Prevalence of persistent primary reflexes and motor problems in children with reading difficulties

Article *in* Dyslexia · November 2004

DOI: 10.1002/dys.282 · Source: PubMed

2 authors, including:

Martin McPhillips
Edge Hill University

Prevalence of Persistent Primary Reflexes and Motor Problems in Children with Reading Difficulties

M. McPhillips* and N. Sheehy

School of Psychology, Queen's University Belfast, Belfast-BT7 1NN, UK

It has been shown that some children with reading difficulties have underlying developmental delay and that this may be related to the persistence of primary reflexes. This study investigated the prevalence of persistent primary reflexes in the ordinary primary school population and how this related to other cognitive and social factors. Three groups of 41 children were drawn from a representative, cross-sectional sample of 409 children (aged 9–10 years) attending 11 ordinary primary schools in N. Ireland. The three groups represented the bottom, middle and top 10% respectively of readers from the total sample population. The relative persistence (on a scale of 0 to 4) of the Asymmetrical Tonic Neck Reflex (ATNR) and the prevalence of motor difficulties were assessed for these 3 groups. The rôle of 5 predictor variables (verbal IQ, social deprivation, sex, month of birth and religious affiliation) in determining the reading level of the total sample was also investigated. It was found that the lowest reading group had a significantly higher mean level of ATNR (1.56 [95% CI 1.22–1.90]) compared with the middle reading group (0.56 [0.22–0.90]) and the top reading group (0.59 [0.25–0.92]). 17% of children in the lowest reading group had extremely high levels of the ATNR while 24% showed no presence of ATNR. This contrasted with 0% and 66%, respectively for both middle and top reading groups. It was also found that there was a significant difference between the lowest reading group and the top reading group on a standardised test of motor ability. Furthermore, there was evidence that ATNR persistence but not motor ability was associated with the sex of the child with boys, in particular, at risk. There was no evidence that ATNR persistence or motor ability was significantly associated with

*Correspondence to: Martin McPhillips, School of Psychology, Queen's University, Belfast, Belfast BT7 1NN, UK. E-mail: m.mcphillips@qub.ac.uk. Contract/grant sponsor: Council for the Curriculum, Examination and Assessment (CCEA)

DYSLEXIA **10:** 316–338 (2004)
Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/dys.282

social deprivation. It was also found that there were no significant differences between dyslexic and non-dyslexic children with reading difficulties in motor (including balance) performance. This study highlights the high levels of primary reflex persistence in children with reading difficulties and it provides further evidence of the association between reading difficulties and movement difficulties in young children. However, while the implications for intervention are discussed, it is stressed that the persistence of primary reflexes cannot be used as a causal model for reading difficulties, including dyslexia.

Keywords: primary reflexes; motor problems; dyslexia

INTRODUCTION

Primary reflexes emerge *in utero* and their appearance at this early stage of development suggests that they may play an important rôle in determining central nervous system functioning (e.g. Illingworth, 1987). Furthermore, there is a substantial body of literature linking the persistence of primary reflexes beyond the first year of life to a range of learning difficulties, including reading delay (Morrison, 1985).

More than 70 primary reflexes have been identified (Illingworth, 1987) including the large stereotypical movement patterns of the fœtus and newborn. They are critical for the survival of the newborn ensuring that the baby can breathe and feed (e.g. infant suck and rooting reflexes). They are readily elicited during the first six months after birth (Capute, Shapiro, Palmer, Accardo, & Wachtel, 1981) and primary reflex tests are routinely used by pædiatricians to assess the neurological integrity of the newborn baby.

As the nervous system develops, however, they are inhibited or transformed and the persistence of primary reflexes beyond their normal timespan (12 months) interferes with subsequent development and indicates neurological impairment (Holt, 1991). Severe persistence of primary reflexes indicates predominantly intractable organic problems as in cerebral palsy (Bobath & Bobath, 1975), while milder persistence is associated with less severe disorders including reading difficulties (Morrison, 1985).

The most frequently observed persistent primary reflex in infants with neurological lesions is the Asymmetrical Tonic Neck reflex (ATNR) (Paine, 1964). This reflex is elicited by a sideways turning of the head and the response consists of extension of the arm and leg on the side to which the head turns and flexion of the opposing limbs (Illingworth, 1987). The ATNR is usually thought to play an important rôle in early visuomotor development as it is present when near point fixation is developing (Illingworth, 1987). The arm stretches out towards the direction that the eyes point and as the hand encounters objects, the foundations of early hand-eye co-ordination are laid (Holt, 1991).

If the ATNR, however, persists beyond its normal timespan, the child is likely to experience fine and gross motor control problems. The ATNR initially stimulates asymmetrical visual and motor exploration of the young child's environment but as it is inhibited symmetrical movements become possible with, for example, objects brought to the midline and passed from one side to the other. The transference of objects across the midline is a significant motor milestone usually achieved between 6 to 8 months after birth (Holt, 1991).

The persistence of the ATNR will also disrupt the emergence of gross motor abilities such as rolling, creeping, crawling, riding a bicycle and catching or kicking a ball. At school, when a child with a persistent ATNR looks towards the hand that is holding a pencil in order to write, the ATNR will cause an extensor tonus in that arm. This presents problems for the child in developing a fine flexor, tripod grip or maintaining a flexed elbow when writing or drawing. The child may have to employ excessive tension and effort and this leads to muscular fatigue in the writing arm and poor motor control. Indeed, there are very close links between the inhibition of primary reflexes and the attainment of gross-motor milestones in young children (e.g. Capute, Accardo, Vining, Rubenstein, & Harryman, 1978).

It is usual for the eyes to cross the midline when reading (as books are usually positioned directly in front of the child). It is not known to what extent a persistent ATNR directly interferes with saccadic eye movements when reading or if it disrupts the general development of visual pursuit skills.

In a study evaluating the effectiveness of a specific movement intervention programme with children aged 8–11 years old with reading difficulties, it was found that it was possible to reduce the level of ATNR interference at this late stage of development and that this led to very significant progress in reading and writing skills (McPhillips, Hepper, & Mulhern, 2000). There are, however, a number of limitations with this study, particularly with regard to issues of representativeness and sampling. As the participants had self-presented initially it is not possible to assess how representative these children are of the reading difficulty population as a whole and there is a high probability of a self-selection bias in the sample.

The purpose of the present study is to evaluate the prevalence of persistent primary reflex problems in the ordinary school population and, in particular, in children with reading difficulties. This is necessary to address issues concerning the rôle of persistent primary reflexes as a possible causal factor in reading difficulty and the relevance and applicability of primary reflex inhibition movement interventions for children with reading difficulties.

Social disadvantage has been shown to correlate significantly with reading failure in numerous studies (e.g. Sammons, 1994; Jefferis, Power, & Hertzman, 2002) and verbal IQ is highly correlated with reading performance (Rust, Golombok, & Truckey, 1993). In the McPhillips *et al.* study, none of the children were entitled to free school meals (a common indicator of social disadvantage) and all of the children fell within the average verbal IQ range. It is not known if children from socially disadvantaged backgrounds or with lower levels of IQ are more likely to experience persistent reflex problems.

Another major concern is how prevalent persistent primary reflexes are in populations of children who are reading at an age appropriate level or at a level in advance of their chronological age. Morrison (1985) criticized the assumed causal association between persistent primary reflexes and learning difficulties and suggested that 'attempts should be made to find children demonstrating reflex dysfunction and not having learning disabilities' (p. 36).

The performance of boys has been of particular concern for many years and it is generally accepted that boys experience more reading difficulties than girls. There was a male:female ratio of 4:1 in the McPhillips *et al*. study. If boys are more susceptible to persistent primary reflex problems and are more likely to underachieve in reading, it could be argued that persistent primary reflexes are not directly predictive of reading difficulty *per se* but are part of a more general developmental lag found in boys (e.g. Brierley, 1976).

