizing a list of words and to predict own performance. Poor prediction is indicative of frontal lobe dysfunction.

Items 129-131 assess visual memory and visual memory with interference. These items are a little more sensitive to right hemisphere than to left hemisphere dysfunction. Item 130 measures motor memory. On the whole nonverbal items missed is associated with right hemisphere dysfunction and verbal items missed is indicative of left hemisphere impairment. Elevation on the memory scale can be highly specific and scale score above 80T is usually associated with left hemisphere or bilateral brain damage.

Intellectual processes: Here items are not designed to assess intelligence the same way as IQ tests do. Items were selected if they efficiently discriminated between brain damaged and normal subjects. These items do not primarily assess parietal functions like for example the WISC-R does, but also other areas of the brain, e.g. frontal areas (138-139) and right frontal areas (interpretation of verbal schemes). However here visual scanning problem can also affect performance caused by various injuries to the premotor areas of the frontal lobes or injury to the occipital cortex. Item 140 may not only be missed by poor intellectual functioning but also because of expressive speech dysfunction.

Items 141-146 are in accordance to WISC-R subtests (test parietal functioning) involving logic, similarities and analogies.

On the whole this scale assesses left hemisphere functioning, especially as children's frontal areas are not fully mature. However very high scale scores usually indicate impaired prefrontal regions, that is if psychiatric thought disorder is not present and the receptive and expressive scales are within normal range (45-55T).

The pathognomic scale: Here items were selected that best discriminated between brain damaged and normal subjects. Old injuries usually show up as low pathognomic scale scores, elevated scores however may reflect progressive brain disease.

The right and left hemisphere scales: Items are mainly from the motor and the tactile scales. These two scales have been shown to lateralize brain damage correctly in 75% of cases among adults (McKay and Golden, 1979). These scales may not be so successful among children because of possibly less lateralization and more plasticity and mass action (see Springer and Deutsch, 1981).

Localization of brain damage among children is very difficult. In most cases lesions are not circumscribed, partial recovery may have taken place and symptoms may have emotional overlay (Lundin, 1982, Note 3).

1.9.5 Lesions of Different Brain Regions

This subsection is adapted from Lundin's (Lundin, 1982, Note 3) unpublished paper on the clinical interpretation and item analysis of the LNNBC-RL.

Frontal regions: The frontal regions of the cortex are associated with motor movements, evaluation, planning and organization of behavior, and higher forms of thinking. The tertiary regions of the frontal lobes may not be fully mature until early adulthood (Golden, 1981). The premotor areas are probably fully mature at an early age. The frontal areas especially the left prefrontal and premotor regions are involved in the evaluation and organization of stimuli and responses.

Children with left frontal injury tend to have elevated pathognomic scale score (80T or more) and a disruption of expressive speech (a premotor function); the expressive scale having a considerably higher score than the receptive scale (difference 15-20T), and more impaired motor functions than tactile functions. However the right and left hemisphere scales may not differ significantly. Motor scale items missed here may often be of the complex nature, where sequential movement is needed. Movements are out of sequence rather than slow, both hands are affected. Frontal injuries may also affect scores on memory, arithmetic and intellectual processes.

Right frontal dysfunction may elevate the receptive scale score, but the expressive scale may show little or no impairment (the opposite to left frontal injury). Items missed on the receptive scale are those involved in pitch discrimination, and speech involving spatial concepts (under, over, behind). This impairment also tends to elevate the tactile scale rather than the motor scale, and will usually not influence intellectual processes except items 136-138.

Central region dysfunction: This region involves the sensorimotor and tactile strips on either side of the central sulcus. Right hemisphere impairment of this region leads to high scores on the right hemisphere scale but does not affect the left hemisphere scale score. Left hemisphere impairment leads to high scores both on the right and on the left hemisphere scale (the left scale is usually 10 points higher). Motor and tactile scores are approximately equal in right hemisphere injury but in left hemisphere injury the motor scale score will be significantly higher than the tactile scale score. This dysfunction also affects the pathognomic scale score (elevates it).

Temporal lobe functions: These regions of either hemisphere are associated with auditory input and the integration of auditory stimuli. However the nature of these functions differs between hemispheres. The right temporal functions concentrate on tonal quality, rhythm, pitch and basic receptive speech. Left side temporal lobe functions are verbal and language related. Right temporal impairment causes less generalized deficit, on the battery (the battery is verbally weighted), also, in Western cultures and schools, verbal functions are usually considered more important than rhythm, intonation, etc.

In right temporal injury the motor scale score is usually higher than the tactile scale score. Especially affected are complex motor functions, leading to construction dyspraxia and poor nonverbal memory. Intellectual processes may also be affected especially sequencing and visual integration (space relations).

Left temporal injuries will usually elevate the receptive scale score (usually more than 10-15 points above the expressive scale score) and to a lesser degree the expressive scale, reading, writing, arithmetic and memory, but does usually not affect the left and right hemisphere scales.

Parietal-occipital functions: This region integrates the tactile-kinesthetic impulses and visual stimuli and auditory stimuli, blending information. This area of the left hemisphere is associated with speech, naming and logical-grammatical transformations. This area of the right hemisphere is involved in spatial functions and constructional activities.

Test items associated with right hemisphere parietal-occipital functions are those involving drawing skills, copying of letters, tactile items involving localization and identification of stimuli, and arithmetic items especially those involving tens, hundreds and columnar construction.

Similarly items that are associated with the same area of the left hemisphere involve complex grammatical construction, affecting reading, writing and intellectual processes. Impairment of this area causes writing errors of letters that require simultaneous kinesthetic movements, and also slurred speech (kinesthetic movements of the lips and tongue).

Further analysis: The major goals of the battery are the diagnosis and localization of brain damage, help planning remediation and alternate teaching strategies and monitoring functional status following accidental injury or surgery. The younger the child the more difficult the diagnosis becomes as more varied normal performance can be expected. Extreme caution should be used regarding statements of intactness of neural structures concerning children under 8 years of age, due to fluctuations of level of maturity of the brain. Additional specific testing is useful here (Lundin, 1982, Note 3).

1.9.6 Applications of the LNNBC-RL

The ideas forwarded in this subsection are those of the present author.

It is hoped that the LNNBC-RL may become a useful tool for identifying learning disabled children, to establish their neuropsychological and academic strengths and weaknesses, to help decide on the basis of test performance the most appropriate remedial program. The battery may also give support to localization and lateralization of brain damage. The test results should only be used together with information from other sources, i.e. parents, teachers, neurologists, school psychologists, etc. Different professionals should meet to decide the remedial program and revisions should be made regularly on the basis of the child's progress.

On the basis of performance on this battery it may never be concluded that a child is brain damaged. However it may be concluded that the child has certain neuropsychological and educational strengths and weaknesses and that the performance pattern indicates that certain areas of the brain are not working as they should be, whichever the reason may be.

Information the battery provides: As a whole the battery gives information on the intactness of several neuropsychological functions as the scale names indicate. Also it gives information on the academic status of the child in writing, reading and mathematics. Additional information can be gained from test results by noting which items the child failed and which were passed, as each item is supposed tion which may play a role in more than one complex function. Together with the test results all other available information should be used, both qualitative and quantitative information should be used to reach a conclusion. For qualitative purposes an interview format is provided at the front of the battery.

The LNNBC-RL and handicapped children: It would be useful to have a neuropsychological battery that could differentiate between brain damaged handicapped (e.g. blind, deaf, paralyzed) children and handicapped children without brain impairment, and that could establish the strengths and weaknesses of these children for remedial and educational planning.

The usefulness of the LNNBC-RL to handicapped children has still to be investigated. For such use the test battery would have to be adapted to each form of handicap, some items deleted (e.g. items that depend on hearing would have to be deleted for deaf children), some changed and some added because of the child's special abilities like sign language. The adaptation for each group of handicapped children would then have to be tried out and standardized on a carefully chosen sample of non-neurological (without brain damage) children with that particular handicap, to find norms.

Practical aspects: The reasons for a child's poor academic performance and slow progress can be varied and multifactorial. However it is important for efficient help in each case to know the causes. A child may suffer from emotional or psychological difficulties (e.g. because of familial problems); the cause may be physiological in origin affecting school performance; or it may be a brain lesion or a mixture of more than one factors (emotional problems often result from the child trying to cope with a brain impairment). If the school psychologist, the teacher and the child's parents know the reasons for poor school progress they can take appropriate measures to help the child overcome the deficit and they can make appropriate demands to the child knowing his or her abilities and limitations.

When parents, school psychologists or teachers notice a child's learning disability and slow academic progress it is important to diagnose that child's problem as soon as possible for effective treatment. A child who is not able to keep up with peers in academic work, often in spite of considerable effort, will very likely become frustrated and develop negative feelings toward school. It is important that the teacher does not label the learning disabled child as of low intelligence without further evidence. Many learning disabled children may have a very specific impairment and be otherwise of good intelligence and quite capable of showing good academic progress when allowed to step around their deficit.

When a learning disabled child is being diagnosed it is important to collect information from several sources, parents, teachers, neurologist, school psychologist and neuropsychologist. Here obviously the neuropsychological battery plays an important role as providing information in support of certain hypotheses regarding the child's undrlying deficit, and establishing a pattern of the child's strengths and weaknesses.

When a child performs normally on a neuropsychological battery, except perhaps on the academic scale (writing, reading, math) this may support the view that the causes are not related to impared brain functions, and would suggest more emphasis on emotional, psychological, motivational factors or even physiological factors.

If on the other hand a child scores outside the normal range on one or more scales of a neuropsychological battery this supports the view (if cooperation is good) that certain areas of that child's brain are not functioning like in a normal child. This theory can be compared to the view of the child's neurologist, which is often based on physical assessment methods (EEG, CAT scan, etc.). The performance on a neuropsychological battery (like the LNNBC-RL) can be used with considerable certainty by a skilled clinician to diagnose and localize brain impairment. In some cases it may be of some importance for parents and teachers to know about possible brain damage as other causes are then less likely. However this information is not of primary importance for the development of remedial and educational measures. Here the neuropsychologist would meet with school psychologist, special teachers and teachers (and perhaps parents) and explain carefully how the child performed on the test battery (scale scores, item analysis, clinical interpretation and qualitative assessment) what the child could do and what not, strengths and weaknesses. It is important to stress at this point that the test involves certain uncertainty and that although the test results may indicate possible brain impairment this does not mean the child is a hopeless case, the test results should only lead to more, goaldirected, efficient special education strategies for that child. Impaired performance may also not necessarily result from a brain lesion, there is always the possibility of developmental lags (late maturation) especially among young children or poor cooperation.

If the child has a specific deficit (e.g. poor phonetic hearing, poor visual-spatial ability) the teacher may be advised that relying solely on conventional teaching strategies that require the impaired functions to be intact will frustrate the child (not able to do it in spite of effort) and not lead to much academic progress. Instead the teacher may be advised to try to teach the child using alternative teaching strategies that do not rely solely on the impaired functions but use functions that are intact (e.g. it is possible to teach a child to read without relying on phonetic hearing). However the teacher may also be adviced to train the impaired functions. For this purpose special teaching material (kits) is available to train motor and tactile functions, visual-spatial functions, etc. (for futher information and for a list of publishers of this material see Lerner, 1981, pp. 490-493). The creativity of the teacher is invaluable here in individualizing educational strategies. For parents it may be pointed out how important it is for the learning disabled child to get plenty of human contact, to listen to or play music, to take part in some sport (swimming, etc.) and to play with toys that are related to academic skills.

To motivate the learning disabled child it is important to let him or her show what he or she is good at especially in the classroom among peers. Special teaching may take place outside the classroom where a more individualized teaching is possible. It is important to diagnose learning disabilities early (age 6-7) as this is more likely to help the child to overcome his or her disability as soon as possible.

1.10 STUDY PROPOSED

The research project proposed here is basically an exploratory study, involving the translation, adaptation (where necessary because of language differences) and standardization of the Manitoba Revision (for ages 8-12) of the Luria-Nebraska Neuropsychological Battery for Children (LNNBC-RL) for Icelandic school children. It is proposed to standardize the Icelandic translation/adaptation of the LNNBC-RL (LNNBC-RL-ICE) on a "normal" standardization sample of "average" (according to school performance) Icelandic school children aged 7-12, 20 boys and 20 girls tested at each of 6 age levels.

Furthermore, it is proposed to investigate the applicability and usefulness of the LNNBC-RL-ICE by testing two clinical groups of children, i.e. a group of learning disabled (LD) children, and a group of brain damaged (BD) children (preferably with well diagnosed and localized brain damage according to physical diagnostic methods such as the CAT scan).

The primary research objective of this exploratory study is to provide Icelandic school psychologist and other professionals with a useful and applicable neuropsychological test battery, adapted and standardized for Icelandic children.

