Prediction of Preschool Sensory and Motor Performance by 18-Month Neurologic Scores Among Children Born Prematurely

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Key Words: human development • outcome study • tests, by title, Miller Assessment for Preschoolers

Objectives. Premature birth places a child at risk for a number of academic and behavioral deficits. The challenge currently facing interventionists is to identify at an early age those preterm children who will develop such deficits. Identified children can then be targeted for intervention to forestall deficits at school age.

Method. This study examined the use of a neurologic assessment, administered at 18 months of age, to identify children who will have difficulties at preschool age. Premature children identified as neurologically normal or neurologically suspicious at the age of 18 months were tested with the Miller Assessment for Preschoolers.

Results. Although there was some variability in performance, as a group the children classified as neurologically suspicious at 18 months continued to fall into a risk category at 4 years of age.

Conclusion. Because such categorization may predict inadequate performance during the school-age years, monitoring of the child's development is warranted.

Premature birth places a child at risk for an array of developmental delays and handicapping conditions. Often the diagnosis of such deficits is not made until the age of 12 months or later to ensure accuracy (Allen & Capute, 1989; Vohr & Coll, 1985). Approximately 5% to 15% of all premature children will demonstrate signs of serious neurologic deficits, such as cerebral palsy or hydrocephalus, visual impairment, or hearing impairment, by 12 to 18 months of age (Coolman et al., 1985; Hoy, Bill, & Sykes, 1988; Nickel, Bennett, & Lamson, 1982). The remaining 85% to 95% of children will develop along neurologically normal lines; however, some of them will show a sufficient number of developmental deviations that their potential long-term developmental outcome can be termed suspicious, or questionable.

Children with specific, identified deficits will likely receive early intervention and follow-along services. Children considered neurologically suspicious and those considered neurologically normal at 12 to 18 months of age are unlikely to qualify for even follow-along services in spite of their at-risk birth categorization. The absence of follow-along care will not be a problem for those children who develop, thrive, and perhaps grow out of their suspicious status with no intervention. However, many authors have pointed to a relationship between premature birth and the development of learning and behavioral deficits during the school-age years in children who seemed to be developing along expected lines (Aylward, Pfeifer, Wright, & Verhulst, 1989; Bauchner, Brown, & Peskin, 1988; Drillien, Thomson, & Burgoyne, 1980; Klein, Hack, Gallagher, & Fanaroff, 1985; Vohr & Coll, 1985). If children who will develop school-related learning problems can be identified during the toddler years, when the con-

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ditions of their counterparts with more significant deficits are differentially diagnosed, follow-along care and intervention can be provided to reduce the likelihood of later developmental or academic problems.

Information regarding the toddler and preschool age performance of premature children is accumulating. It seems that some of these children do not perform adequately on measures of intelligence and some aspects of perceptual performance (Forslund & Bjerre, 1990; McDonald, Sigman, & Ungerer, 1989). As noted above, premature birth alone may suffice to classify a preschool child as at risk for future delay or deficits. However, in many states, the classification of at risk is insufficient to qualify a child for early intervention. To help establish an empirical relationship between at-risk classification and performance of premature children born in the University Hospital in Edmonton, Alberta, Canada, during a 12-month period (N = 78) were identified and followed from birth through 18 months of age. Subjects were excluded from the original study if overt congenital abnormalities were noted. We examined neurobehavioral status and motor development during this 18-month time span. At 18 months of age, the subjects were given the Neurological Examination of the Collaborative Perinatal Project (Hardy, Drage, & Jackson, 1979) by a pediatric neurologist. This tool uses neurologic function, developmental skill acquisition, and physician judgment to determine overall neurologic status. Subjects in the current study were classified neurologically normal (NN), neurologically suspicious (NS), or neurologically abnormal on the basis of the results of this evaluation.

For the current study, attempts were made to contact all 66 subjects who had been identified NN and NS at the 18-month time point. Thirty subjects were successfully contacted. Others either could not be reached by telephone or mail or were known to have moved out of the immediate area. There were no differences between the subjects in the original study and the subjects in the current study on birth weight or gestational age (see Table 1). In addition, there were no significant differences between the NN group (n = 20) and the NS group (n = 10) for the study cohort on birth weight (t = −0.45, p = .66) or gestational age (t = −0.41, p = .69).

**Characteristics of the Study Sample**

At the time of the current study, all children were between the ages of 3 years 11 months and 4 years 8 months. Average age was 4.5 years. Age was not corrected for prematurity.