Other research has also suggested that boys exhibit significantly more problems in motor coordination than girls (e.g. Landgren *et al*., 1996) and that reading difficulties are associated with a range of problems that extend beyond the cognitive domain. Dyslexic children have been found to have significant difficulties in the development of motor skills (Fawcett & Nicolson, 1995) and direct evidence of cerebellar impairments in dyslexic children and adults has also been shown (e.g. Fawcett, Nicolson, & Dean, 1996; Nicolson, Fawcett, Berry, & Dean, 1999). Indeed, Fawcett *et al*. (2001) suggested that 'cerebellar' tests for dystonia might prove a valuable method of differentiating between poor readers with and without IQ discrepancy.

Other studies have suggested, however, that motor and balance problems are predominantly found in dyslexic children with co-morbid attention deficit and hyperactivity disorder (ADHD) or developmental co-ordination disorder (DCD) and not in pure dyslexia (e.g. Wimmer, Mayringer, & Raberger, 1999; Ramus, Pidgeon, & Frith, 2003).

RESEARCH QUESTIONS

Children from different backgrounds experience reading difficulties in various school settings. The present study aims to determine the prevalence of persistent primary reflexes in the ordinary primary school population (irrespective of co-morbidity issues) and aims to address the following research questions:

1. What level of a persistent primary reflex (ATNR) do children with reading difficulties have and to what extent is this different from children who do not experience reading problems?
2. Are children with reading difficulties more likely to have significant motor problems than children who do not have reading difficulties and to what extent are persistent primary reflexes and motor difficulties co-morbid?
3. Do children from socially disadvantaged backgrounds experience more reading difficulties than children who are not socially disadvantaged and do they have more persistent primary reflexes or motor problems than other children with reading difficulties?
4. Is it possible to distinguish between dyslexic and non-dyslexic poor readers on the basis of ATNR persistence or motor difficulties?
5. Do more boys experience reading difficulties than girls and are they more likely to have persistent primary reflexes or motor difficulties than girls, irrespective of other factors?

METHOD

Design

Three groups of 41 children were drawn from a representative, cross-sectional sample of 409 children (aged 9–10 years) attending 11 ordinary primary schools in N. Ireland. The three groups represented the bottom, middle and top 10%, respectively, of readers from the total sample population. The relative persistence of the Asymmetrical Tonic Neck Reflex (ATNR) and the prevalence of motor difficulties was assessed for these three groups. This assessment was conducted independently of the initial screening for reading level by a second assessor who was 'blind' to the group allocation of the child and the purpose of the study.

Participants

All 409 children (aged 9–10 years) in the initial sample were assessed for reading level in the final term of their primary 5 year. They were all attending mainstream primary schools in N. Ireland. The top, middle and bottom 10% of readers were further assessed for ATNR persistence and motor difficulties in the first term of their primary 6 year. The percentage of children that had been previously diagnosed as dyslexic or with specific learning difficulties is not reported as the total sample was drawn from across the five education boards or areas of N. Ireland which vary in how they approach the diagnosis of learning difficulties and dyslexia.

Procedure

Eleven schools were selected as representative of the N. Ireland primary school population according to geographical location (urban, suburban and rural), social disadvantage (free school meal entitlement) and religious background. In Northern Ireland, primary schools are predominantly segregated on the basis of religious affiliation into Catholic ('maintained') or Protestant ('state') schools.

In the first phase of the study, all of the children attending the primary 5 classes in the sample schools were individually assessed for reading level using the Wechsler Objective Reading Dimensions (Basic Reading) (Rust *et al.*, 1993) and the Neale Analysis of Reading Ability (Neale, 1989). This assessment was conducted by the first author and took approximately 15–20 min per child. They were also assessed in their class groups for verbal IQ using the Non-Reading Intelligence Test (Young, 1989). This is an orally administered standardised group test for primary school children that assesses both receptive and expressive language skills. The population characteristics of the initial sample are detailed in Table 1.

In the second phase of the study, the top, middle and bottom 10% of readers (based on WORD percentile scores with ties resolved by reference to NARA percentile scores) were further assessed for the persistence of the ATNR using the Schilder test (see Appendix A) and motor difficulties using a standardised test of motor impairment, Movement ABC (Henderson & Sugden, 1992). Movement ABC is an individually administered, standardized motor assessment that is designed to provide objective, quantitative data on motor performance. It may be

Table 1. Population characteristics of total sample

		Frequency	(%)
Sex	Male	195	47.7
	Female	214	52.3
Religious affiliation	Roman Catholic	218	53.3
	Protestant	188	46.0
	Other	3	0.7
Free school meals entitlement	Not entitled	315	77.0
	Entitled	94	23.0[a]
Month of birth	July–September	110	26.9
	October–December	98	24.0
	January–March	109	26.6
	April–June	92	22.5

[a] Free school meal entitlement for N. Ireland = 26% (Department of Education, N. Ireland, 2000). $N = 409$.

used with children aged 4–12 years and it involves 8 subtests that assess manual dexterity, ball skills, static and dynamic balance.

The Movement ABC and reflex assessments were conducted independently by Dr Michael Gormley who was 'blind' as to the reading status of the children. The assessments took approximately 30 min per child.

Analysis

Analysis of the data was conducted in two parts. A multiple regression analysis was conducted for the total sample of 409 children with reading level as the dependent variable. Three groups representing the top, middle and bottom 10 percentiles in reading level were drawn up from the total sample and analysis of variance was used to evaluate differences between the groups on ATNR persistence and motor difficulties.

Total Sample Analysis

A multiple regression analysis was conducted to evaluate significant predictors of reading level using the five predictor variables available in this study: social disadvantage, verbal IQ, sex, religious affiliation and month of birth. Social disadvantage was indexed by entitlement to free school meals and the dependent or criterion variable was based on the W.O.R.D. (Basic Reading) standard score for each child.

Group Analysis

Three groups of 41 children were established: the bottom 10%, middle 10% and top 10% of readers using percentile scores from the WORD (Basic Reading) test (Rust *et al.*, 1993) for the total sample. It was calculated that 41 children in each group provided 70% power to detect a significant difference between groups assuming a medium effect (0.25) using GPOWER version 2.0 (Faul & Erdfelder, 1992).

The persistence of the ATNR and motor difficulties data were analysed using one-way analysis of variance.

RESULTS

Total Sample

The reading performance of each child was assessed using two different reading tests. The correlation between the Neale Analysis of Reading (NARA) and the WORD (Basic Reading) test was extremely strong ($r = 0.98$). All results for the dependent variable (reading level) are given in terms of the WORD test.

The bivariate correlations obtained using all five predictor variables and the dependent variable (reading level), suggested that verbal IQ had a very strong, positive correlation ($r = 0.65$), month of birth had a medium positive correlation ($r = 0.21$) and social disadvantage had a medium negative correlation ($r = -0.21$) with reading level. The correlations of these three predictor variables with reading level were highly significant ($p < 0.001$).

A medium negative correlation was also found between social disadvantage and verbal IQ ($r = -0.32$, $p < 0.001$) while a small positive correlation was found between sex and verbal IQ ($r = 0.16$, $p < 0.01$) and a very small correlation between sex and reading level ($r = 0.08$, $p < 0.05$). The correlation between social disadvantage and religious affiliation ($r = -0.26$, p,0.001) may simply reflect the composition of the sample as there were more Catholic than Protestant schools from disadvantaged areas included in the sample.

The regression equation with all five predictor variables was significantly related to reading level, $R = 0.68$, $R^2 = 0.46$, adjusted $R^2 = 0.45$, $F(5, 403) = 68.609$, $p = 0.001$. The sample multiple correlation coefficient was 0.68 indicating that 46% of the variance in reading level in the sample can be accounted for by the linear combination of the five predictor variables. The relative strength of the individual predictors is summarized in Table 2.