Besides this primary research objective, the present study leads to some secondary objectives or goals:

a) To explore if there is a significant difference between the performance of children in Manitoba and children in Iceland. How do children in different cultures and in different countries perform on items of a neuropsychological test battery? Can similar performance be expected or does performance change with different environment and cultural factors? Different countries and different school systems might affect test performance. The maturation of the brain is governed by genetic factors and in that sense universal, however environmental stimulation is necessary for normal brain maturation, and will indeed shape the brain in different ways (Mussen et al., 1979). In Luria's view behavioral processes are social in origin (Luria, 1980). It can therefore be expected that performance may differ according to the nature of cultural and educational stimulation provided. In the present study it is known that Icelandic children start in elementary school at age 7 and they are not expected to be able to read until age 8. Manitoba children start at least one year earlier in elementary school and on the whole they are expected to work harder than Icelandic children, the time they spend in school is longer (6 hours versus 2 hours, daily) and the school year is longer in Manitoba (10 months versus 8 months). It would therefore be expected that Icelandic children did not perform as well as Manitoba children at ages 7 and 8 on items which test academic status. There may also be other factors influencing test performance like child-rearing practices. It is also known that general health and food shortage may affect brain maturation (Mussen et al., 1979). However both Canada and Iceland have high standard of living so differences would not be expected on this dimension.

b) Sex differences. It is common knowledge that girls develop faster than boys (e.g. see Mussen, Conger and Kagan, 1979, p. 112). It has also been found (Springer and Deutsch, 1981) that brain lateralization is different in girls as compared to boys. Girls seem to have their complex neuropsychological functions less lateralized than boys, and girls usually have better verbal abilities than boys (Springer and Deutsch, 1981). Boys have their verbal abilities usually well lateralized in the left hemisphere and their visual/spatial abilities located in the right hemisphere and on the whole boys have been shown to do better than girls on visual-spatial abilities and mathematics (Springer and Deutsch, 1981). Therefore sex differences can be expected on items related to the above mentioned functions. Usually it has also been found that learning disabilities are more common among boys than girls (Mussen, Conger and Kagan, 1979), the reason may be cultural or related to brain organization (probably both). Boys tend to be more active than girls, and more hyperactive, and as a result they tend to have less ability to attend than girls (Mussen, Conger and Kagan, 1979). Verbal skills are demanded at school and girls tend to be better at verbal skills (Springer and Deutsch, 1981). In Western societies girls are expected to be behave better than boys, they are probably more likely to use their spare time for activities that enhance school performance than boys (like learning to play the piano, etc.) (for reference see Mussen, Conger and Kagan, 1979). The above mentioned factors may at least partly explain girls' academic superiority over boys. Similar trends can be expected in Iceland.

c) Age differences. As the normal child grows older, develops and matures, it is expected that performance will improve on all items in a neuropsychological battery until a ceiling effect is reached, i.e. no further improvement on that particular task is possible. At younger ages on some items a floor effect can be expected, i.e. the item is too difficult and no one passes. Although improvement is expected with age other factors can alter these trends, such as motivational factors, and in a study like this, small sample size. Because of the fast development of children and because of differences in the rate of development as well as sex differences it is important to compare learning disabled children and brain damaged individuals with their appropriate age/sex and culture group.

d) The performance of learning disabled children. Learning disabled children are expected to do poorly on certain scales and to have a pattern of items they do not pass, showing their neuropsychological and academic weaknesses. They are also expected to do well on other scales, showing their specific strengths. If the child is doing poorly in school because of motivational and emotional factors, this child would be expected to do poorly on scales measuring academic status (reading, writing and mathematics) but to do normally on other items.

e) The performance of brain damaged children. It is to be expected that brain damaged children do poorly on most scales, however some relative srengths and weaknesses may be noticed. Performance of children with low intelligence can be expected to be similar (this will not be investigated in the present study).

Chapter II

METHOD

2.1 SUBJECTS

2.1.1 Normal Children (N)

The "normal" subjects, the standardization sample, were aged 7-12 and at the time of testing they were less than three months from their birthday. The subjects came from schools in socio- economically "average" areas. In Iceland people tend to live in their own housing. The size of their housing and if they live in apartments, townhouses or houses is often more related to age than to level of education or job. There has been practically no unemployment in recent years, and most people tend to work hard to be finally able to move into their own house. In most school areas there is a mixture of apartment blocks, townhouses and houses and the occupation of those who live in houses can not be predicted (they are not necessarily doctors, lawyers, etc.). However in some areas of Reykjavik people live who are significantly better off than the rest. These areas are usually expensive, do usually not include apartment blocks, houses are large. Here well payed professionals live: medical doctors, lawyers, dentists, airline pilots, etc. These areas are usually large enough to have their own elementary school.

Schools in these areas were avoided in the present study. On the other hand there are areas in Reykjavik where people live who have not been able to care for themselves (are poor, ill, mentally defective, drug abusers, etc). The city tends to provide these people with apartments in apartment blocks which are usually confined to certain areas of Reykjavik. The schools in these areas were also avoided in the present study. The schools selected for testing children were in the areas of Reykjavik with mixed socio-economic neighbourhood, with apartment blocks, townhouses and houses, and not in the predominantly rich or predominantly poor areas. Similar areas were selected in Kopavogur and Hafnarfjordur.

The children who were chosen for testing were, according to school performance, as evaluated by their teachers, the average students in their class. It was tried to eliminate children from the standardization sample whose parents were either unskilled or had a college degree (doctors, lawyers, teachers, etc.) as such children might not be representative of the average child. The reason for choosing average children regarding school performance and socio-economic status, was that as the standardization sample was small, extreme scores in either direction might significantly affect the mean and the standard deviation for each item. The normal children were randomly selected from 10 schools, 7 in Reykjavik, 2 in Kopavogur and 1 in Hafnarfjordur. Children were aged 7-12 and age levels were 6. At each age level there were equal numbers of boys and girls tested, 20-25 children of each sex. In all 261 normal children were tested, 130 girls and 131 boys. See Table 1. Table 1 shows the number of children tested in each age-sex group, and the total numbers of children tested. In Reykjavik there were (at the time of testing) 7338 school children aged 7-12. Here 169 normal, average children (aged 7-12) were tested, which is 2.3% of the population of school children aged 7-12. In Kopavogur and Hafnarfjordur 92 normal, average children, aged 7-12 were tested, which is approximately 3.0% of the population of school children aged 7-12 in those areas.

2.1.2 Learning Disabled (LD) Children

School psychologists in Reykjavik, Kopavogur and Hafnarfjordur referred the LD children for testing. They were asked to refer children for testing who were of average or above average intelligence, who had some specific learning disability, if possible equal number at each age level and preferably equal number of boys and girls. Number of LD children tested was 53, 46 boys and 7 girls. The LD sample had the following age/sex distribution: at age 7 five boys were tested; at 8 two boys; at 9 eight boys; at 10 ten boys and three girls; at 11 fifteen boys and two girls; and at 12 six boys and two girls. Although not included in this sample 15 more children were tested aged 13-14. See Table 2.

Table 1

Number of Normal Children Tested at Each Age/Sex Level

	Age						
Sex	07	08	09	10	11	12	Total
Girls	25	24	20	20	20	22	131
Boys	25	24	20	21	20	20	130
Total	50	48	40	41	40	42	261

Table 2

Number of Learning Disabled (LD) Children Tested at Each Age/ Sex Level, Divided into IQ Levels.

	Sex						
	Girls			Boys			
	IQ Levels			IQ Levels			
Age	NIQ	-IQ	IQ?	NIQ	-IQ	IQ?	Total
06	0	0	1	0	0	0	1
07	0	0	0	4	0	1	5
08	0	0	0	1	0	1	2
09	0	0	0	6	1	1	8
10	2	0	1	8	0	2	13
11	1	0	1	13	0	2	17
12	2	0	0	6	0	0	8
13	0	0	0	4	0	5	9
14	0	0	0	2	0	0	2
Tot.	5	0	3	44	1	12	65

Note. NIQ=Normal IQ; -IQ=below Average IQ; IQ?=IQ not Known.

Table 2 shows the number of LD children at each age and sex level. The group is divided here into individuals of normal intellegence (NIQ), below average intelligence (-IQ) and intelligence not known (IQ?). As can be seen from Table 2, majority of learning disabled children (57 out of 65 or 88%) provided by school psychologists were boys, 49 (75%) were reported of average or above average intelligence, and 49 (75%) of the learning disabled children were 10 years or older (88% were 9 years or older). The reasons for the absence of younger children in the group of LD children referred for testing is probably the Icelandic school system. Children are not expected to be show their academic abilities (reading, writing, etc.) until age 8 or 9, and therefore learning disabilities are detected relatively late (age 8-10).

2.1.3 Brain Damaged (BD) Children

The above mentioned school psychologists and one pediatrician were asked to refer for testing brain damaged (BD) children preferably with well diagnosed and localized brain damage. However not many such children were available, and most of them were diagnosed as "suspected brain damage". In all nine brain damaged boys were tested and one brain damaged girl. See Table 3. If all brain damaged children are included (also those aged 13 and 14) in all 14 children were tested. Table 3 shows how many children were tested at each

Table 3

Number of Brain Damaged (BD) Children Tested at Each Age/Sex Level, Divided into IQ Levels.

	Sex						
	Girls			Boys			
	IQ Levels			IQ Levels			
Age	NIQ	-IQ	IQ?	NIQ	-IQ	IQ?	Total
06	0	0	0	0	0	0	0
07	0	0	0	0	0	1	1
08	0	0	0	0	0	2	2
09	0	0	0	0	1	0	1
10	0	1	0	0	0	1	2
11	0	0	0	0	1	2	3
12	0	0	0	1	0	0	1
13	0	0	0	2	0	1	3
14	0	1	0	0	0	0	1
Tot.	0	2	0	3	2	7	14

Note. NIQ=Normal IQ; -IQ=below Average IQ; IQ?=IQ not Known.

age-sex level and further divides the sample into children of normal intelligence, below average intelligence, and unknown intelligence. Here 12 children out of 14 are boys (86%), brain damaged children are evenly scattered across age levels but the sample is very small.

In all 79 LD and BD children were tested, see Table 4. From Table 4 it can be seen that 63 of these children were 7-12 years, but of the whole sample 69 children were boys (87%) and 10 were girls (13%). Of the 63 children aged 7-12, 8 were from Kopavogur and Hafnarfjordur (about .26% of that population) and 55 were from Reykjavik (.75% of that population).

2.2 INSTRUMENT

The instrument was the Icelandic translation/adaptation of the Manitoba Revision (for children aged 8-12) of the Luria-Nebraska Neuropsychological Battery for Children (LNNBC-RL-ICE). (For discussion of the Manitoba Revision see subsection 1.10.2; for the complete Manitoba Revision and changes made in the Icelandic translation see Appendix A; for the complete Icelandic translation see Appendix B). This battery was individually administered to each child in all three subject groups, according to standardized procedures. (See Appendices A & B).

The test battery consists of 149 items. These items are divided into 11 scales (Motor, Rhythm, Tactile, Visual, Re-

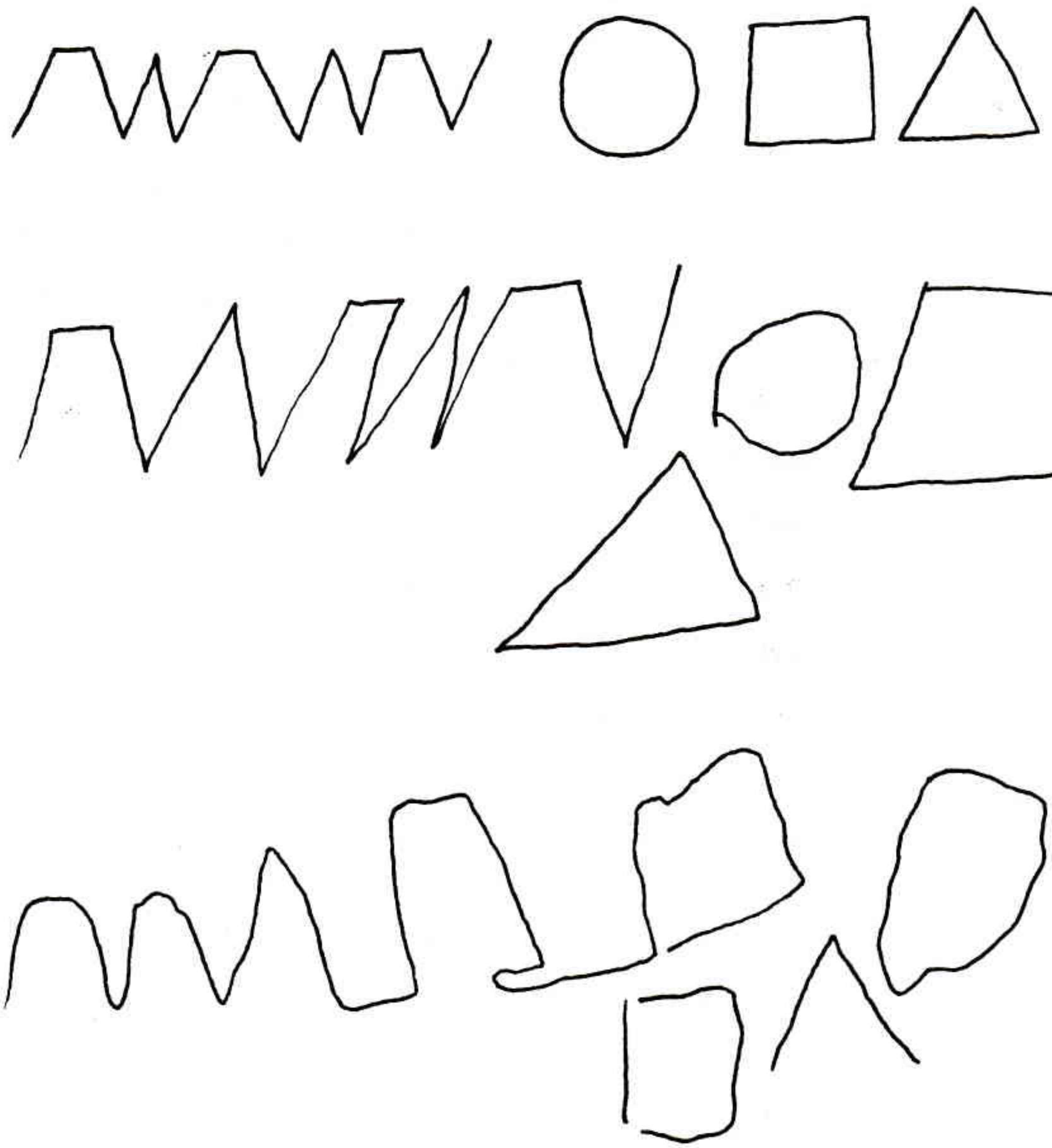
Table 4

Number of Learning Disabled (LD) and Brain Damaged (BD) Children (Aggregated) in Each Age/Sex Group.

