Season of Birth Is Related to Child Retention Rates, Achievement, and Rate of Diagnosis of Specific LD

Roy P. Martin, Patricia Foels, Greg Clanton, and Kathryn Moon

Abstract

A sizable literature has demonstrated that the achievement of children in early elementary school is related to their season of birth: Those born in summer typically perform less well than those born in the fall. A small literature indicates that more children diagnosed with specific learning disabilities (SLD) are born in the summer. We have begun to explore the possibility that the same processes may account for both outcomes. In order to better understand these processes, the standardized achievement levels and rates of diagnosis of SLD for children born during each season were studied in one geographical area of the State of Georgia served by 28 school districts. Standardized achievement scores in reading, mathematics, and science were reliably lower for those born in the summer. Furthermore, there was a strong relationship between season of birth and the rate at which children received a diagnosis of SLD. Summer-born children were diagnosed with SLD at a higher rate than their peers. Four hypotheses for both the lower performance in the general school population and the greater rate of SLD diagnosis among these children are discussed.

Two different bodies of evidence, one emanating from the psychopathology literature and one from the education achievement literature, have documented that children born in the period from late winter through summer have higher rates of cognitive and emotional disabilities and lower levels of achievement than their peers born in the fall and early winter. The specific timing of the peak period of disability varies with the psychopathological condition and the outcome under consideration. It is not known whether the factors contributing to seasonal patterns of pathological conditions and those contributing to seasonal variations in school achievement are related. It is also not known whether the same seasonal pattern of disability (i.e., for pathology and for achievement) is observed in the same population. The research described in this article makes an initial step toward addressing the latter question by considering seasonal variations in rates of diagnosis of learning disabilities (LD) and in achievement patterns among children in one large sample.

For about 5 decades, evidence has been accumulating that people with a wide range of neurological abnormalities show birth patterns that differ from those of the general population. This area of inquiry is typically referred to as *season-of-birth research,* although birth patterns may be studied at a weekly, monthly, or any other continuous rate. For example, more than 100 studies have been published demonstrating that individuals with schizophrenia are born in disproportionately high numbers in late winter or early spring (Barr, Mednick, & Munk-Jorgensen, 1990; Dalen, 1975; Takei, Sham, O'Callaghan, & Glover, 1995), most commonly in the northern hemisphere in February or March. Season-of-birth effects have been observed for mental retardation (Takei, Murray, et al., 1995), affective disorders (Machon, Mednick, & Huttunen, 1997), autism (Mouridsen, Nielsen, Rich, & Isager, 1994), and other neurologically related diseases (Castrogiovanni, Iapichino, Pacchierotti, & Pieraccini, 1998). The seasonal variation found in these studies has often been tied to upper respiratory disease (e.g., influenza) occurring in the late fall or winter.

The size of seasonal variation varies considerably from study to study. Mouridsen et al. (1994), studying Danish boys with infantile autism, found a maximum amplitude (difference between maximum and mean value in the sinusoidal oscillation) of 56% for March, a drop to 76% below mean levels in late May, and another maximum amplitude of 89% in late August. Machon et al. (1997) found a sixfold increase in affective disorders for persons born between February and May following an influenza epidemic compared to births during the same season in control years.

There is also a literature indicating that season of birth is related to rates of LD diagnosis. In a typical investigation, Erion (1986–1987) studied 67 children with specific learning disabilities (SLD) and 67 matched controls in first through sixth grades. Summer-born children were found to have higher rates of SLD. Similar results have been obtained by Badian (1984); Bookbinder (1967); DeMeis and Stearns (1992); Diamond (1983); Livingston, Balkozar, and Bracha (1993); Tarnowski, Anderson, Drabman, and Kelly (1990); Wallingford and Prout (2000); and Williams (1964). Most school districts have established a fall cutoff date for school entrance (e.g., September 1; Graue & DiPerna, 2000). Children whose birth dates fall in the months just prior to the cutoff date, therefore, are the youngest in their grade. Thus, the preceding findings have most often been attributed to differences in maturity as reflected by relative age in a given school grade. The magnitude of the effect of relative age on LD diagnoses varies considerably from study to study; however, most studies have found differences that have real practical implications. For example, Diamond (1983) found that about twice as many children with SLD were the youngest versus the oldest in their grade. Badian found that the rate of LD for summer-born boys was seven times the rate for fall- and winter-born boys.