Although the bivariate correlations between verbal IQ, month of birth and social disadvantage and reading level were all highly significant, only the partial correlations between verbal IQ and month of birth and reading level were

Table 2. The bivariate and partial correlations of the predictors with reading level

Predictors	Correlations between each predictor and reading level	Partial correlations between each predictor and reading level controlling for all other predictors
Month of birth	0.213^{***}	0.245^{***}
Sex	0.083^{*}	-0.023
Religion	0.041^{**}	-0.021
Social deprivation	-0.210^{***}	-0.012
Verbal IQ (NRIT)	0.652^{***}	0.635^{***}

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.

significant. The results of the multiple regression analysis showed that verbal IQ ($t = 16.52$, $p < 0.001$) and month of birth ($t = 5.07$, $p < 0.001$) were very significant predictors of reading level. Indeed, verbal IQ alone was a very strong predictor of reading level in this model.

As the regression model is based on a principle of parsimony, it would appear that in the presence of the predictor verbal IQ, social disadvantage is subsumed despite having almost the same correlation to reading level as month of birth. This is due to the relatively high bivariate correlation between verbal IQ and social disadvantage.

Reading Level

The frequency distributions for the total sample of 409 children on WORD standard scores and WORD percentile scores are shown in Figures 1 and 2 respectively.

These show that the distribution of reading scores is skewed towards lower reading scores overall with, for example, considerably more children in the bottom 10 percentiles than in the top 10 percentiles. This provides evidence of an overall tail of underachievement in reading in this population.

Verbal IQ

The powerful rôle of verbal IQ in determining reading performance that was highlighted by the multiple regression for the total sample is evident in the group data as well.

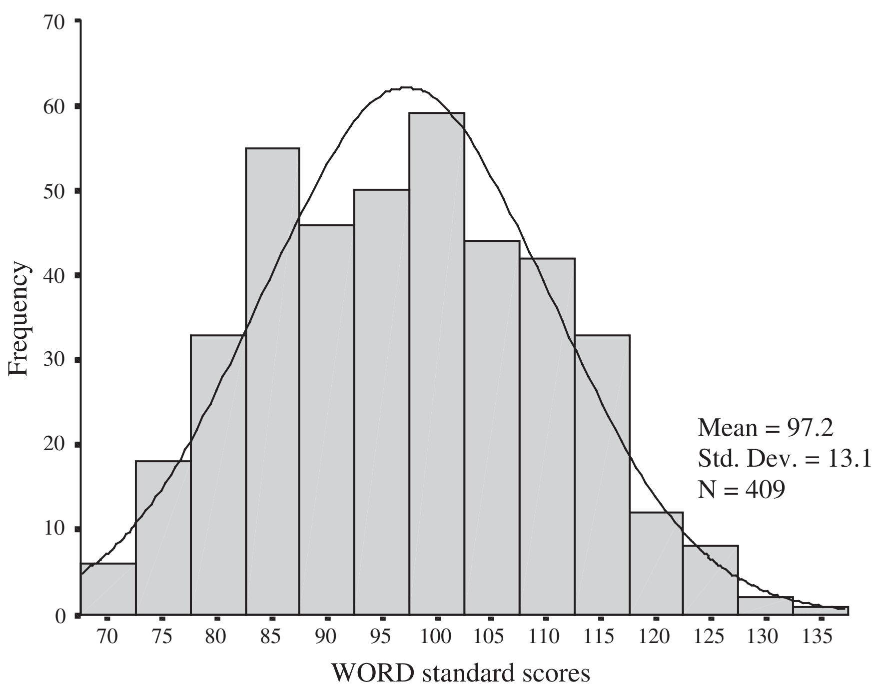

Figure 1. Histogram of frequency distribution of WORD standard scores.

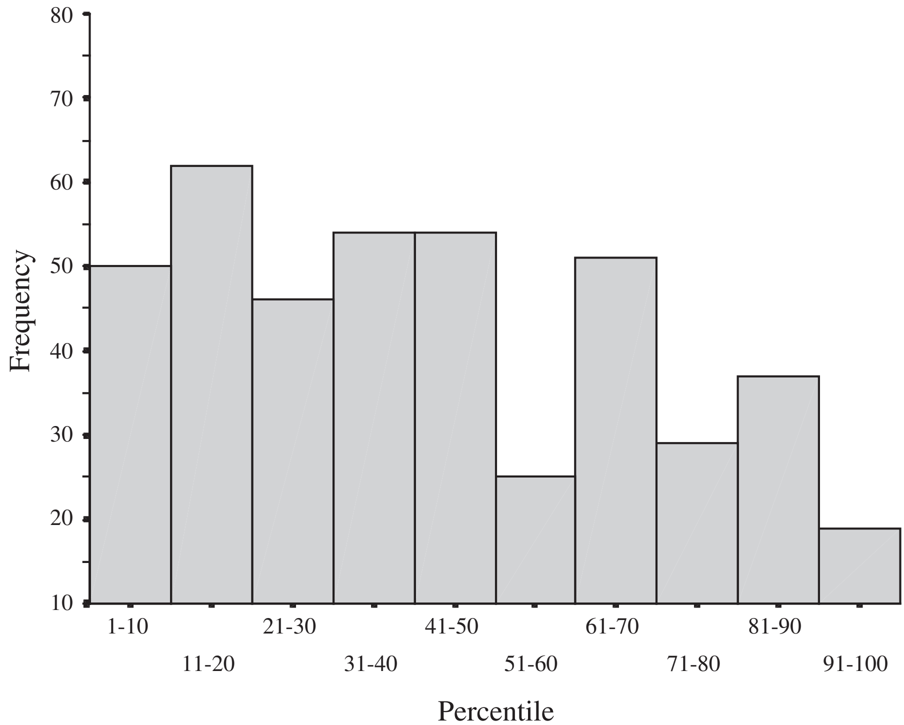

Figure 2. Histogram of frequency distribution for WORD reading scores (percentiles).

A histogram of the NRIT scores for the whole sample (see Figure 3) shows the distribution of scores and a boxplot of the NRIT scores for each of the reading groups reveals the positive linear relationship between increasing verbal IQ scores and improved reading performance, see Figure 4.

Sex of Child

The regression analysis did not suggest that the sex of the child was a significant predictor of reading delay although there was a small, significant correlation between sex of the child and reading score ($r = 0.08$, $p < 0.05$) and a significant correlation between verbal IQ and sex of the child ($r = 0.16$, $p < 0.01$). Furthermore, when the sample is looked at from the perspective of the 3 groups established on the basis of reading performance, there is a high ratio of almost 3 boys to every 1 girl in the bottom reading group (see Table 3).

The male/female ratio suggests that while boys dominate the lowest reading group they are at least equally represented in the top group. Although boys seem to be gravitating to the extremes of reading performance, a larger sample would be required to investigate this trend further.