	Sex		
Age	Girls	Boys	Total
06	1	0	1
07	0	6	6
08	0	4	4
09	0	9	9
10	4	11	15
11	2	18	20
12	2	7	9
13	0	12	12
14	1	2	3
Total	10	69	79

ceptive Speech, Expressive Speech, Writing, Reading, Arithmetical Skills, Memory, and Intellectual Processes), different number of items in each scale. There are three extra scales made up from several items of the battery, i.e. the Right Hemisphere Scale, the Left Hemisphere Scale and the Pathognomic Signs Scale. The 11 main scales of the battery are divided into subscales, in all these subscales are 49 (see Appendix B).

There are several forms of scoring the items: a) to count number of errors, or there is only one error possible, correct/incorrect; b) how long it takes to perform a task, measured in seconds; c) degrees of deviation from an angle; d) millimeters between two points; e) how many words expressed in 10 seconds; f) how often performance can be repeated in 10 seconds; and g) the qualitative assessment of figure drawing (item 018, the pattern on card D1; items 21-32, the drawings of circles, triangles and squares). A clearly deficient performance (difficult to recognize picture or pattern from drawing) received a score of 2; a drawing that was well recognizable but had some flaw (e.g. wrong angles, some proportions too large or small, lines did not meet, lifting pencil) received a score of 1; and drawing without obvious flaws received a score of 0. In the scoring of drawings an absolute scoring system was used, performance of all age levels compared to best performance norms, see Drawings 1, examples how drawings are scored.



Key:

A

B

C

Drawings 1. An Illustrative Example of the Qualitative Assessment of Children's Drawings. Drawings A Receive a Score of 0; Drawings B Receive a Score of 1; and Drawings C Receive a Score of 2.

Besides the written material the test kit includes a tape with recorded sounds (for the Rhythm Scale) a copy made from the original was used in Iceland; some cards, photocopies were used in Iceland; and several other items, such as a rubber band, a pin, a comb, a screwdriver, etc. this was provided by the examiner. (For a list of material needed for the administration of the LNNBC-RL-ICE see Appendix A).

Testing is individualized, the child and the examiner face each other across a table. The examiner asks the child to perform certain tasks: fine motor movements, movements that involve spatial orientation, drawing figures, evaluating acoustic stimuli, solve visual-spatial problems, understand complex verbal instructions, expressing him/herself verbally, writing, reading, doing simple arithmetic, memorizing, answering difficult questions, etc.

Many of the items have a time limit or maximum number of errors allowed.

2.3 PROCEDURE

Procedure can be divided into 13 steps:

1. The LNNBC-RL translated into Icelandic (see Appendix B) and adapted where necessary (see Appendix A) because of language differences.

2. Applied for permission to do the research in Reykjavik, Kopavogur and Hafnarfjordur. Permitted in December 1982.

3. Headmasters contacted in Reykjavik (8), in Kopavogur (2), and in Hafnarfjordur (1). In cooperation with teachers 10 out of 11 headmasters gave their permission that children might be tested in their schools (for list of schools see Appendix D). Schools were selected if they were in mixed socio-economical areas.

4. Class lists acquired, teachers asked to indicate average students according to school performance; students who were plus or minus three months from their birthday selected; attempt made to establish the educational/job status of parents; a sample made up of children that satisfied the above requirements; students randomly selected from this sample for testing.

5. Letter written and sent to parents of these children requesting permission to test the selected children (for this letter in Icelandic and in English see Appendix C).

6. Where answers were positive children were asked if they were willing to be tested.

7. All children in the standardization sample tested January to October 1983. They were tested individually, with the whole battery, according to standardized procedures, in a quiet room in the child's school during his/her school hours. One examiner tested all children.

8. School psychologists in the three school districts were contacted, and asked to refer appropriate LD children for testing. The test battery was introduced to the school

psychologists, and so was the research project. The school psychologists referred LD children for testing and accepted responsibility for their testing.

9. LD children were tested mainly from June to October 1983. They were tested in the same way as the normal children, during school hours or by appointment.

10. The performance of each LD child was analyzed and a profile made up according to Canadian norms. Children's performance was presented and discussed at a meeting with school psychologists and teachers. The focus here was on the individual's strengths and weaknesses and possible remedial programs.

11. One pediatrician and the school psychologists asked to refer BD children for testing, according to the criterion for BD children described earlier (subsection 2.1.3).

12. All BD children available tested, the same way as the LD children. School psychologists assumed responsibility for their testing.

13. Testing finished by the 31st of October 1983. Data analyzed and thesis written.

The names of all individuals tested were hidden with code numbers. (For explanation of codes for normal, brain damaged and learning disabled children see Appendix E).

2.4 PROBLEMS ENCOUNTERED

The following paragraphs are based on the present author's ideas and experiences.

On the wole the research project was well received in Iceland. Very few individuals refused cooperation, and many expressed the hope that the test battery would be available as soon as possible. However the preparation of testing and the testing itself was very time consuming.

One headmaster refused cooperation, and a few teachers refused to indicate which students in their classes were average. Naturally these classes had to be deleted from the sample. Approximately 20% of parents would not have their children tested, but all students, when asked, were willing to be tested and were on the whole very positive toward the testing. The present author does not expect that the refusal of cooperation by some parents and teachers will have biased norms to a signigicant degree, as children were selected according to a strict criterion, regarding age, occupation of parents, socio-economic environment and school performance.

In many cases the occupation of parents was not listed in the child's school record. In Iceland people tend to feel that their occupation is a private matter, so the information on parent's occupation was used whenever available in children's records, but if this information was not available further steps were not taken to gain this information.

As far as could be seen, average students most often came from average families.

To ensure further that children came from average families schools in mixed socio-economical areas were selected.

The quality of the photocopies and the quality of the tape used may not have been as the originals' and this may have affected performance on some items. Intelligence testing or any other psychological testing is not a standard procedure in Iceland, usually normal children are not tested psychologically during their school years, and very few LD children are tested. Therefore although the school psychologists were asked to provide LD children of average intelligence, such information was often not available.

Learning disabilities are detected relatively late in Icelandic schools as children are not expected to show their academic abilities until age 8 or 9. This is probably the reason why most of the LD children provided are age 10 or above. Also most of the children referred for testing were boys.

The concept "learning disabled" is probably a relatively new one in Iceland. It was the present author's experience that parents tended to have very unclear ideas about the reasons for their children's poor school performance, and are probably often not informed in detail by school psychologists or other professionals like neurologists. A part of the problem is that often professionals do not work together in Iceland to arrive at a conclusion about a child's disability and the best way to treat that disability. School psychologist in Iceland tend to be preoccupied with children's (usually boys') behavior problems, these problems seem to be so extensive that little time is left for other considerations such as learning disabilities caused by brain impairment. However it is important to bear in mind that brain impairment is often masked by behavior and emotional problems. School psychologists in Iceland tend to assume (perhaps too often) that reasons for poor school performance are emotional, psychological, familial or societal. A neuropsychological test battery has not been available in Iceland and physical methods (such as the CAT scan) have practically not been used to diagnose learning disabilities. Professionals in Iceland have focused on qualitative assessment of children's strengths and weaknesses and at least some view neuropsychological testing with some scepticism. The lack of focus on the diagnosis of brain impairment in Iceland may have affected which children school psychologists selected for testing.

The CAT scan is very rarely used on Icelandic children and the Icelandic population is small (240.000), this means that children with well diagnosed and localized brain lesions are extremely few, if any.

This research project was financed through a personal loan from the Icelandic Government's Students' Loan Fund, and professional assistance was not available in Iceland.

Chapter III

RESULTS

3.1 STATISTICAL ANALYSIS

In the statistical analysis of the data it was decided to opt for an absolute scoring system, which means that a child's converted raw score (0, 1 or 2) on each item is not related to the child's age, but only to the child's performance. Each score of every individual tested (across age levels) was compared to a "best performance norm" (norms of the age level that performed best, usually age 12) developed for each item. This also means that as children get older they are expected to perform better in terms of 0, 1, 2 scores (fewer ones and twos are present).

The reasons for choosing an absolute scoring system were: a) that it is easier to train a school psychologist to develop a uniform scoring system for all age groups rather than make the scoring age-specific; and b) an absolute scoring system is necessary to be able to study age trends, and to be able develop comparable graphs for all items.

3.1.1 Finding Outlyers

Because learning disabilities are often detected relatively late among Icelandic school children (8-9 years) it was suspected that the normal standardization sample might accidentally include some outlyers, i.e. children that had in fact undetected learning disabilities. The following method was used intended to rid the standardization sample of possible outlyers: To find outlyers the raw score performance of each individual was compared to the raw score performance of his/her age peers. Mean and standard deviation (SD) was calculated for each item (from raw scores) and noted which individuals performed worse than two SD's from the mean. The test battery is made up from 49 subscales, each subscale includes one or more items which assess very similar microfunctions. Now it was counted on how many of the subscales each individual performed, at least on one item, significantly worse (worse than two SD's from the mean) than his/her age/sex peers. These numbers of all the individuals in each age/sex group were then added together and mean and SD calculated. The individuals who performed poorly on a great number of subscales (worse than two SD's from the mean) were considered to be outlyers and were deleted from the standardization sample. (The reason for selecting number of subscales missed instead of number of items missed was that it is quite natural for a normal child to miss a few items, but when the items missed are in a sequence, like items in a subscale, localized lesion may be suspected). For number of outlyers found at each age/sex level, see Table 5. Table 5 shows that at each age/sex level 0-4 outlyers were found, in all 18 children were found to be outlyers. As could be expected 72% of outlyers found were aged 7-9.

3.1.2 Graphing Items for Ceilings and Floors

Having eliminated outlyers from the standardization sample, one graph was plotted for each one of the 149 items, from the raw scores. Each graph showed the raw score performance of all age/sex groups on a particular item. Usually the raw score mean of each age/sex group was calculated and plotted on the graph, but in the cases where items were scored correct/incorrect percentage passing the item (in each age/sex group) was plotted. In this way each graph had one profile showing the performance of boys across age levels and another profile showing the performance of girls across age levels. This makes it possible to quickly compare the performance of girls to the performance of boys on each item. These graphs also show floor effects (no one of a particular age/sex group passes) and ceiling effects (everyone of a particular age/sex group passes), and lastly they show age trends, i.e. how performance changes with age.

Below each graph the raw score mean and SD of each age/sex group on that particular item was recorded (or in the case of correct/incorrect items, percentage passing was recorded).

Table 5

Number of Outlyers Found in Each Age/Sex Group.

Age	Sex: Girls	Boys	Total
07	2	3	5
08	1	4	5
09	2	1	3
10	0	0	0
11	3	1	4
12	0	1	1
Total	8	10	18

See examples provided, Figures 2-5.

3.1.3 Graphing According to 0-1-2 System

By calculating means and SD's of each age/sex group it was possible to establish which age group (aggregating boys and girls) performed best on each item (usually age 12). By using the mean and SD of the age group that performed best, "best performance norms" were established for each item (see Appendix F). All scores were then transformed to 0, 1 or 2 according to best performance norms (a performance better than minus 1 SD from the mean received a score of 0; a performance in the minus 1 SD to minus 2 SD range received a score of 1; and a performance worse than minus 2 SD from the mean received a score of 2; incorrect received a score of 2 and correct received a score of 0. The 0,1,2, scoring system used in the present study is an absolute scoring system, i.e. it depends on the child's level of performance, not on the child's age.