Maternal education level is considered a potentially important characteristic that may influence long-term developmental outcome insomuch as it reflects the quality and socioeconomic level of the caretaking environment (Cohen, Sigman, Parmelee, & Beckwith, 1982). Educational level of the mothers of the original birth cohort and the mothers of children included in the current study is presented in Table 2. As can be seen in this table, the children in this study were from environments in which education level was relatively high, suggesting that the means of the maternal education level for the original sample: NS-S = neurologically normal, original sample: NS-S = neurologically normal, study sample; NS-O = neurologically suspicious, original sample; NS-S = neurologically suspicious, study sample.

*p > .10.

**Table 1**

<table>
<thead>
<tr>
<th>Variable</th>
<th>NN-O (n = 48)</th>
<th>NN-S (n = 20)</th>
<th>t</th>
<th>NS-O (n = 18)</th>
<th>NS-S (n = 10)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (g)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SD</td>
<td>± 556.52 ± 450.10</td>
<td>± 591.77 ± 467.09</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gestational age (wks)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>SD</td>
<td>± 2.78 ± 2.53</td>
<td>± 3.05 ± 2.55</td>
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</tr>
</tbody>
</table>

*Note. Values are ± standard deviations. NN-O = neurologically normal, original sample; NS-S = neurologically normal, study sample; NS-O = neurologically suspicious, original sample; NS-S = neurologically suspicious, study sample.*

**Table 2**

<table>
<thead>
<tr>
<th>Level</th>
<th>NN Group</th>
<th>NS Group</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Education I</td>
<td>3.1 ± .93</td>
<td>2.8 ± .97</td>
<td>−.85</td>
<td>.40</td>
</tr>
<tr>
<td>(n = 48)</td>
<td>(n = 18)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal Education II</td>
<td>2.9 ± .96</td>
<td>2.6 ± 1.2</td>
<td>0.26</td>
<td>.80</td>
</tr>
<tr>
<td>(n = 20)</td>
<td>(n = 10)</td>
<td></td>
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</tbody>
</table>

*Note. Maternal Education I = maternal education level for the original sample; Maternal Education II = maternal education level of this sample group; at time of present study. Education levels: 1 = grade school; 2 = high school; 3 = some university or technical school; 4 = bachelor's degree; 5 = advanced degree. Values are M ± SD.
A child's environment was not impoverished. Although this situation may limit the generalizability of the findings, it also removes the possible confounding influence that the social environment may have on the development of children.

Assessment

The Miller Assessment for Preschoolers (MAP) (Miller, 1988b) was used to assess all subjects. In addition, parents completed an adapted form of the behavioral questionnaire included with the MAP.

The MAP is a preschool screening tool designed to assess sensory processing; fine, gross, and oral motor development; motor planning; and aspects of cognitive function. It has been used extensively with the preschool population and has been shown to have both reliability and validity (Miller, 1987; Miller, 1988a; Miller, 1988b). Scores on the MAP have been shown to be predictive of school-related behavior (Miller, 1987; Miller & Schouten, 1988).

The MAP consists of five indexes: Foundations, Coordination, Verbal, Nonverbal, and Complex Tasks. Scores can be obtained on each index. In addition, a Total Score reflecting a composite of the above index scores can be calculated. All scores are reported as percentiles and are conservatively interpreted as follows: 0% to 5% indicates at-risk performance and need for referral; 6% to 25% indicates areas of concern and need for follow-up; 26% and above indicates normal performance (Miller, 1988b). The MAP can be administered by a trained evaluator in approximately 30 to 40 min.

Procedure

The MAP was administered in a quiet, distraction-free room equipped with a one-way mirror. Parents and the first author observed most assessment sessions through this mirror. The evaluator (the second author) was trained in MAP administration by the first author, who has had extensive experience with this tool. The evaluator was blind to the subjects' neurologic categorization. The MAP is designed to allow the examiner some degree of flexibility in administration, and item order can be altered to meet the needs of the child. Because of this design, all but one subject in the NS group successfully completed all items on the MAP. This subject was unable to complete any subtest and was subsequently dropped from the study. In the NN group, one subject was unable to complete the Foundations subtest. Other subtests were completed, and data from subtests completed were included in the analyses.

Results

For the total group, the MAP index scores were within the low normal range with the exception of the Nonverbal index, for which the mean was 52.9%. Total Score fell within the need for follow-up range, at 24.2% (see Table 3).

Examination of the MAP results by neurologic group classification indicated that the mean performance for those subjects classified NS fell within the need for follow-up range on the Foundations, Coordination, and Complex Tasks indices and on the Total Score. This mean performance compares unfavorably to the mean performance of the NN subjects, which fell within the normal range on all indices (see Table 3). Statistical analyses indicated significant differences between neurological groups on the Foundations and Nonverbal indices and for the Total Score. The groups appeared to differ considerably on the Coordination index as well, but the difference in mean scores failed to reach conventional significance levels ($p = .078$).