Free School Meal Entitlement

The significant correlation between social disadvantage and reading level described earlier is evident in the group data also where social disadvantage

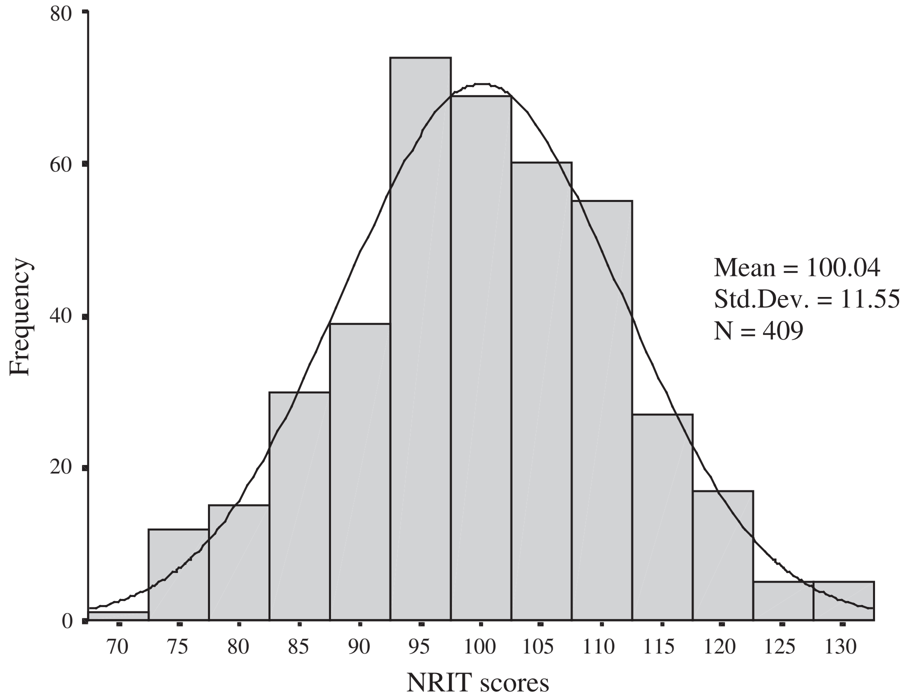

Figure 3. Histogram of frequency distribution of NRIT (verbal IQ) scores.

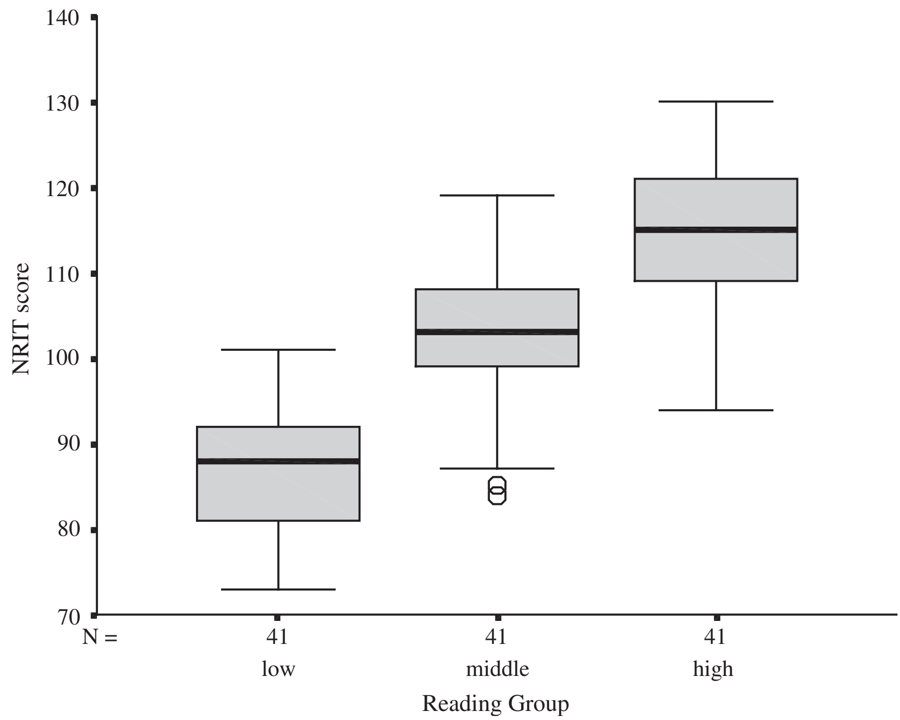

Figure 4. Boxplot of NRIT score by reading group.

Table 3. Sex, free school meal entitlement and month of birth percentages for the three reading groups

	Reading group		
	Low	Middle	High
Sex (% male)	73.2	34.2	56.1
Free school meals (% entitlement)	43.9	22.0	9.8
Month of birth (%):			
July–September	29.3	19.5	19.5
October–December	36.6	22.0	29.3
January–March	24.3	31.7	19.5
April–June	9.8	26.8	31.7

increases the likelihood of reading delay. Almost 45% of children in the bottom 10% of readers were entitled to free school meals compared with 10% in the top 10% of readers (see Table 3).

Month of Birth

The school year in N. Ireland begins on the 1 July and ends on the 30 June. This means that the oldest children within a year group are born in July with the youngest born in the following June. The multiple regression analysis for the total sample found that month of birth was a significant predictor of reading level and in order to look at this further, the months of birth for the 3 reading groups have been grouped into four quarters with July, August, September representing the months of birth of the oldest children and April, May, June representing the months of birth of the youngest children. All of these analyses were conducted using standard scores so that the children's performance was related to their chronological age.

In this sample there were more children with reading difficulties born in the first half of the school year with a very significant decrease in the final quarter. In particular, there were more children born in October, November, December who were experiencing reading difficulties than in any other month of birth quarter although the difference (7.3%) with the oldest birthdates (July, August, September) was not large. Conversely, the youngest children in their year group were the least likely to experience reading delay (see Table 3).

Asymmetrical Tonic Neck Reflex (ATNR)

A one-way analysis of variance was conducted to evaluate the relationship between reading level and persistence of the ATNR with the 3 reading groups representing 3 levels of the independent variable and the ATNR scores as the dependent variable. The ANOVA was significant, $F(2, 120) = 11.26$, $p < 0.001$. The strength of the relationship between ATNR persistence and reading group was moderate with different reading levels accounting for 16% of the variance ($\eta^2 = 0.16$) of the dependent variable.

Follow-up tests were conducted to evaluate pairwise differences among the means and as the variances among the 3 groups ranged from 0.85 to 1.79, it was assumed that the variances were not homogenous and *post hoc* comparisons were conducted using the Dunnett's C test. The results of these tests, as well as the means and standard deviations for the ATNR scores for the 3 reading groups are presented in Table 4.

This analysis shows that the lowest reading group had a significantly higher mean level of ATNR (1.56 [95% CI 1.22–1.90]) compared with the middle reading group (0.56 [0.22–0.90]) and the top reading group (0.59 [0.25–0.92]). There was no significant difference between the middle and top groups.

A line graph of ATNR persistence for each reading group is shown in Figure 5. The most obvious trend in the graph is how the middle and high groups have very similar patterns of persistence while the low reading group has a very different pattern.

The two extremes of the graph are particularly revealing with 66% of the middle and top reading groups showing no evidence of ATNR persistence compared with only 24% of the low reading group. It is also probable that a score

Table 4. Differences between reading groups in the level of ATNR

Reading group	Mean	Standard deviation	Low	Middle
Low	1.56	1.34		
Middle	0.56	0.92	—	
High	0.59	0.95	*	NS

NS indicates non-significant differences between pairs of means, while an asterisk (*) indicates significance using the Dunnett's C procedure.

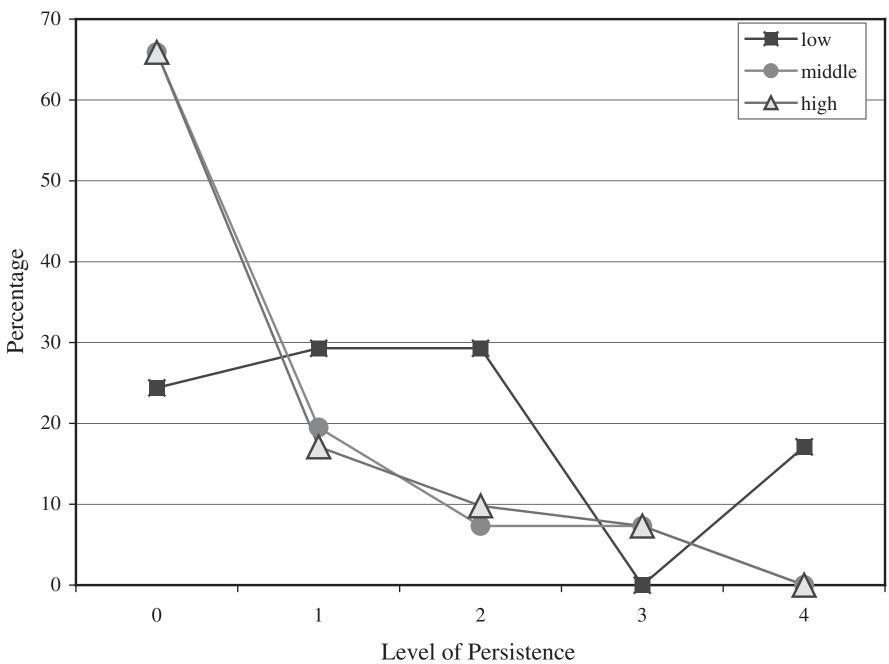

Figure 5. A line graph of ATNR persistence by reading group.

of 1 represents a negligible score of ATNR persistence and that this is within the error margin of a clinical test such as the Schilder test used for assessment in this study.