See examples provided, Figures 6-9.

3.1.4 Making Profile Sheets

Now profile sheets were made, one for each age level separate values for boys and girls. All scores were transformed into 0-1-2 by using best performance norms (see also subsection 3.1.3; Appendix F). The scores of each individual were then added up for each scale. These individual scale scores

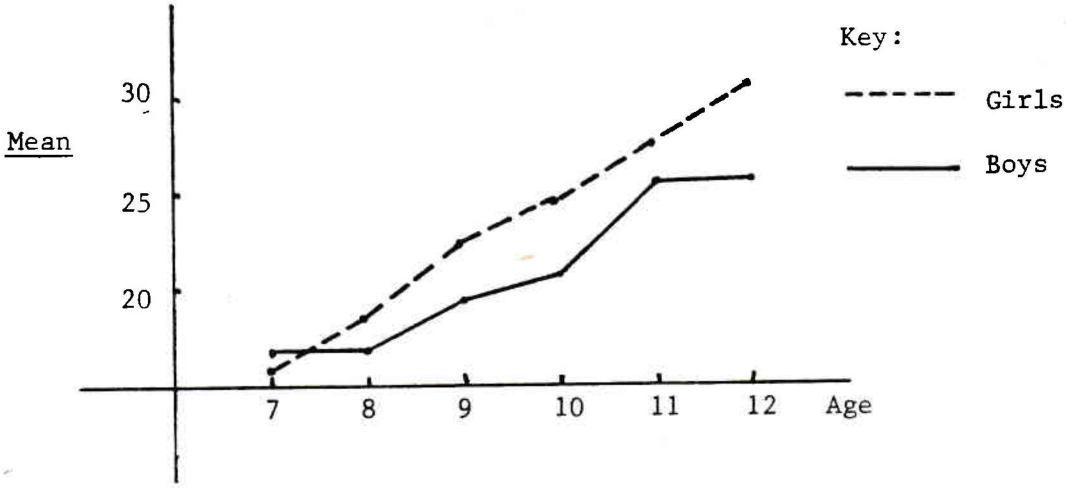


Figure 2. This Is an Illustration of the Mean Raw Score Performance of Each Sex Group at Each of the Six Age-Levels for Item Number 1.

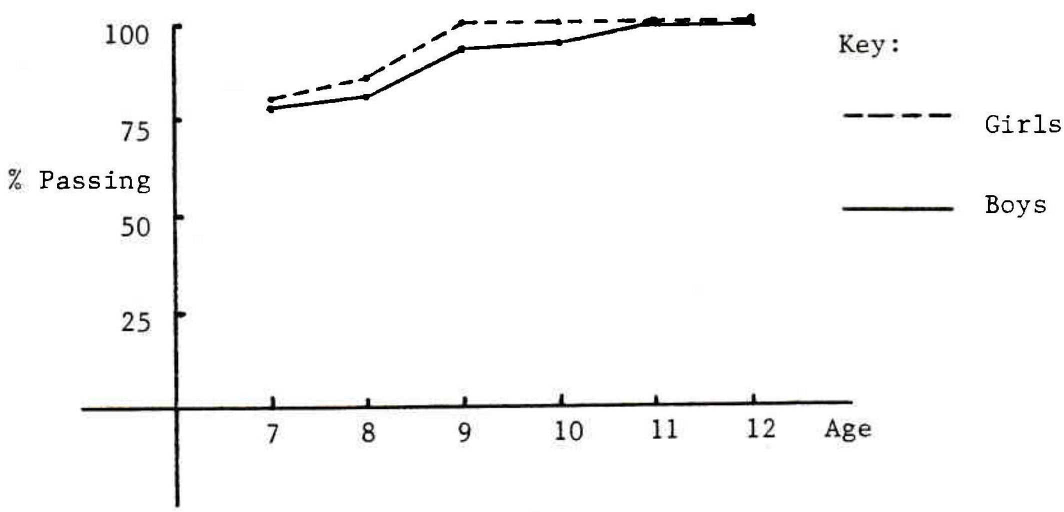


Figure 3. This Is an Illustration of the Percentage of Each Sex Group that Passed Item 6 at Each Age-Level.

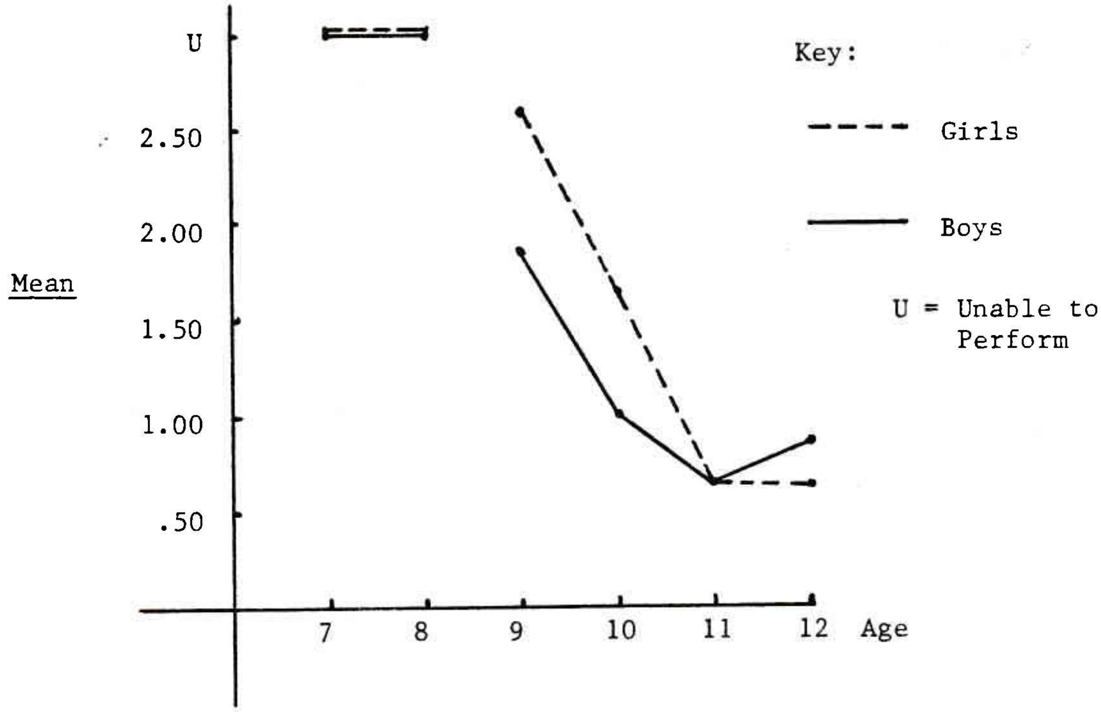


Figure 4. This Is an Illustration of the Mean Raw Score Performance of Each Sex Group at Each of the Six Age-Levels for Item Number 127.
Notice the Floor Effect at Ages 7 and 8.

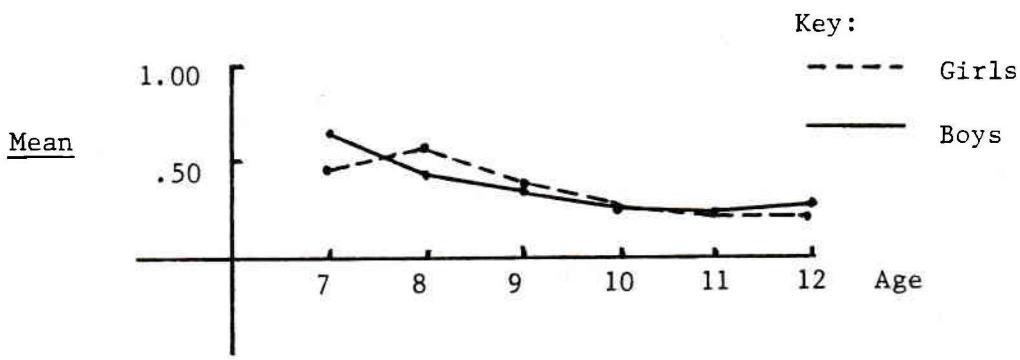


Figure 5. This Is an Illustration of the Mean Raw Score Performance of Each Sex Group at Each of the Six Age-Levels for Item Number 128.

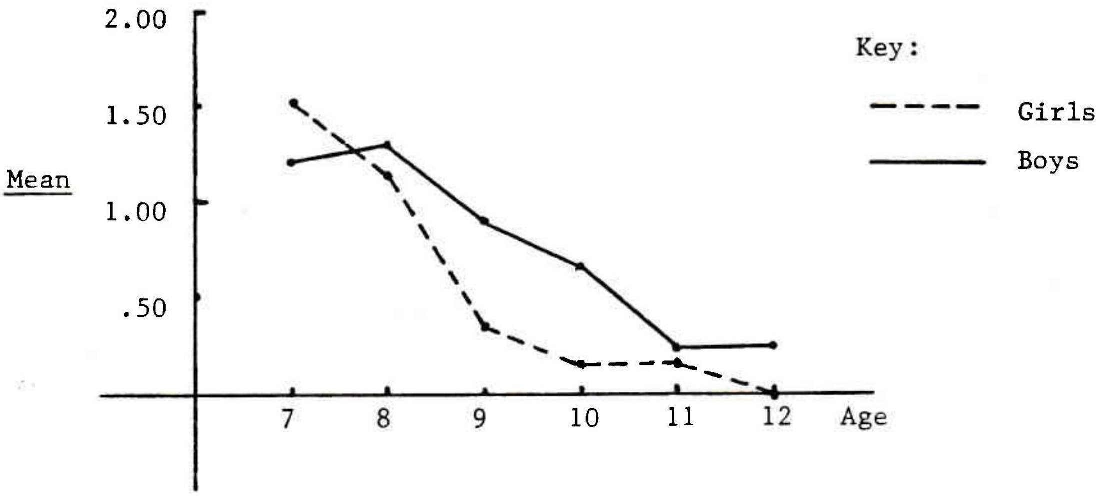


Figure 6. This Is an Illustration of the Mean 0,1,2 Score Performance of Each Sex Group at Each of the Six Age-Levels for Item Number 1.

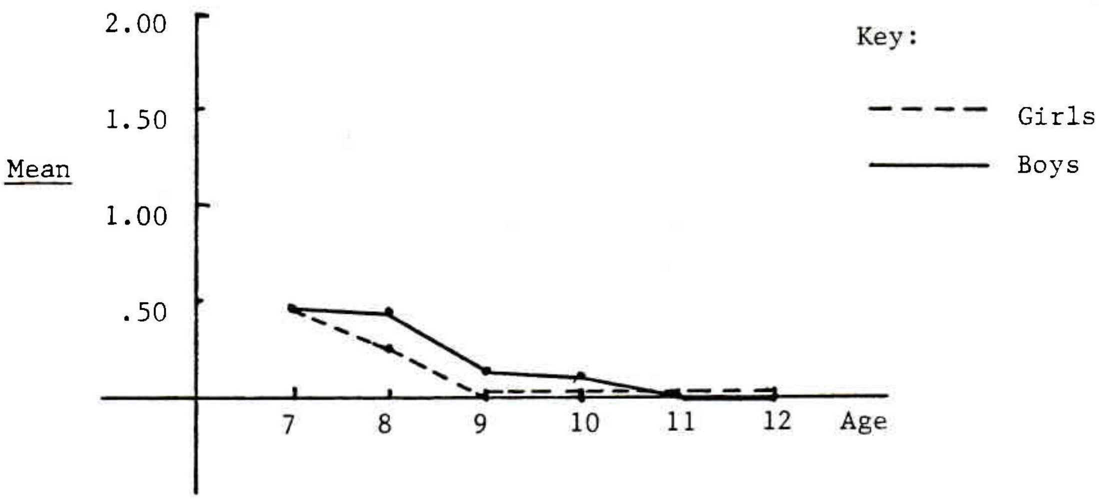


Figure 7. This Is an Illustration of the Mean 0,1,2 Score Performance of Each Sex Group at Each of the Six Age-Levels for Item Number 6.