A sizable body of research indicates that summer-born children are at an achievement disadvantage. For example, Thompson (1971) studied 1,136 boys at a private school in England. By the fourth year of school, autumn-born children (the oldest in their grade) tended to be in the top "stream," whereas summer-born children (the youngest in their grade) tended to be in the bottom stream. In a more recent study, Jones and Mandeville (1990) investigated the association between age at school entry and reading failure in Grades 1, 2, 3, and 6. The sample included all children tested in the State of South Carolina in 1987 in these grades (n = 190,292). Children were excluded if they had repeated or had been advanced a grade. Jones and Mandeville reported that the risk of failure was 13% to 58% higher for younger students (summer-born children) than for older students, with the highest level of risk associated with the lower grades. Similar results were found by Graue and DiPerna (2000) in a study of more than 8,000 students in Wisconsin. Their results indicated that nearly four times as many children were retained in first through third grade if they were summer versus fall born. Other studies that found a significant relationship between relatively poor academic achievement and age include those of Bergund (1967); Davis, Trimble, and Vincent (1980); DeMeis and Stearns (1992); France and Wiseman (1966); Jinks (1964); May and Welch (1986); and Pumfrey (1975).

Because summer-born children tend to perform more poorly particularly in the early grades, it might be expected that some cognizant parents would voluntarily not enter their summer-born children in school at the time of their initial eligibility but would hold them back in kindergarten one additional year. This process is sometimes referred to as *academic redshirting* (see Graue & DiPerna, 2000), a term borrowed from college athletics, where a young player's participation in sports is sometimes delayed one year to increase their competitive advantage. Zill, West, and Lomax (1997) estimated that about 9% of all kindergarten children are redshirted. In an extensive review and analysis of this practice, Graue and DiPerna (2000) revealed that summer-born children are 5 to 15 times more likely to be redshirted than their fall-born peers.

If summer-born children in general experience more school failure, they may be more likely than their peers to be referred for psychological assessment to determine if they qualify for special education programs. There are a few studies that indicate this is the case (e.g., DiPasquale, Moule, & Flewelling, 1980; Drabman, Tarnowski, & Kelly, 1987). For example, Drabman et al. (1987) studied 343 children referred to a hospital evaluation center. Results demonstrated that significantly more referred children were born in the summer, just prior to the cutoff date of September 1 for school entry.

Several explanations have been offered for the higher risk for academic failure or SLD among summer-born children. Perhaps the most straightforward hypothesis is that the youngest children in any grade are on average 9 to 12 months less neurologically mature than their peers. This hypothesis will be referred to as the *maturity hypothesis.* This neurological maturation could manifest itself in self-regulation of attention and emotion and other functions (e.g., memory; Siegler, 1991), particularly those subserved by the frontal lobes. Such functions include selective attention (Miller, 1991), some aspects of metacognition (Garner, 1991), and inhibitory control (Barkley, 1998). All of these functions are known to become more efficient with age and to be related to neurological maturation. The second hypothesis, which is related to the maturity hypothesis, will be referred to here as the *self-concept hypothesis.* It posits that the youngest children in a grade cohort may be at a social disadvantage to others in the given grade with regard to physical stature, physical strength and skills, social skills, and perhaps aspects of cognitive maturity. This hypothesis holds that the cumulative effect of these relative disadvantages is lowered self-esteem, resulting in lower task involvement in school and poorer achievement (Pellegrini, 1992). This hypothesis, which seems to be prominent in the ideas of some teaching professionals and parents, has been directly studied on several occasions but, to date, has not received empirical support (Bickel, Zigmond, & Strayhorn, 1991; Spitzer, Cupp, & Parke, 1995).

Two other hypotheses come primarily from the psychopathology literature. These hypotheses attribute some cognitive and emotional disabilities to prenatal insults to the development of the central nervous system (CNS). Both hypotheses are grounded in the notion that children born in the late spring and summer are more likely to have suffered perturbations of neurological development, because their mothers were in mid-gestation during a period of known risk for fetal development (i.e., winter months). These perturbations can be severe, resulting in diagnosable clinical conditions, or mild, resulting in subclinical performance decrements.

Two specific hypotheses are based on two different types of gestational risk. One risk that occurs during the winter is the increased rate of upper respiratory infections, particularly pneumonia and influenza. This hypothesis will be referred to here as the *gestational infection hypothesis.* Pneumonia and influenza typically reach a peak each year between the beginning of December and early March (Glezen & Couch, 1997). Such infections are hypothesized to be associated with a variety of malformations of the developing CNS of the fetus, with the strongest research evidence pointing to schizophrenia (Mednick, Machon, Huttunen, & Bonett, 1988; Takei, Murray, et al., 1995).

A second risk for fetal development that occurs during the winter months is the reduced availability of sufficient ultraviolet light of the type that produces vitamin D. Reduced ultraviolet light at moderate to high latitudes results in a sizable percentage of women of childbearing age having vitamin D deficiency during this period (Nesby-O'Dell et al., 2002). This hypothesis will be referred to as the *gestational vitamin D hypothesis.* There is a growing body of evidence that vitamin D plays a critical role in CNS development during the fetal period (Eyles, Brown, Mackay-Sim, McGrath, & Feron, 2003). The vitamin D hypothesis would predict latitude effects for CNS malformations. This hypothesis has not been studied for many CNS pathologies. However, McGrath (2001) has reported significant latitude effects for schizophrenia, with increased prevalence at higher latitudes.