In contrast, both middle and high reading groups do not show any evidence of having the highest level of persistence compared to 17% for the low reading group. There is also evidence of greater persistence at lower levels of the ATNR for the low reading group in comparison to the other groups.

The results of these analyses suggest that persistence of the ATNR is related to reading level although there is also evidence of lower level persistence in children who are average or above average readers.

Motor Difficulties

A one-way analysis of variance was conducted to evaluate the relationship between reading level and motor difficulties with the 3 reading groups representing 3 levels of the independent variable and standard scores on a standardised test of motor impairment, Movement ABC (Henderson & Sugden, 1992), as the dependent variable. The ANOVA was significant, $F(2, 120) = 5.218$, $p = 0.007$. The strength of the relationship between motor difficulties and reading group was weak with reading level accounting for 8% of the variance ($\eta = 0.08$) of the dependent variable.

Follow-up tests were conducted to evaluate pairwise differences among means and as the variances of the 3 groups ranged from 163 to 280, it was assumed that the variances were not homogenous and *post hoc* comparisons were conducted using the Dunnett's C test. The results of these tests, as well as the means and standard deviations for the Movement ABC scores for the 3 reading groups are presented in Table 5.

This analysis, in conjunction with the ANOVA, shows that the lowest reading group had a significantly lower mean Movement ABC standard score (90.1 [95% CI 85.7–94.4]) compared with the top reading group (100.0 [95.6–104.4]) but not with the middle reading group (96.6 [92.2–101.0]). There was no significant difference between the middle and top groups.

A line graph of the Movement ABC percentiles for the 3 groups is shown in Figure 6. Henderson and Sugden (1992) state that 'scores below the 5th percentile should be considered as indicative of a definite motor problem' and that 'scores between the 5th and 15th percentile suggest a degree of difficulty that is borderline'. Furthermore, they state that the 'movement competence of all other children is deemed to be adequate or better' (p.108). For these reasons the percentile range used in the graph has been chosen to reflect the extremes of

Table 5. Differences between reading groups in movement ABC standard scores

Reading group	Mean	Standard deviation	Low	Middle
Low	90.1	12.8		
Middle	96.6	12.7	NS	
High	100.0	16.7	*	NS

NS indicates non-significant differences between pairs of means, while an asterisk (*) indicates significance using the Dunnett's C procedure.

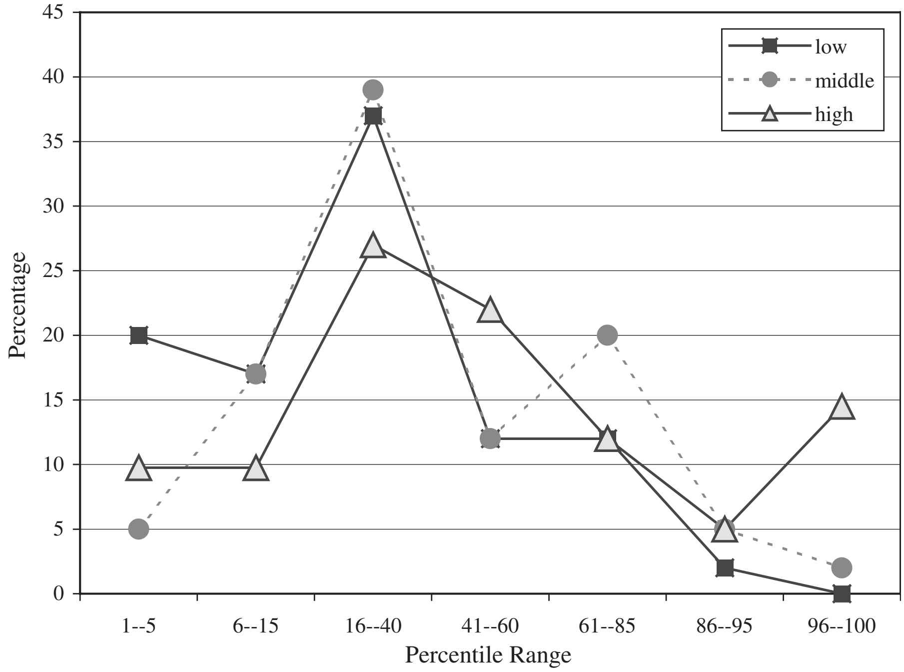

Figure 6. A line graph of movement ABC percentiles by reading group.

performance and, in particular, to highlight scores in the 1st–15th percentile range.

11% (14 children) of the 123 children from all 3 reading groups that were tested achieved scores on the Movement ABC test that placed them in the lowest 5 percentiles. This suggests that there are a considerable number of children attending ordinary primary school who have significant motor deficits.

Eight of the 14 children were from the lowest reading group and it is evident from the line graph (see Figure 6) that 20% of children with very significant reading difficulties also have very significant motor difficulties. However, it should be noted that 5% of children with average reading scores and almost 10% of children with above average reading scores also have significant motor difficulties. At the other extreme of the distribution (the top 5 ABC movement percentiles) there were no children from the lowest reading group compared to almost 15% from the top reading group.

The movement ABC test battery is composed of eight subtests or components: three tests of 'manual dexterity' (shifting pegs by rows on a pegboard, threading nuts onto a bolt, drawing a continuous line within a set trail); two tests of 'ball skills' (bouncing a ball of a wall and catching it, throwing a bean bag into a box) and three tests of 'dynamic and static balance' (balancing on a board, hopping in squares, and balancing a ball on a board).

When the performance of the three reading groups is compared with these three component subtests (see Figure 7), the results reflect the overall trend of the full assessment with the highest reading group performing significantly better (scoring the lowest impairment scores) than the lowest reading group on 'manual dexterity' and 'balance' ($F(2, 120) = 6.157$, $p = 0.003$ and $F(2, 120) =$

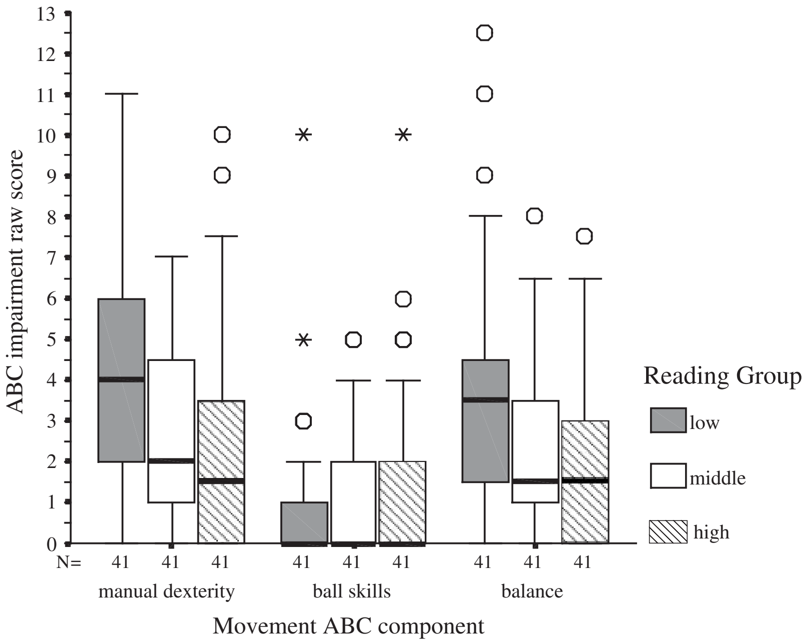

Figure 7. Boxplot of the movement ABC component scores for the three reading groups.