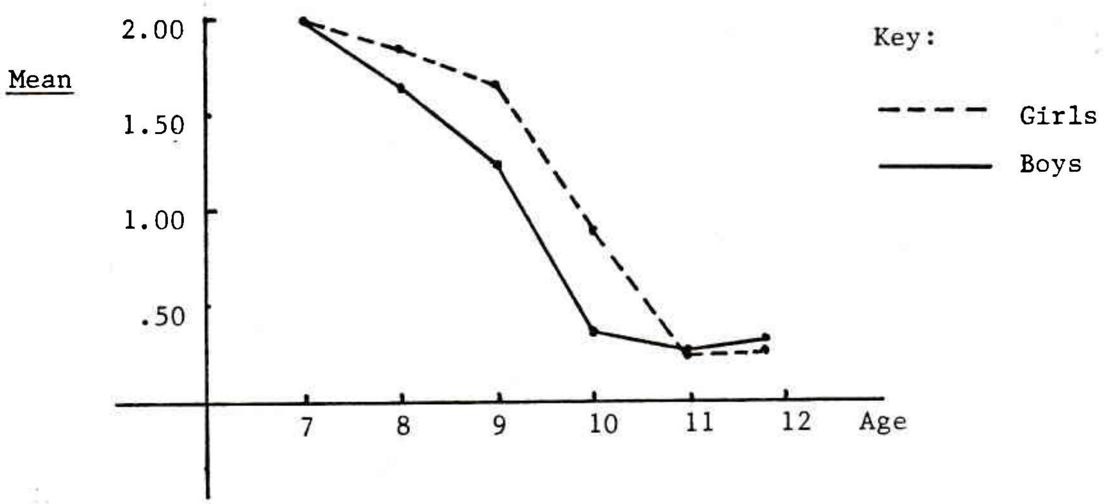


Figure 8. This Is an Illustration of the Mean 0,1,2 Score Performance of Each Sex Group at Each of the Six Age-Levels for Item Number 127.

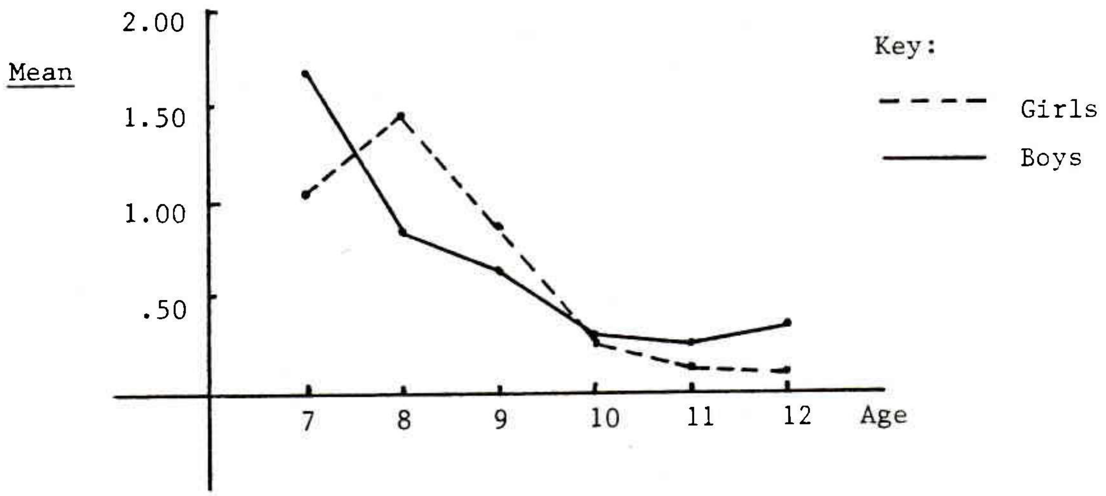


Figure 9. This Is an Illustration of the Mean 0,1,2 Score Performance of Each Sex Group at Each of the Six Age-Levels for Item Number 128.

were then divided by the number of items in that particular scale to get comparable scores for all the fourteen scales. These scores of all the individuals in that age/sex group were then added up and mean and SD calculated. For each age/sex group (e.g. 7 year old boys) the mean of average scale scores was given a value of 50T. The raw score SD was then used to calculate and record plus one SD, and minus one, two and three SD's, T-values. This was repeated for all age/sex groups, all scales. The values of three extra scales (the Right Hemisphere Scale, the Left Hemisphere Scale, and the Pathognomic Signs Scale) were also calculated. Tables were made for each age/sex group to transform scale values to T-scores (see Appendix H). (For an example of the process described above see Example 1).

3.1.5 Diagnostic Rules Developed

The scale scores of all normal (N) individuals (each age/sex group), all learning disabled (LD) individuals and all brain damaged (BD) individuals were then recorded on the age-appropriate profile sheets in the appropriate SD ranges of T-scores. Then all age levels were aggregated and results summarized in Table 6. Table 6 shows the percentage of each sample group (N, LD, BD), for each scale, that scored in each SD range of T-scores, from 70T to 100T and above. Table 6 shows that each scale distinguishes overall between N, LD and BD children; on the average BD children

Example 1

Making Profile Sheets
The Visual Scale - 10 year old boys.

	Items (Raw Scores)							Items (0,1,2)								
S	59	60	61	62	63	64	65	59	60	61	62	63	64	65	Total	Total/7
1	0	0	2	0	0	0	1	0	0	2	0	0	0	1	3	.43
2	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	.14
3	0	0	1	0	1	0	0	0	0	1	0	1	0	0	2	.29
4	0	0	1	0	1	0	1	0	0	1	0	1	0	1	3	.43
5	0	0	1	0	0	0	1	0	0	1	0	0	0	1	2	.29
6	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	.14
7	0	0	3	0	0	0	7	0	0	2	0	0	0	2	4	.57
8	0	0	3	0	1	0	1	0	0	2	0	1	0	1	4	.57
9	0	0	1	0	0	0	6	0	0	1	0	0	0	2	3	.43
10	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	.14
11	0	0	3	0	0	0	0	0	0	2	0	0	0	0	2	.29
12	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	.14
13	0	0	1	0	0	2	0	0	0	1	0	0	2	0	3	.43
14	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	.14
15	0	0	1	0	0	1	0	0	0	1	0	0	1	0	2	.29
16	0	0	1	0	0	1	0	0	0	1	0	0	1	0	2	.29
17	0	0	1	0	1	1	0	0	0	1	0	1	1	0	3	.43
18	0	0	1	0	1	1	1	0	0	1	0	1	1	1	4	.57
19	0	0	3	0	0	0	0	0	0	2	0	0	0	0	2	.29
20	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	.14

Mean = .32

SD = .15

Note. Each Raw Score Is Compared to Best Performance Norms of That Particular Item and Transformed to 0, 1 or 2. Each Individual's 0, 1, 2 Item Scores for a Particular Scale Are Added up and the Sum Divided by the Number of Items in That Particular Scale. The Scores of All the Individuals in That Particular Age/Sex Group Are Added up and the Mean and SD Calculated. The Mean Is Given the Value of 50T on the Profile Sheet, and Each SD Is Given the Value of 10T Units.

S=Subjects

LNNBC—RL
STANDARDIZED IN ICELAND
BY JONAS G. HALLDORSSON

AME:

OB:

OT:

Example 1

This Profile Sheet Is Made for 10 Year Old Boys and Girls.
The Visual Scale Has the Value .32 for Boys at 50T.
Each 10T Unit Are Here Equal to .15 Scale Score Units
Which Have not Been Transformed to T-Scores (the SD=.15).

10 ♂/♀ PROFILE SHEET

MOT 1	RHY 2	TAC 3	VIS 4	REC 5	EXP 6	WRI 7	REA 8	MAT 9	MEM 10	INT 11	RHS 12	LHS 13	PSS 14
.74	.70	.40	.92	.22	.46	1.39	.56	.53	1.18	1.09	.80	.74	.55
.44	.42	.51	.93	.44	.69	1.07	.41	.88	1.09	1.16	.55	.53	.54
.60	.56	.31	.77	.17	.37	1.12	.44	.42	.94	.89	.65	.61	.44
.36	.33	.40	.76	.35	.55	.84	.32	.70	.89	.97	.44	.43	.43
.46	.42	.22	.62	.12	.28	.85	.32	.31	.70	.69	.50	.48	.33
.28	.24	.29	.59	.26	.41	.61	.23	.52	.69	.78	.33	.33	32
.32	.28	.13	.47	.07	.19	.58	.20	.20	.46	.49	.35	.35	.22
.20	.15	.18	.42	.17	.27	.38	.14	.34	.49	.59	.22	.23	.21
.18	.14	.04	.32	.02	.10	.31	.08	.09	.22	.29	.20	.22	.11
.12	.06	.07	.25	.08	.13	.15	.05	.16	.29	.40	.11	.13	.10
.04	0		.17		.01	.04				.09	.05	.09	0
.04			.08						.09	.21	0	.03	

Table 6

Percentage of Normal (N), Learning Disabled (LD) and Brain Damaged (BD) Children Within Each SD of T-Scores from 70T to 100T+ on Each of the Fourteen Scales.

T	G	01	02	03	04	05	06	07	08	09	10	11	12	13	14
	BD	30	60	30	30	90	70	60	90	60	30	50	90	70	40
	LD	2	30	13	4	38	23	19	56	25	6	9	25	34	17
	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100+															
	BD	10	10	10	30	0	0	10	0	0	20	10	0	10	30
	LD	9	6	4	6	8	6	25	4	11	11	9	23	15	11
	N	0	.4	.4	0	.8	0	.4	.4	0	0	0	0	0	0
90															
	BD	10	10	10	10	0	0	10	0	30	30	30	10	20	10
	LD	9	9	13	6	9	13	2	11	13	19	15	11	11	17
	N	.4	.4	.4	.4	0	.4	.8	.8	.8	0	.8	.4	0	1
80															
	BD	50	10	30	20	0	10	10	0	0	20	0	0	0	10
	LD	9	8	21	15	15	11	30	8	6	21	11	15	13	19
	N	5	5	4	4	3	3	3	3	4	4	1	4	4	4
70															

Note. T=T-Score; G=Group of Children.
Total Number of N Children = 243
Total Number of LD Children = 53
Total Number of BD Children = 10

receive higher (worse) scores than LD children, but N children receive far lower (better) scores than both the clinical groups. On the average less than 1% of the normal sample exceeds 80T on each scale.

From Table 6, Figure 10 was developed. Figure 10 shows the percentage of each sample group (N, LD, BD) that exceeds 80T, for any of the 14 scales. The LD group shows a more elevated profile than N children. The profile indicates which scales are especially associated with learning disabilities (e.g. rhythm, receptive speech and reading). The BD children show a still more elevated profile, but their profile has similar pattern as the profile of the LD sample.

By collecting more information from the preparation of Table 6, Figures 11-14 were developed. Each of these figures shows the percentage of each subject group (N, LD, BD) that exceeds XT (X = 70T, 80T, 90T or 100T) on Y number of scales (Y = 1, 2, 3 or 4).

From this information Figure 15 was developed. Figure 15 shows the number of individuals in each sample (N, LD, BD) that exceed 80T on Z number of scales (Z = any number from 0 to 14).

Figures 11-15 were developed in order to try to decide the most appropriate and effective cut-off point on the profile sheets, to differentiate between N and LD children. From the information presented in Figures 11-15, it was decided that 80T would be the most effective cut-off point,

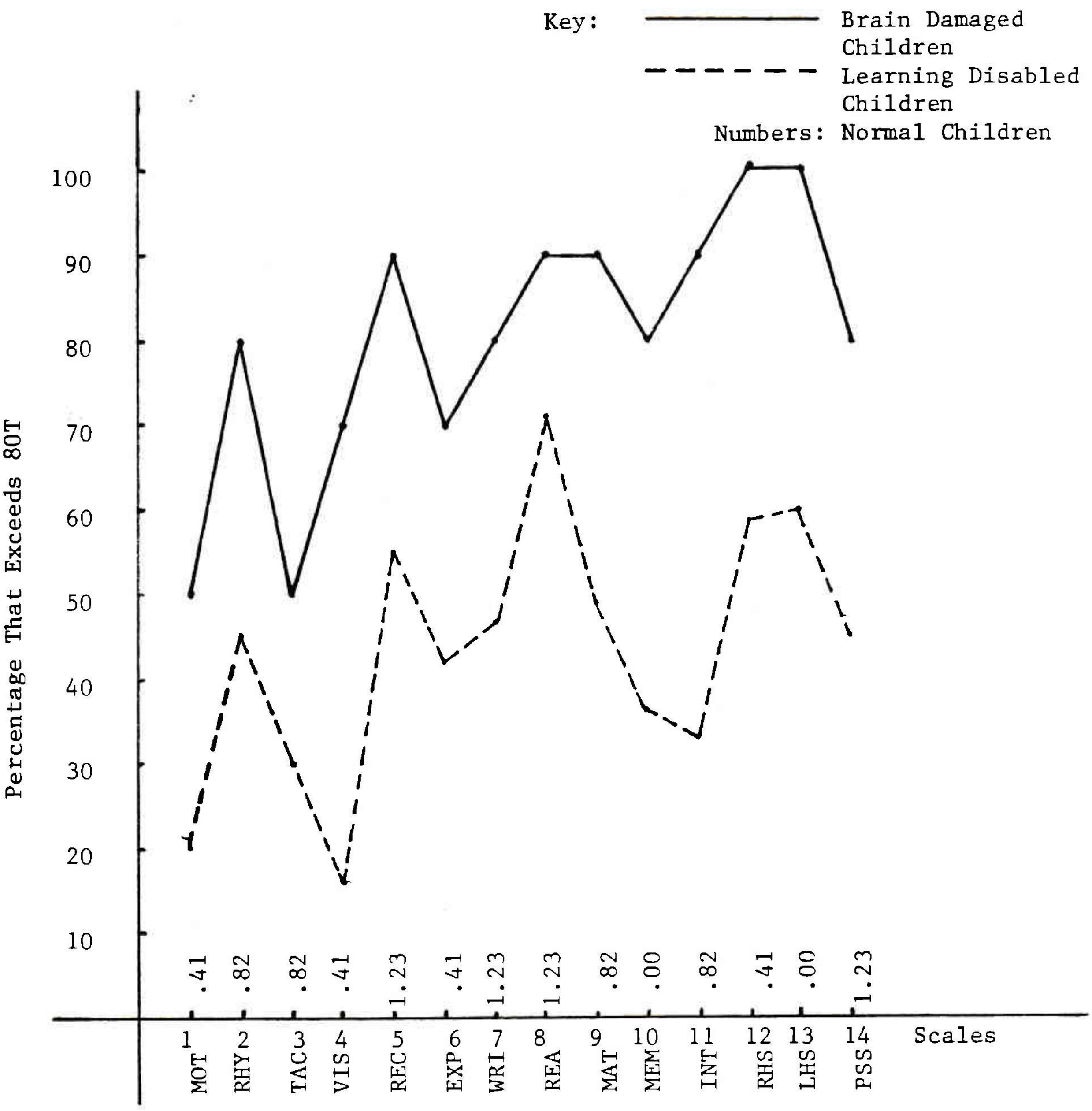


Figure 10. This Is an Illustration of the Percentage of Individuals in Each Sample Group (N, LD, BD) That Exceeds 80T on Each of the Fourteen Scales Shown.