Percentages of NN and NS children falling in the 0% to 5% and 6% to 25% categories on the MAP can be found in Figures 1 and 2 respectively. As can be seen, more children classified NS than NN attained scores in the 0% to 5% range for all MAP indices except Nonverbal. No children fell into the 0% to 5% range for the Nonverbal index from either group. Furthermore, more children classified NS than NN attained scores in the 6% to 25% range on all MAP indices except Verbal and Complex Tasks. A high percentage of NN children attained scores in the 6% to 25% category on these. Of the 20 children classified NN at 18 months, 13 obtained MAP Total Scores of greater than 25% at 4 years of age, and 7 obtained MAP Total Scores of less than 25%, justifying concern over their performance. Of the 9 NS children at 18 months of age, 8 obtained MAP Total Scores of less than 25% at 4 years of age. Sensitivity of the 18-month neurologic examination was 0.65, while specificity was 0.89. Chi-square analysis indicates that actual outcome for 4-year-olds differs from expected outcome ($df = 1, n = 29$, $[Chi]^2 = 7.22, p < .05$); a difference attributable to the change in

| Table 3 |
| T-Test Results: MAP Percentile Scores |
| Performance Subscales | Total Group | NN ($n = 9$) | t |
| Foundations | 36.61 ± 4.3 $^a$ | 43.84 ± 3.3 $^b$ | 21.33 ± 4.2 | -2.70* |
| Coordination | 31.03 ± 4.5 $^b$ | 37.84 ± 5.8 $^b$ | 19.22 ± 5.2 | -1.83 |
| Verbal | 39.32 ± 6.0 $^a$ | 42.05 ± 7.6 $^c$ | 33.52 ± 10.3 | -0.65 |
| Nonverbal | 52.90 ± 6.6 $^b$ | 59.44 ± 6.7 $^b$ | 33.52 ± 8.9 | -2.25* |
| Complex Tasks | 54.28 ± 6.8 $^b$ | 41.33 ± 8.4 $^c$ | 23.89 ± 11.5 | -1.02 |
| Total Score | 24.21 ± 3.2 $^b$ | 31.34 ± 3.9 $^c$ | 11.33 ± 2.6 | -3.20** |

Note. Scores reflect percentiles ± standard error. NN = neurologically normal, NS = neurologically suspicious.

$^a n = 28$

$^b n = 29$

$^c n = 19$

$^d n = 20$

$p < .05$

**$p < .01$
status within the NN group. Gender differences were not apparent on any MAP index.

Discussion

These results indicate that among children born prematurely, 18-month neurologic status, as determined by a trained pediatric neurologist, is significantly predictive of sensorimotor deficits at 4 years. In this study the neurologic status factor detected significant differences between children in NN and NS categories for three MAP indices: Foundations, Nonverbal, and Total Score. There was a trend for neurologic status to also predict percentile rank on the Coordination index; however, this relationship was less robust in this sample. Although some investigators report a relationship between gestational age or birth weight or both and later developmental outcome (Mazer, Piper, & Ramsay, 1988), others have found that these characteristics do not add to the predictive value of neurodevelopmental status assigned at 1 year of age (Stewart et al., 1989). These infant characteristics were not significantly different between the two groups examined in this study and as such could not be predictive of differences in MAP performance. Thus, the results of the current study support those of Stewart et al. (1989) and indicate that an 18-month neurologic assessment is useful in the early identification of which children who are premature and of low-birth weight are at risk for later deficits in areas related to motor and cognitive performance, and warrant at least follow-along services.

Low percentile scores for the NS group on the MAP Foundations and Coordination indices point to continued concern in neumaturational, gross, fine, and oral motor areas. Poorer performance of preterm 4-year-olds relative to full-term 4-year-olds in balance, coordination, gross motor skill, and spontaneous movements has also been noted (Forslund & Bjerre, 1989). In addition, Stewart et al. (1989) demonstrated that 57% (8 of 14 children)
of a sample determined to have minor neurologic impairment at 12 to 18 months continued to show deficits at age 4, and an additional 18% (25 of 140 children) of children considered normal at 12 to 18 months demonstrated at least minor impairments at the age of 4. In this case the later, minor deficits included those of higher motor or cognitive functioning (according to the McCarthy Scale of Children’s Abilities), as well as sensory deficits. These findings suggest that 18-month suspicious neurologic status may be a prelude to continued subtle motoric deficits, at least in children born prematurely. Of concern and interest in this regard is the finding of Miller and Schouten (1988) that low scores at preschool ages on the MAP Coordination index were good predictors of Weschler Intelligence Scale for Children—Revised performance IQ at school age. This finding parallels the suggestion of other investigators (Drillien et al., 1980; Drillien, Pickering, & Drummond, 1988) that early signs of poor neurologic integrity, such as transient neurologic signs, may be an indicator of school-age deficits.