6.172, $p = 0.003$ for 'manual dexterity' and 'balance' respectively). However, this is not the case for the component 'ball skills' where the lowest reading group shows the least impairment relative to the other two reading groups although it is not significant ($F(2, 120) = 0.936$, $p = 0.395$).

ATNR and Movement ABC

The bivariate correlation coefficient between ATNR persistence and motor difficulties (as assessed by the Movement ABC) indicated that there was a moderately significant correlation, ($r = 0.36$, $p < 0.001$). This suggests that children with a persistent ATNR are also at risk of having motor difficulties (and *vice versa*).

ATNR, Movement ABC and Verbal IQ

The bivariate correlation coefficient between verbal IQ and ATNR persistence was moderately significant ($r = -0.31$, $p < 0.001$) while the correlation between verbal IQ and motor difficulties was just significant ($r = 0.18$, $p < 0.05$). This suggests that higher levels of verbal IQ are associated with lower levels of ATNR and with higher levels of motor skill.

ATNR, Movement ABC and Sex differences

A two-way contingency table analysis was conducted to evaluate whether persistence of the ATNR was associated with the sex of the child irrespective of reading level. The two variables were sex of the child with two levels (either male or female) and ATNR persistence with two levels (low for ATNR scores of 0 and 1 and high for ATNR scores of 2,3,4).

ATNR persistence and sex of the child were found to be almost significantly related (Pearson $\chi^2(1, N = 123) = 3.56$, $p = 0.059$, Cramér's $V = 0.17$). The proportions of males with low and high levels of ATNR persistence were 0.67 and 0.32, respectively, compared with the respective proportions of 0.82 and 0.18 for females.

A two-way contingency table analysis was conducted to evaluate whether motor difficulties as measured by Movement ABC (Henderson & Sugden, 1992) were associated with the sex of the child irrespective of reading level. The two variables were sex of the child with two levels (either male or female) and Movement ABC percentiles with two levels (low for percentile scores of 1–15 and high for percentile scores of 16 and above). Children in the bottom 15 percentiles on the Movement ABC are considered to have either definite or borderline motor problems (Henderson & Sugden, 1992).

There was no evidence of a significant relationship between Movement ABC scores and the sex of the child, (Pearson $\chi^2(1, N = 123) = 0.002$, $p = 0.962$, Cramér's $V = 0.004$). The proportions of children with low and high levels of motor difficulties was 0.75 and 0.25 respectively for both males and females.

These analyses suggest that ATNR persistence is possibly related to the sex of the child with boys more at risk than girls while motor difficulties as measured by the Movement ABC test seem to be very evenly distributed between the sexes.

ATNR persistence, Movement ABC and Social Disadvantage

Of the 32 children (from the 3 group sample of 123) categorized as having a high ATNR level (scores of 2, 3, and 4), 9 (28%) were also entitled to free school meals. The level of free school meals for the total sample and for the 3 group sample was 23 and 25%, respectively. There is little evidence to suggest that children with high ATNR persistence come predominantly from socially deprived backgrounds. ATNR persistence seems to be unrelated to social background.

The proportions for the Movement ABC test are very similar. Of the 31 children (from the 3 group sample of 123) categorised as having a definite or borderline motor problem, 8 (26%) were also entitled to free school meals. Motor difficulties also seem to be unrelated to social background in this sample.

Dyslexia

A discrepancy criterion (a difference of 16 or more points between the WORD standard score and the NRIT score (verbal IQ)) may be used to identify dyslexic children in the total or group samples. The discrepancy reflects the underachievement in reading scores relative to verbal IQ.

It was found that 50 children (12%) from the total sample could be classified as dyslexic on this basis. 15 of these children (30% of the dyslexic group) came from the lowest reading group while 4 came from the middle reading group. There were no children with dyslexia identified in the top reading group. In other words, 37% of the poorest readers and 10% of average readers could be classified as dyslexic in this sample.

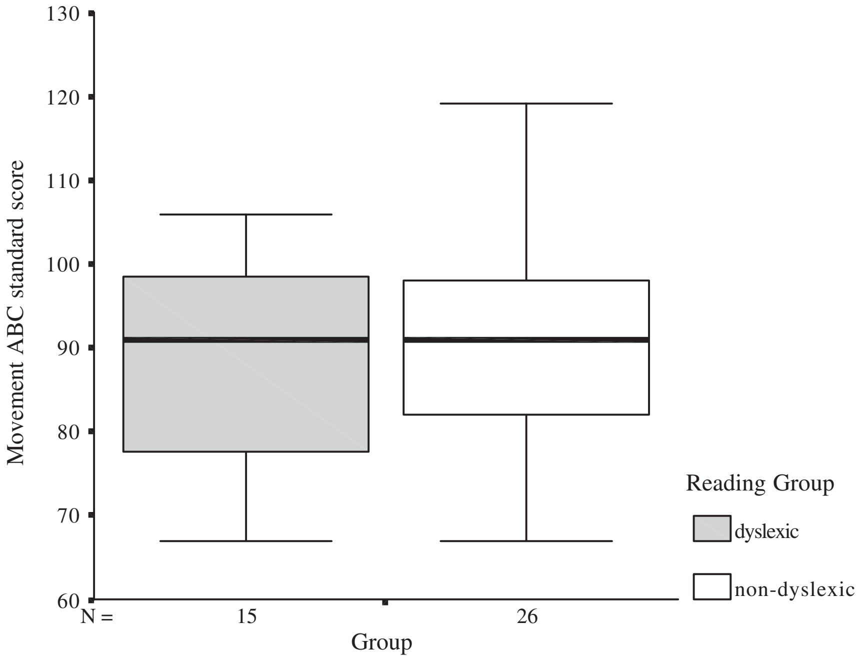

Figure 8. Boxplot of the Movement ABC standardized scores for dyslexic and non-dyslexic children with reading difficulties.

Four (27%) of the 15 dyslexic children were entitled to free school meals as opposed to 17 (65%) of the 26 poor readers without IQ discrepancy.

Nine (60%) of the 15 dyslexic children in the lowest reading group had a significantly persistent ATNR while none of the 4 children in the middle reading group had. 10 (39%) of the 26 non-dyslexic children in the lowest reading group had a significantly persistent ATNR. However, there was no significant difference in levels of the ATNR between the dyslexic and non-dyslexic children in the lowest reading group ($F(1, 39) = 1.86$, $p = 0.18$).

There was no significant difference between the 15 dyslexic and 26 non-dyslexic children from the lowest reading group on the Movement ABC test ($F(1, 39) = 0.69$, $p = 0.41$) indicating that the standardized motor scores for both dyslexic and non-dyslexic poor readers were very similar (see Figure 8).

Furthermore, there were no significant differences found when the performance of the dyslexic and non-dyslexic reading difficulty children were compared on the three component subtests of Movement ABC, ('manual dexterity' ($F(1, 39) = 0.17$, $p = 0.68$), 'ball skills' ($F = (1, 39) = 1.15$, $p = 0.29$) and 'static and dynamic balance' ($F(1, 39) = 2.39$, $p = 0.13$)). The dyslexic children seemed to be poorer than the non-dyslexic poor readers on the balance subtests but there was considerable overlap in their respective impairment scores (see Figure 9).