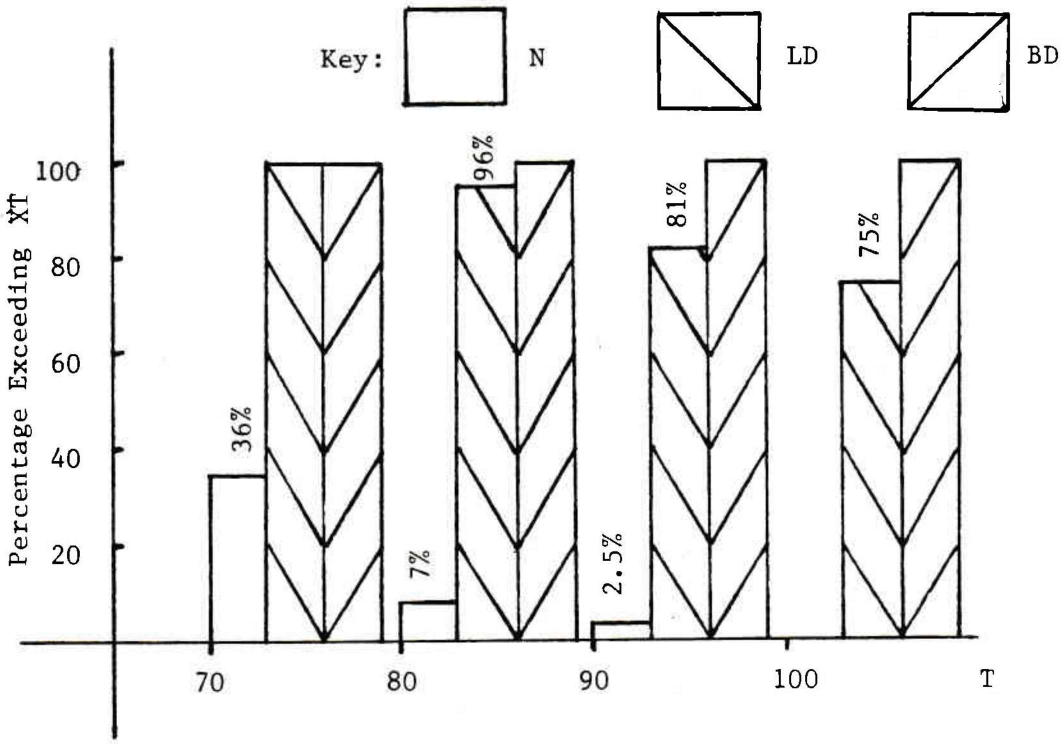


Figure 11. This Is an Illustration of the Percentage of Individuals in Each Sample Group (N, LD, BD) That Exceeds XT (X = 70T, 80T, 90T or 100T) on One or More Scales.

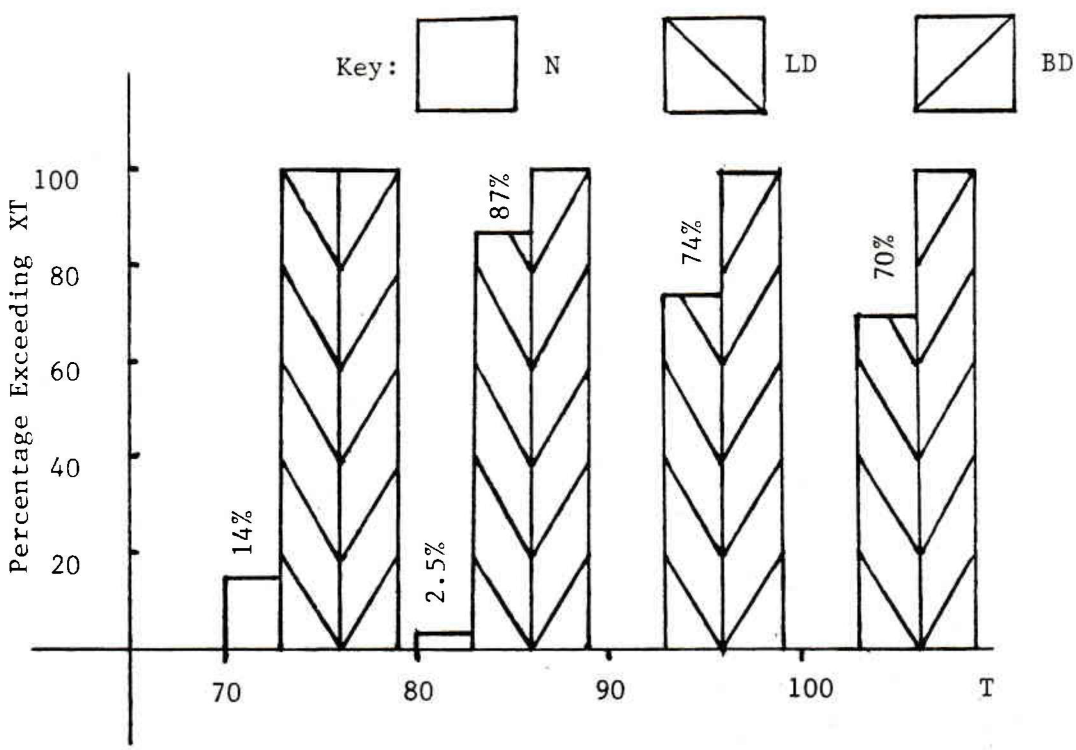


Figure 12. This Is an Illustration of the Percentage of Individuals in Each Sample Group (N, LD, BD) That Exceeds XT (X = 70T, 80T, 90T or 100T) on Two or More Scales.

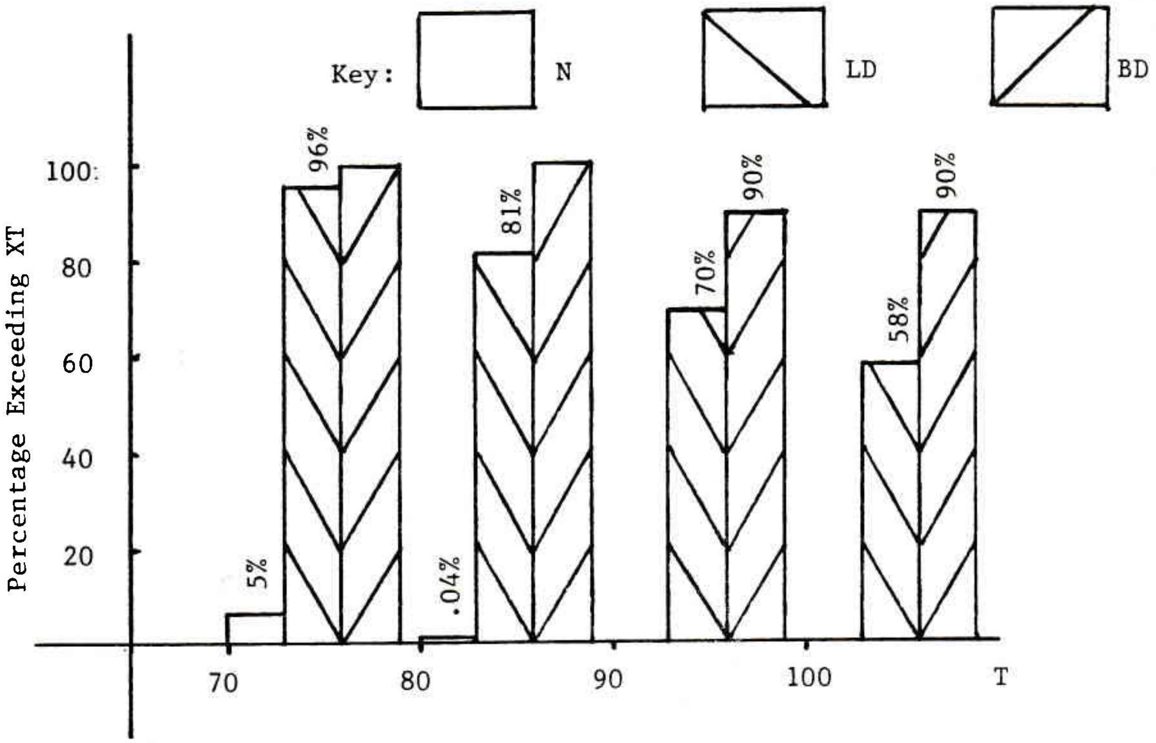


Figure 13. This Is an Illustration of the Percentage of Individuals in Each Sample Group (N, LD, BD) That Exceeds XT (X = 70T, 80T, 90T or 100T) on Three or More Scales.

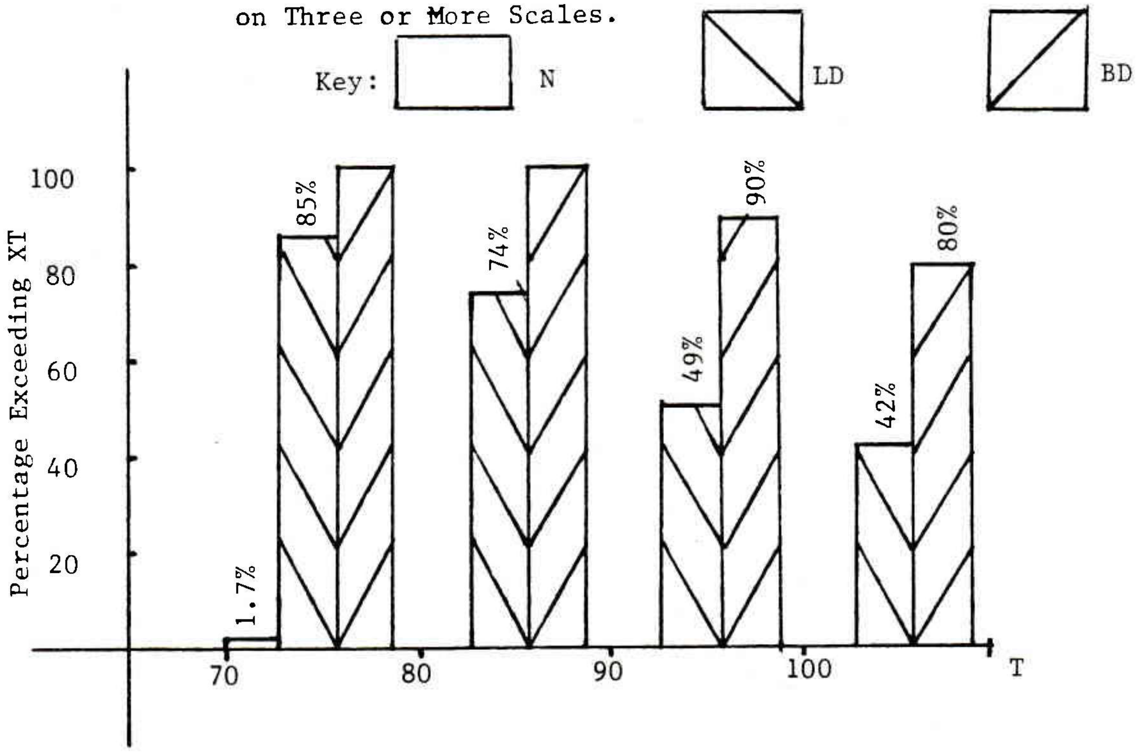


Figure 14. This Is an Illustration of the Percentage of Individuals in Each Sample Group (N, LD, BD) That Exceeds XT (X = 70T, 80T, 90T or 100T) on Four or More Scales