Mean scores attained on the Complex Task index by the NS children fell within the need for follow-up range, while those for the NN children fell within a normal range. This index is a measure of combined abilities and includes measures of motor planning and visual–motor skill. Performance on this index has been shown to be an excellent predictor of later verbal IQ performance (Miller & Schouten, 1988). Visual motor skills have been noted by other investigators to be deficient in children born prematurely (Jacob, Benedict, Roach, & Blackledge, 1984; Li, Sauve, & Creighton, 1990; Taub, Goldstein, & Caputo, 1977; Vohr & Coll, 1985). Forslund and Bjerre (1990) demonstrated that 4-year-old preterm children performed more poorly on eye–hand tasks than did 4-year-old full-term children. Although the difference between groups was small, it was considered important for learning. Furthermore, some investigators have indicated that visual–motor, or perceptual motor, performance during the preschool years is predictive of performance in school related areas during school-age (Klein et al., 1985; Sell, Gaines, Gluckman, & Williams, 1985). In fact, Largo and colleagues (Largo, Graf, Kundu, Hunziker, & Molinari, 1990) reported that a performance score obtained by combining eye–hand and performance subscales of the Griffiths Test of Mental Abilities (Griffiths, 1954) was one of the best predictors of school age mental functioning. This would suggest that the children performing poorly on this index of the MAP may be at high risk for the development of school related deficits.

The low Total Score percentile rank attained by the NS preterm group reflects the low scores obtained on the above described indices. However, it is worth noting that Miller, in a study that evaluated children during preschool age and again 4 years later, demonstrated that the Total Score effectively discriminated between children with and without school related problems at the ages of 6 to 10 years (Miller, 1988a). The problems noted by Miller included grade retention; below-average report card grades in language, reading, and math; and below-average teacher-rated performance in many academic and performance areas. Miller’s results indicated that children falling into the school problem group at 6 to 10 years of age had attained a percentile rank of 40 to 47 when first assessed on the MAP. Even the neurologically normal group in the current study attained a Total Score below this level; thus, they too may be at risk for the development of school-related problems.

The finding that a large percentage (35%) of children classified NN at 18 months obtained MAP Total Scores of less than 25% at 4 years of age is of some concern. Having demonstrated adequate neurologic performance at 18 months of age, this group of children would not have been referred for intervention, nor would they necessarily have received follow-up care before they reached school age. Nonetheless, this study indicates that before they reach school age, approximately one third of the children within this group will experience delays that are suggestive of future school-related difficulties. Thus, although the 18-month neurological examination will identify some children who will continue to be at risk for future deficits and delays, the sensitivity of this tool is not ideal.

That socioeconomic status in this study did not contribute to differences in performance on the MAP between NS and NN subjects at 4 years of age can be attributed to two factors. The first of these is that educational level was not different between these two groups, and thus any influence this might have had on outcome should be essentially the same for both groups. More important, parents of subjects in this study sample had at least a high school education, and some had training at the university or technical school level. An educational level is considered an adequate index of social status, these children were being reared in an environment likely to be conducive to adequate development.

The strength of these findings indicates that premature children exhibiting what may be construed as soft or transient neurologic signs during their first and second year continue to experience difficulties in many performance areas throughout their preschool years. Use of an 18-month neurological examination affords the opportunity to identify these children early and to provide appropriate services. These children are at risk for the development of school-related difficulties. This continued at-risk classification appears to occur in the absence of a poor social environment. Apparently, our subject group of preterm, NS children has not demonstrated the ability to overcome the insults of prematurity, even by 4 years of age. These children demonstrated characteristics at 18 months of age such as toe walking, other subtle muscle tone abnormalities, or slightly delayed speech and language or fine motor skills, which were of developmental concern and warranted follow along. At 4 years of age,
they again fell into a category suggestive of future problems with school related performance.

The desire of many early interventionists is to identify and follow as many children at risk for the development of later problems as possible. However, in the face of continuing health care funding cuts, it is critical to be selective in referring children for early intervention. The results of this study indicate that a neurologic screening carried out at approximately 18 months of age can aid in the identification of the premature children most likely to continue to experience at least subtle deficits related to motor and cognitive functions that may interfere with their ability to perform during their school-age years. A weakness of the 18-month neurologic examination is that it failed to identify problems in approximately 25% of this total sample. Thus, it may be beneficial to NN children to provide at least one additional screening before school age is reached. Early intervention with children experiencing deficits during preschool years can address these areas of concern and perhaps circumvent the onset of problems once these children face the stressors of school.

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References