DISCUSSION

The results for the whole sample show that verbal IQ is the strongest predictor of reading level for the 409 (9–10 year old) children involved in this study. This is

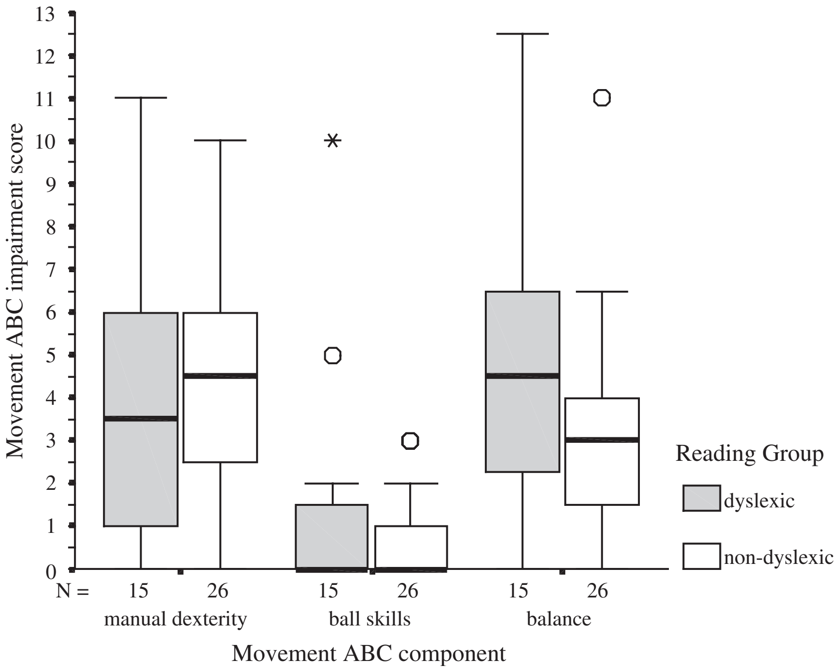

Figure 9. Boxplot of the movement ABC component scores for the dyslexic and non-dyslexic reading difficulty children.

consistent with the high correlation between reading level and verbal IQ described in other work (Rust *et al.*, 1993).

Furthermore, the results show that social disadvantage which has also been identified as a significant predictor of early academic performance (e.g. Jefferis *et al.*, 2002) is very closely associated with verbal IQ. This suggests that children from disadvantaged backgrounds may experience difficulties in gaining exposure to a range of verbal/language concepts that underpin progress in attaining literacy. This supports the notion that literacy is a cultural phenomenon and that attempts to overcome inadequate literacy levels should include a large social dimension that addresses fundamental problems such as poverty and deprivation directly.

The significant rôle of month of birth in predicting the reading level of children completing their fifth year of compulsory schooling is not unexpected as previous research has shown the possible long-term effects of age-position in class groups on academic performance (e.g. Hedger, 1992).

However, what is very surprising about the results of the present study is that the youngest children appear to be significantly out-performing their older classmates on reading ability. This is contrary to the perceived reading abilities of younger children in N. Ireland who are referred to the educational psychological service in significantly higher numbers than any other age group (Menet *et al.*, 2000). Further research is required to identify why younger children in N. Ireland should be outperforming their older classmates in reading.

The results for the three groups representing low, average and high reading levels show that persistence of the Asymmetrical Tonic Neck Reflex (ATNR) is significantly related to reading delay. This suggests that persistence of the ATNR plays a rôle, direct or indirect, in delaying the reading progress of a significant number of children attending ordinary primary schools.

Furthermore, the results show that there are some children who are performing at their age-appropriate level or above who have some degree of ATNR persistence. It is beyond the scope of this study to evaluate if there are other detrimental effects associated with ATNR persistence for these children in terms of overall academic performance or behavioural/social difficulties.

The results suggest that 17% of children with reading difficulties experience extremely high levels of ATNR persistence with a further 29% experiencing milder but significant persistence. In other words, 46% of children in the bottom 10% of readers may be carrying significant ATNR levels. For children with average or high reading ability there is evidence that around 15% of these children experience significant ATNR persistence although it is at a milder level generally than for children with reading difficulties.

Motor difficulties are also significantly associated with reading delay although the relationship is not as strong as for ATNR persistence. It should be of great concern that of the 123 children in the three reading group sample, 11% have a significant motor deficit and should be receiving specific, specialized motor interventions. As children attending ordinary school in N. Ireland are not routinely assessed for motor delay, it is unlikely that these children will receive help and there is evidence that motor deficits persist into young adulthood (e.g. Losse *et al*., 1991).

However, it should be pointed out that Wright and Sugden (1996) advocate that when identifying children with developmental coordination disorder (DCD) the standardized test used in this study should be accompanied by the Movement ABC checklist (Henderson & Sugden, 1992) which evaluates functional motor competence in everyday activities such as tying shoelaces, dressing, etc. They suggest that the use of the Movement ABC standardised test in combination with the checklist will lead to a more conservative estimate of DCD prevalence (Sugden & Wright, 1998, p. 51).

Although prevalence estimates of developmental problems such as motor coordination vary greatly it is also important to remember that such problems rarely exist in isolation. Landgren, Pettersson, Kjellman, and Gillberg (1996) found that 10.7% of a sample of 589 six year-olds had significant neurodevelopmental or neuropsychiatric disorders with evidence of co-morbidity across a number of developmental problems including motor delay, attention deficit and hyperactivity. (In Sweden, children are screened for deficits in attention, motor control and perception at 6 years of age).

It is surprising that there is no evidence of a sex difference in performance on the standardized test for motor problems used in this study as other research suggests that boys have significant problems in motor development (e.g. Landgren *et al*., 1996). There is, however, strong evidence of a sex difference for ATNR persistence even though this just failed to reach statistical significance. The ratio of boys to girls with a significant persistent ATNR is almost 2:1.

There is no evidence that social disadvantage increases the probability of having a persistent ATNR or a motor deficit. However, it should be noted that the measure of social disadvantage used in this study is based on free school meal entitlement and may not be sensitive to more subtle social factors that could impact on motor development such as access to play areas or space in the home.

The results indicate a prevalence rate of 12% for dyslexia in the overall sample with 30% of the dyslexic children in the bottom 10% of readers. This suggests that the majority of children with the most significant reading problems may not be classified as dyslexic using a discrepancy definition and that it is possible for children with average reading ability (8%) to be underachieving relative to their verbal IQ.

With regard to differentiating between poor readers with and without IQ discrepancy, the results suggest that there is considerable overlap between the performance of these two subgroups of children on motor and balance tests. This does not concur with the Fawcett, Nicolson, and Maclagan (2001) findings where poor readers without IQ discrepancy performed significantly better than the dyslexic children on tests of postural stability and muscle tone. The sample size in this latter study was extremely small ($n = 7$) and the major conclusions were based on the inclusion of dyslexic children from an earlier study (Fawcett *et al.*, 1996) where the children were not tested 'blind'.

It would appear that a persistent ATNR may be a particular problem for many dyslexic children but it is not a defining characteristic of dyslexia and it is important to stress that the phenomenon of persistent primary reflexes and their association with reading difficulties does not constitute a coherent theory of reading development. It may be more appropriate to construe the persistence of primary reflexes as a developmental 'risk factor' that in conjunction with other factors may impact on specific aspects of development (including cognitive development). In other words, persistent primary reflexes cannot adequately explain the emergence of reading difficulties but they may indicate children at risk of reading difficulties.

Similarly, the trend towards higher levels of reflex persistence and balance problems in children with dyslexia, when compared with poor readers without IQ discrepancy, may simply reflect the impact of other variables that affect reading performance. The poor readers without IQ discrepancy experience higher levels of social deprivation, for example, than the dyslexics and, therefore, the nature of their reading difficulties may be more diverse. Certainly, the results from this study suggest that there are huge overlaps in the levels of persistent reflexes and motor/balance difficulties between poor readers with and without IQ discrepancy.