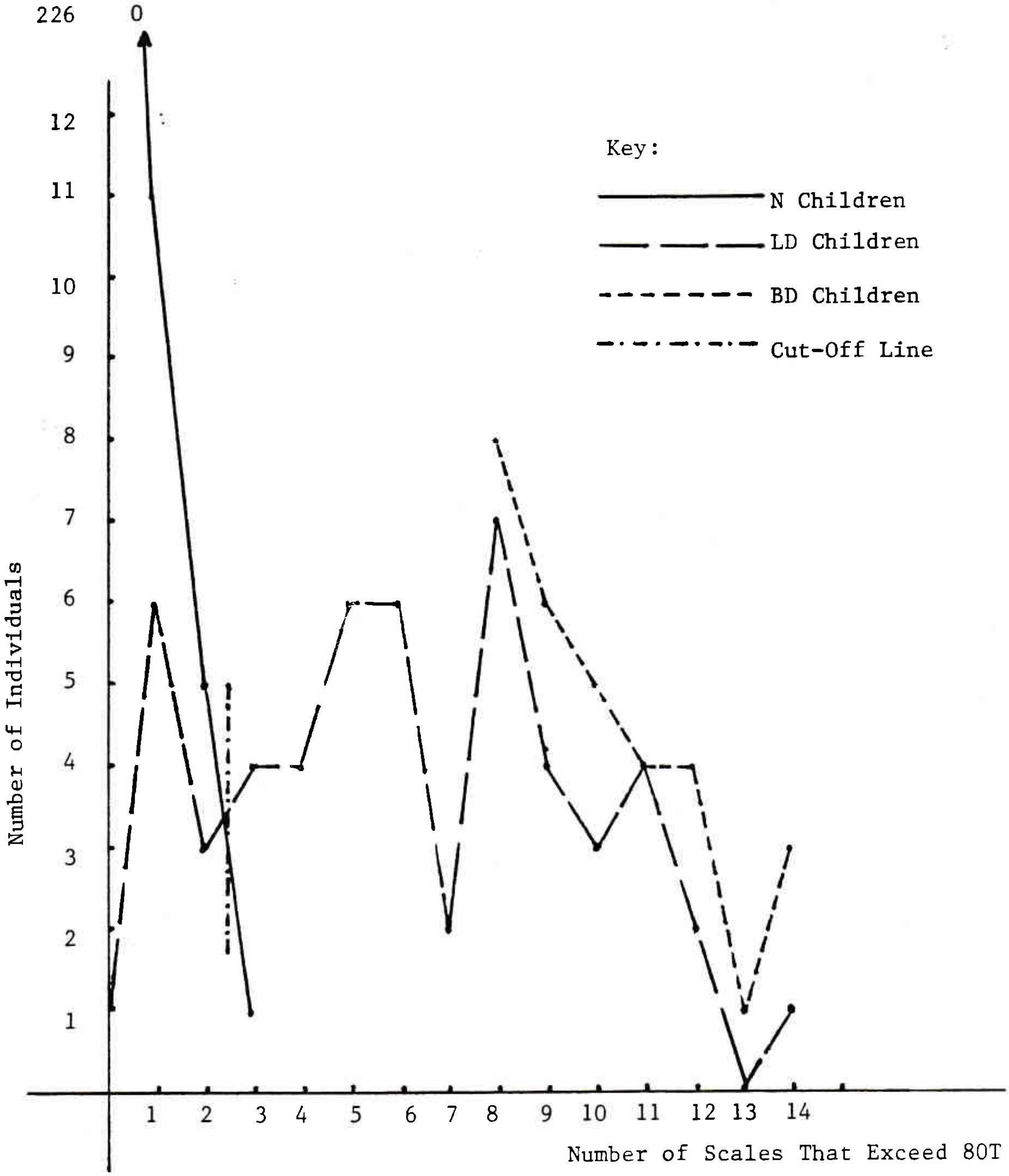


Figure 15. This Illustration Shows the Number of Individuals in Each Subject Group (N, LD, BD) That Exceed 80T on Z Number of Scales (Z = Any Number from 0 to 14). Also Shown Is the Cut-Off Line between 2 and 3 Scales.

however, allowing a normal child to exceed 80T on two scales. Using these diagnostic rules only misclassifies 1 N child (.04%) as learning disabled, and correctly classifies 81% of the LD sample as learning disabled. These rules are also able to differentiate 100% between N children and BD children (see Figures 13 and 15). Looking at the performance of N children it was further decided, regarding the two scores that may exceed 80T, that for a normal child only one of these scores may exceed 90T, and no score may exceed 100T. Adding these rules correctly classified 83% of the LD sample.

Figure 15 shows the cut-off line and the number of children that are correctly classified and incorrectly classified according to it.

From the above information (e.g. Figure 15) Figure 16 was developed to help decide the most effective diagnostic rule to correctly differentiate between LD and BD children. By using the rule that children must exceed 80T on eight or more scales to be classified as brain damaged, all BD children were correctly classified, but 40% of the LD children were classified as brain damaged. This rule is therefore 60% effective in differentiating between the two clinical samples.

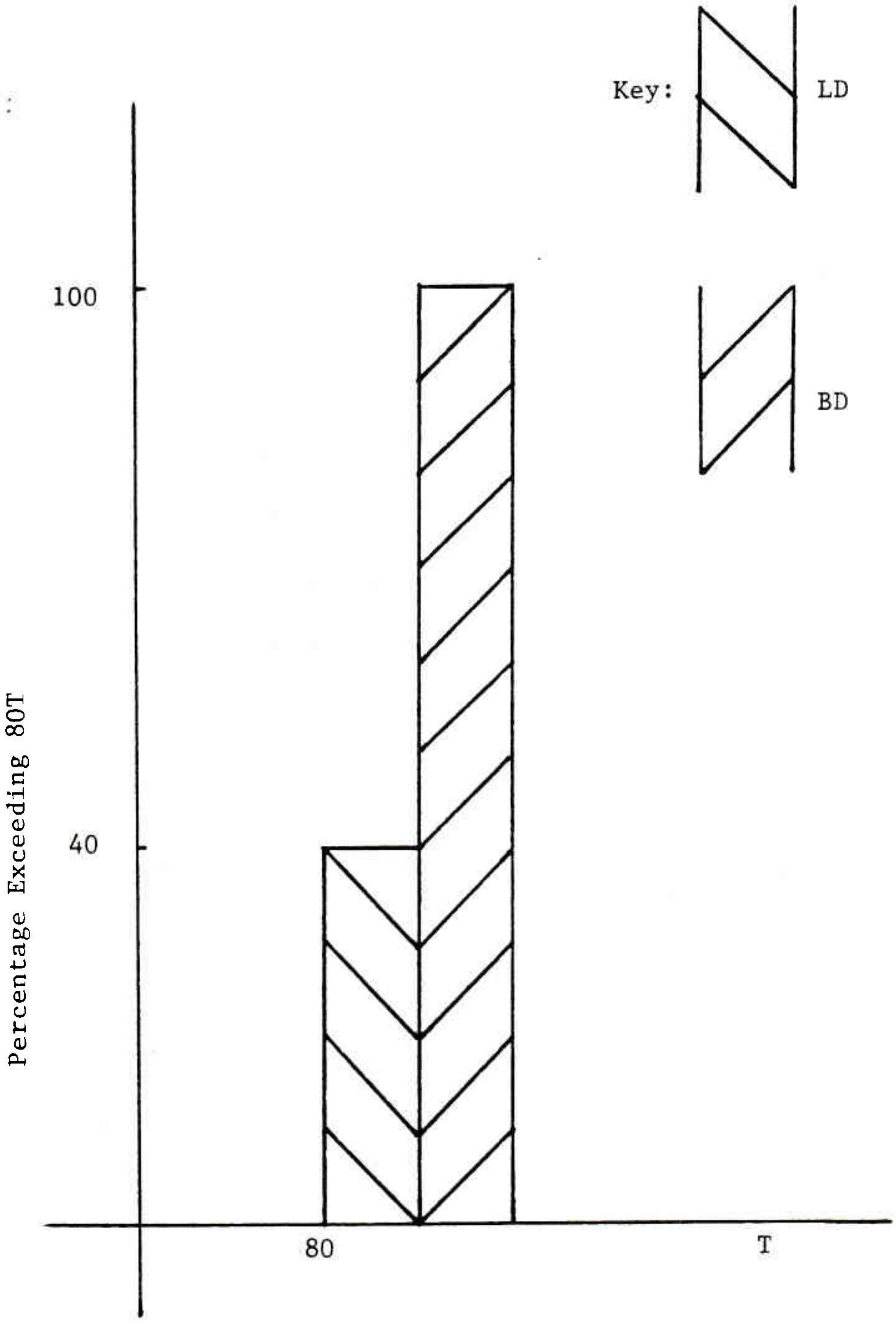


Figure 16. This Illustration Shows the Percentage of LD and BD Children Exceeding 80T on Eight or More Scales.

3.1.6 Sex Differences on the Profile Sheet

To try to establish if there were sex differences present in the performance of the normal standardization sample, Table 7 was developed. This table indicates which of the two sex groups, boys and girls, is performing better at 80T on the profile sheets, for each age level and each scale.

From this information Figure 17 was developed, summarizing the information and indicating the overall superior performance of girls on motor functions, rhythm, tactile functions, receptive, writing, reading, math, and right and left hemisphere functions. Boys are superior only on expressive speech and intellectual processes. No overall differences are present on visual functions, memory and the pathognomic signs scale.

3.1.7 Age and Sex Norms for Each Item

Age and sex norms were established for each item: better than minus one SD from the mean gets a score of 0, minus one to minus two SD receives 1, and worse performance a score of 2 (see Appendix G).

On most items performance got better with age. However there are some exceptions, probably in most cases due to small sample size or because of motivational variables. E.g. when drawing a circle, a nine year old child may spend more time doing so than a seven year old, wanting to do a good job. In order to get age trends it was considered ap-

Table 7

This Table Shows Which Sex Group, Boys (b) or Girls (g), Is Performing Better at 80T on Each Scale and at Each Age-Level.

Age	Scales 01	02	03	04	05	06	07	08	09	10	11	12	13	14
12	g	g	g	g	x	b	g	x	g	b	b	g	g	b
11	g	g	g	b	b	g	g	g	g	g	b	g	g	g
10	g	g	b	g	b	b	g	g	b	g	b	g	g	g
9	g	g	g	b	g	b	b	g	b	g	b	g	b	b
8	g	b	g	b	g	b	b	b	g	b	b	b	b	b
7	g	g	g	g	g	b	g	g	x	b	b	g	g	g

Note. x=no Difference between Boys and Girls.

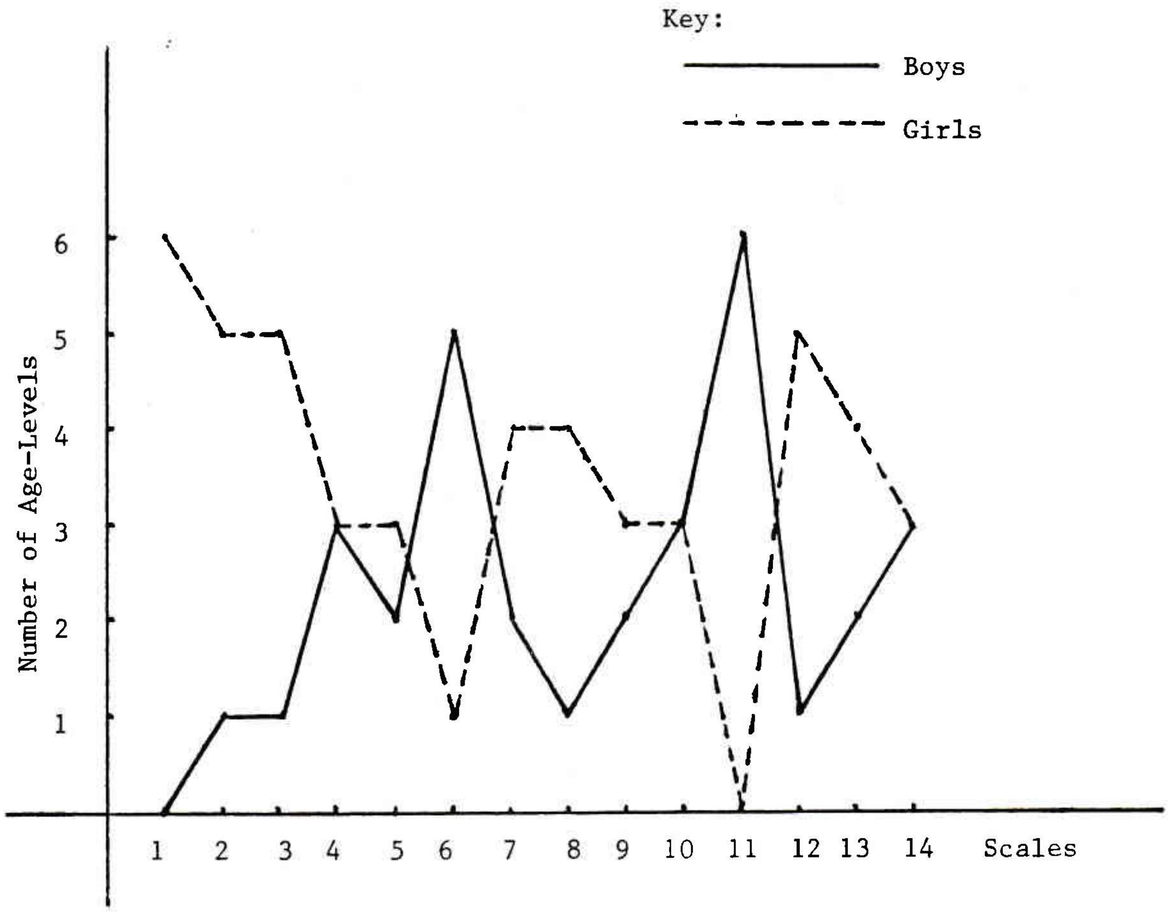


Figure 17. Number of Age-Levels Each Sex Group Is Performing Better at 80T on Each Scale.

propriate to aggregate across age groups, and also by that getting a common norm.