Only one primary reflex, the ATNR, was assessed in this study and it is possible that other primary reflexes may play a rôle in learning difficulties as well. However, it may be concluded that a persistent ATNR is significantly associated with reading delay in young children but that it may also occur to a much lesser extent in children without obvious reading problems.

This supports the employment of intervention strategies that address this underlying developmental issue directly through the use of specific movement programmes and this study suggests that there is a significant population of children attending ordinary primary school who should be receiving specific motor interventions of various kinds. However, it should be noted that such methods cannot be presented as a panacea for reading delay as there are many other factors that are very important in the development of literacy.

Finally, this study was undertaken to evaluate the prevalence of the ATNR in children with reading difficulties because in a previous intervention study all of the children who self-presented had an ATNR (McPhillips *et al.*, 2000). This study suggests that great care must be exercized in drawing conclusions from any sample that is not representative of the broad category of reading difficulty, particularly where samples may have a level of self-selected bias. This issue is particularly relevant in areas such as dyslexia where there are a considerable number of relatively small sample studies that are not drawn from the larger population of reading difficulty.

APPENDIX. A: THE ASYMMETRICAL TONIC NECK REFLEX (SCHILDER TEST)

The test position and procedure are demonstrated. The child, then, stands upright with feet together and arms held straight out in front at shoulder level but with the wrists relaxed ('hands floppy'). The tester stands behind the child and gives the instruction: 'In a moment, you will close your eyes and I will turn your head slowly first to one side and then the other, all you have to do is to keep your arms in exactly the same position as they are now; only your head moves'. The tester then slowly turns the child's head to one side (70–80° or until the chin is over the shoulder), pauses for 5 s and then slowly turns the head to the other side. After another pause for 5 s the whole sequence is repeated once more.

Positive indicators of this reflex include movement of the extended arms in the same direction as the head turn, dropping of the arms or swaying and loss of balance.

Scoring:

0 no response (the arms remain straight out in front);
1 slight movement of the arms (up to 20°) to the same side as the head is turned (or slight dropping of the arms);
2 movement of the arms (up to 45°) as the head is turned (or marked dropping of the arms);
3 arm movement greater than 45° either to the side or down, swaying and loss of balance.

Each side is scored separately and then a total obtained for both sides.

ACKNOWLEDGEMENTS

Special thanks to the primary schools that took part in this study: Botanic Primary School, Belfast; Edmund Rice Primary School, Belfast; Fivemiletown Primary School; Harding Memorial School, Belfast; Howard Primary School, Dungannon; Maguiresbridge Primary School; Mercy Primary School, Belfast; Omagh County Primary School, Saints & Scholars Integrated Primary School, Armagh; St Michael's Primary School, Belfast; St Mary's Star of the Sea Primary School, Belfast.

This research was funded by a grant from the Council for the Curriculum, Examinations and Assessment (CCEA), N. Ireland.

References

Bobath, K., & Bobath, B. (1975). *Motor development in the different types of cerebral palsy.* London: Heinemann.

Brierley, J. (1976). *The growing brain: Childhood 's crucial years*. NFER: Windsor.

Capute, A. J., Accardo, P. J., Vining, E. P. G., Rubenstein, J. E., & Harryman, S. (1978). *Primitive reflex profile.* Baltimore: University Park Press.

Capute, A. J., Shapiro, B. K., Palmer, F. B., Accardo, P. J., & Wachtel, R. C. (1981). Primitive reflexes: A factor in nonverbal language in early infancy. In Stark (Ed.), *Language behavior in infancy and early childhood* (pp. 157–161). North-Holland: Elsevier.

Faul, F., & Erdfelder, E. (1992). *GPOWER: A priori, post-hoc and compromise power analyses for MS-DOS (Computer program).* Bonn, FRG: Bonn University, Department of Psychology.

Fawcett, A. J., & Nicolson, R. I. (1995). Persistent deficits in motor skill for children with dyslexia. *Journal of Motor Behaviour, 27*, 235–240.

Fawcett, A. J., Nicolson, R. I., & Dean, P. (1996). Impaired performance of children with dyslexia on a range of cerebellar tasks. *Annals of Dyslexia, 46,* 259–283.

Fawcett, A. J., Nicolson, R. I., & Maclagan, F. (2001). Cerebellar tests may differentiate between poor readers with and without IQ discrepancy. *Journal of Learning Disabilities, 24*(2), 119–135.

Hedger, K. (1992). 'Seen it, been there, done it': The analysis of GCSE examination results in Shropshire. *Management in Education, 6*(1), 29–33.

Henderson, S. E., & Sugden, D. A. (1992). *Movement assessment battery for children.* London: The Psychological Corporation.

Holt, K. S. (1991). *Child development: Diagnosis and assessment*. London: Butterworth-Heinemann.

Illingworth, R. S. (1987). *The development of the infant and young child: Normal and abnormal.* Edinburgh: Churchill Livingstone.

Jefferis, B. J. M. H., Power, C., & Hertzman, C. (2002). Birthweight, childhood socioeconomic environment and cognitive development in the 1958 British birth cohort study. *British Medical Journal, 325,* 305–308.

Landgren, M., Pettersson, R., Kjellman, B., & Gillberg, C. (1996). ADHD, DAMP and other neurodevelopmental/psychiatric disorders in 6 year old children: Epidemiology and co-morbidity. *Developmental Medicine and Child Neurology, 38,* 891–906.

Losse, A., Henderson, A. E., Elliman, D., Hall, D., Knight, E., & Jongmans, M. (1991). Clumsiness in children—do they grow out of it? A ten-year follow-up study. *Developmental Medicine and Child Neurology, 33,* 55–68.

McPhillips, M., Hepper, P. G., & Mulhern, G. (2000). Effects of replicating primary-reflex movements on specific reading difficulties in children: A randomised, double-blind, control trial. *The Lancet, 355,* 537–541.

Menet, F., Eakin, J., Stuart, M., & Rafferty, H. (2000). Month of birth and effect on literacy, behaviour and referral to psychological service. *Educational Psychology in Practice, 16*(2), 225–234.

Morrison, D. C. (1985*). Neurobehavioral and perceptual dysfunction in learning disabled children*. Lewiston, NY: C.J. Hogrefe Inc.

Neale, M. D. (1989). *Neale analysis of reading ability: Revised British edition.* Windsor: National Foundation for Educational Research.

Nicolson, R. I., Fawcett, A. J., Berry, E. L., & Dean, P. (1999). Association of abnormal cerebellar activation with motor learning difficulties in dyslexic adults. *The Lancet, 353,* 1162–1667.

Paine, R. (1964). The evolution of infantile postural reflexes in the presence of chronic syndromes. *Developmental Medicine and Child Neurology, 6,* 345.

Ramus, F., Pidgeon, E., & Frith, U. (2003). The relationship between motor control and phonology in dyslexic children. *Journal of Child Psychology and Psychiatry*, *44*(5), 712–722.

Rust, J., Golombok, S., & Trickey, G. (1993). *Wechsler Objective Reading Dimensions*. London: The Psychological Corporation.

Sammons, P. (1994). Gender, ethnic and socio-economic difference in attainment and progress: A longitudinal analysis of student achievement over nine years. *British Educational Research Journal*, *21*, 465–485.

Sugden, D. A., & Wright, H. C. (1998). *Motor coordination disorders in children.* London: Sage Publications.

Wimmer. H., Mayringer, H., & Raberger, T. (1999). Reading and dual task balancing: Evidence against the automatisation deficit explanation of developmental dyslexia. *Journal of Learning Disabilities*, *32*(5), 473–478.

Young, D. (1989). *Non-reading intelligence tests*. London: Hodder & Stoughton Educational.