3.1.8 National Differences

According to age/sex norms for Icelandic children and age norms for Winnipeg children (see Appendix G), Winnipeg children are performing better than Icelandic children on a few items, e.g. fingertip touching, right/left orientation, counting backwards in three's. Also Winnipeg children tend to do better on items where the present study used photocopies of original cards, a copy of the original tape, and where adaptations were made to the battery because of language differences (see Appendix A).

Table 8 was developed to try to decide if there were overall national differences present regarding test performance. Table 8 shows which of the two national groups (Winnipeg children (W) or Icelandic children (I)) was performing better on greater number of item norms, at each age level, for each scale (aggregated across sex).

Figure 18 summarizes this information. On the whole Icelandic children are performing worse at ages 7-9, but better at ages 10-12.

Table 8

This Table Shows Which National Group, Winnipeg Children (w) or Icelandic Children (i), Is Performing Better on Greater Number of Item Norms on Each of the Basic Eleven Scales.

	Scales													
Age	01	02	03	04	05	06	07	08	09	10	11	12	13	14
12	i	i	i	i	i	i	i	i	i	i	i			
11	i	i	i	i	i	i	i	i	i	x	i			
10	w	i	i	w	i	i	w	i	i	w	w			
9	w	i	i	w	i	w	w	i	w	w	w			
8	w	w	w	w	i	w	w	i	w	w	w			
7	w	w	w	w	w	w	----	----	----	----	----			

Note. x=no Difference between the Two National Groups.

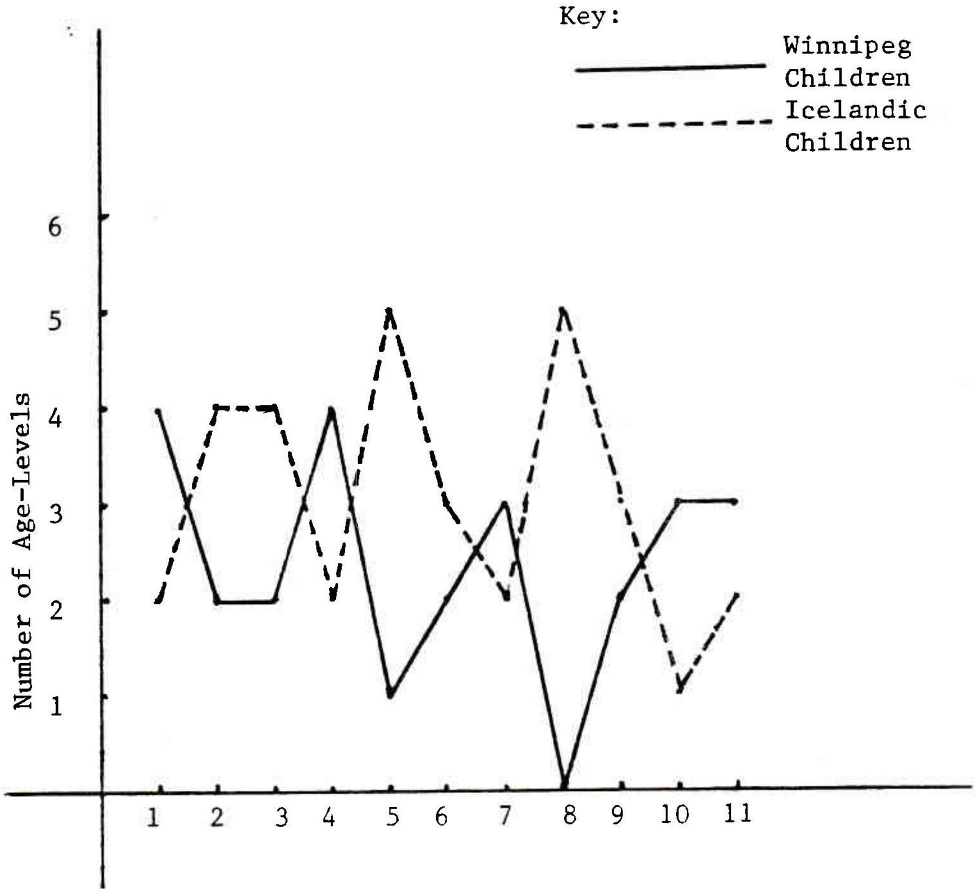


Figure 18. Number of Age-Levels Each National Group (Winnipeg Children vs Icelandic Children) Performs Better (i.e. Has Superior Norms on Greater Number of Items) on Each Scale.

3.1.9 Validity and Reliability

Split-half and alpha reliability coefficients were calculated for each of the fourteen scales and each age/sex group at two age-levels, ages 7 and 12. Split-half reliability coefficients range from .00 to .64 with a mean of .18 (for all age/sex groups aggregated). Alpha coefficients ranged from .00 to .72 with a mean of .25 (aggregated across all four age/sex groups). Table 9 shows the split-half and alpha coefficients for all the fourteen scales and for all four age/sex groups. Reliability seems to be somewhat higher for the scales assessing academic abilities, such as reading, writing and arithmetic, than for scales assessing other functions like visual, rhythm and the hemisphere scales (more heterogeneous items).

The reason for low reliability coefficients may be that the items making up each scale are heterogeneous, each item is supposed to assess the fuctioning of one microfunction, one specific area of the cortex. Each scale is not assessing a unitary concept (like e.g. intelligence tests).

However, the reliability measure in the present study gives perhaps more information on the nature of the sample of children tested than the reliability of the test battery and its scales. The sample size is very small (20) and the sample is homogeneous, both these factors contribute to low reliability coefficients.

Table 9

Split-Half Reliability Coefficient and Alpha Coefficient for Each of the Fourteen Scales at Four Age/Sex Levels (7 Year Old Boys, 7 Year Old Girls, 12 Year Old Boys and 12 Year Old Girls).

	A/S	01	02	03	04	05	06	07	08	09	10	11	12	13	14	M
Split-Half	7b	.25	.17	.23	.00	.39	.00	.54	.61	.55	.27	.40	.43	.31	.31	.32
	7g	.00	.01	.30	.00	.00	.00	.61	.64	.32	.27	.21	.39	.13	.00	.21
	12b	.00	.42	.00	.21	.00	.00	.29	.00	.00	.37	.19	.12	.06	.33	.14
	12g	.00	.00	.00	.00	.00	.00	.00	.00	.00	.38	.37	.05	.00	.02	.06
Coefficient Alpha	7b	.35	.00	.65	.00	.49	.29	.45	.72	.48	.00	.31	.18	.00	.00	.28
	7g	.02	.00	.69	.00	.24	.53	.41	.55	.38	.18	.30	.00	.00	.00	.24
	12b	.66	.26	.25	.00	--	.00	.05	--	.19	.31	.00	.20	.17	.14	.19
	12g	.55	.00	.38	.00	--	.48	.00	--	.31	.53	.62	.00	.00	.44	.27

Note. A/S=Age/Sex Group; b=Boys; g=Girls; M=*Mean*; --=All Scores Equal to Zero.

Other neuropsychological test batteries, e.g. the HRNTB have the same problem in establishing evidence for reliability, because of the nature of item selection and because of the learning effect in the test-retest situation.

The present study supports the view that the Luria batteries have construct validity (assessing theoretical construct or trait), as the LNNBC-RL-ICE effectively differentiated between subject groups.

3.1.10 <u>Performance of LD and BD Children</u>

As was expected, on the whole BD children tended to score higher on each scale, and to score high on greater number of scales than LD children (see Table 6 and Graph 1). Qualitatively there seemed also to be a difference between these two groups, as on some items (e.g. finger touching, tapping) BD children were not able to perform the task at all, while LD children could perform the task, however more slowly or not as often as their age/sex peers.

See examples of profiles of N, LD and BD children provided.

3.2 <u>MANUAL</u>

By extending the appendices of this research paper the plan is to provide a preliminary test manual for the Icelandic Standardization (LNNBC-RL-ICE).

Chapter IV

DISCUSSION

In the present study the LNNBC-RL has been translated into Icelandic, adapted where necessary because of language differences, and standardized on a sample of normal, average Icelandic school children aged 7-12. Norms, profile sheets and diagnostic rules have been established.

The applicability and usefulness of the battery has been investigated to some degree. In the present study the test battery was able to differentiate between N and LD children, correctly classifying more than 99% of the N sample and 83% of the LD sample. It should be noted however that although the battery did incorrectly classify 17% of the LD sample as normal, according to scale scores, further item analysis and qualitative assessment (which is a part of the battery's assessment procedure) might have provided important information on these children regarding the causes for their poor school performance. It may also be that children classified by Icelandic school psychologists as learning disabled may in some cases have behavioral rather than neuropsychological problems.

The test battery was able to distinguish between LD and BD children to some extent (60% of LD children were correctly classified as LD, 40% were classified as BD). However it is very likely that some of the LD children were in fact brain impaired, which makes these results understandable.

The power of the test to localize brain damage was not tested in the present study, as no children with well localized brain damage, as decided by physical diagnostic methods, were available in Iceland.

It seems to be from the results of the present study that Icelandic children perform overall poorer than their Winnipeg age-peers on the test, at ages 7-9. This is to be expected as Icelandic children start at a later age in school and spend fewer hours a day in school, and fewer days a year. However at ages 11 and 12 Icelandic children are overall performing better than Winnipeg children. The reason for this may be that the Winnipeg norms are not fully established as yet.

At this stage it is difficult to compare the performance of Icelandic and Winnipeg children and there are a few reasons for this: a) The battery was translated which may have caused subtle changes in text and instructions; photocopies were used and a copy of the original tape. b) The examiner was not the same one in Winnipeg and in Iceland. c) The standardization sample may have been selected slightly differently in Iceland (e.g. age levels and IQ levels). d) Scoring of items may have been slightly different. e) The Manitoba data have not yet undergone the same statistical procedures as the Icelandic data.

From the results of the present study it is clear that it was justified not to aggregate boys and girls. On the whole girls are performing better than boys which could be expected as girls tend to mature faster than boys (Mussen et al., 1979).

Most items show age trends as was expected, however in some cases younger age groups perform better than older age groups. The reasons for this may be motivational or caused by small sample size.

4.1 CONCLUSIONS

On the whole the LNNTBC-RL Icelandic Standardization is promising to be a useful tool to spot learning disabilities, establish a child's neuropsychological and educational strengths and weaknesses. It may also give support to possible localization and presence of brain damage. On the basis of test performance specific teaching methods can be recommended.

This research project has provided a standardized, Icelandic neuropsychological test battery for school psychologists and teachers in Iceland, to diagnose learning disabilities and help in rehabilitation planning.

It is suggested that continued research in this field focus on the adaptation of this battery for younger age groups and subsequent standardization of this adaptation, and also to closly study the specific teaching methods that may be recommended based on a child's test performance.

It is also important in the future to enlarge the standardization sample, to include a wider range of intelligence (or school performance) levels, and socio-economic levels (try to establish parents' occupation). It would be interesting to see if the battery is able to discriminate between brain impared children and children with below average IQ.

It is expected that in the future the CAT scan will be more frequently used in Iceland, testing learning disabled children. This will open up an opportunity to compare the LNNBC-RL Icelandic Standardization and its diagnostic and localizing-lateralizing powers to physical diagnostic methods.

Yet another interesting research project would be to translate and adapt the Halstead-Reitan Neuropsychological Test Battery for Children on Icelandic school children and to compare the applicability and usefulness of this battery to the power of the LNNBC-RL-ICE.

In conclusion the present study has indicated that it is justified to continue research on the Luria Batteries.

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