If one or both of these gestational hypotheses are correct, they should result in a higher incidence of neurological soft or hard signs among children born in the late spring and summer. There is very little research that directly addresses this issue. However, in support of gestational hypotheses, Livingston et al. (1993) studied the neurological soft signs for 585 boys in a clinical population. They determined that neurological soft signs showed a sporadic peak across the birth years of their sample for late spring and early summer births, particularly in the month of June.

These four hypotheses do not exhaust the list of potential contributors to poor achievement and increased risk of pathology, including SLD, among summer-born children. However, they represent the major classes of influences that seem most likely given our current understanding. Unfortunately, at present, there are not enough data to eliminate one or more of these hypotheses from consideration. Furthermore, some of the available data are contradictory. The maturational and self-concept hypotheses were accorded some support by the strongest extant study of SLD diagnostic rates by season of birth (Diamond, 1983). Diamond studied children with an SLD diagnosis in the State of Hawaii during the 1979–1980 school year. At that time, the cutoff date for school entry was January 1. Month of birth was numbered from 1 to 12, beginning in January. The correlation between month of birth and the proportion of all students born each month who had been given an SLD diagnosis was .86 for girls and .94 for boys. Approximately 50% more children required special services if they were born in December (youngest in grade) rather than January (oldest in grade). The results of the Diamond study are important primarily because they demonstrated that even with a January 1 cutoff date for school entry, there was a strong relationship between number of SLD diagnoses and relative age in grade, with the youngest students receiving more SLD diagnoses. Although this finding provides support for the maturation or self-concept hypotheses, the gestational hypotheses cannot be eliminated. For example, it is unclear what the seasonal infection patterns were in Hawaii at the time of the study.

This summary of the SLD and achievement literatures related to season of birth indicates that most studies support the notion that children born in the summer have an increased probability of lower achievement levels, school failure, referral for psychological evaluation, and being diagnosed with SLD. However, the literature that relates season of birth to these outcomes is small and suffers from several design shortcomings that limit its impact. For example, in the fewer than 20 studies that have been published on season of birth and SLD, many researchers have studied small samples (e.g., Erion, 1986–1987), have not included girls (e.g., Badian, 1984), or have failed to control for typical birth patterns in the population (e.g., Livingston et al., 1993). Furthermore, in no study was it demonstrated that a lower general achievement score in a given school population had a similar season-of-birth pattern as the rate of LD diagnosis in that school population. Finally, the results are somewhat contradictory.

Given the shortcomings of this literature, we decided to determine for one geographical location if the retention rates, achievement levels, and rates of SLD diagnosis followed the same general pattern relative to season of birth. If each of these outcomes does follow a similar season-of-birth pattern, then we are one step closer to hypothesizing that the same causative factors that contribute to some forms of SLD also account for some forms of lower achievement in the general school population.

Method

Participants

Participants in this investigation were 2,768 (2,007 boys, 72.5%; 761 girls, 27.5%) public school students receiving special education services in Georgia under a diagnosis of specific learning disabilities. The State of Georgia uses a discrepancy model for the diagnosis of SLD; that is, students are eligible for SLD services if they exhibit a severe discrepancy between actual achievement and expected performance. The actual achievement is determined by two or more achievement measures tapping oral expression, listening comprehension, written expression, basic reading skills, reading comprehension, mathematics calculation, or mathematical reasoning. Expected performance is determined by measures of general cognitive ability. Severe discrepancy is defined as a 20-point discrepancy or larger at initial placement when both measures have a mean of 100 and a standard deviation of 15.

These children resided in the 28 northeast Georgia counties and attended county school districts. Participants included only those children in the region who were described by their parents as European American, excluding those described as Hispanic American, Asian American, African American, Native American, or mixed. These five groups were eliminated because they represented a small proportion of the SLD sample (18.2%), and the research design required very large sample sizes. The participants were also limited to children born from September 1, 1984, through August 31, 1990. These children were typically in the fourth through ninth grades at the time of data collection. Too few children were diagnosed and placed in the first 3 years of elementary school to constitute an appropriate sample for statistical analysis. Furthermore, after the ninth grade, some children began to drop out of school, so the representativeness of children in these grades was suspect.

The participants were selected from 33 county school systems. These school systems were chosen based on two criteria: First, they represented the contiguous counties in the northeast portion of the State of Georgia. Second, Atlanta counties and those immediately contiguous to these counties were excluded (Fulton, Gwinnett, Dekalb, Rockdale, Clayton, Fayette, Douglas, Cobb, Cherokee, and Forsyth counties). The research reported here was part of a larger study in which environmental conditions during gestation were of interest. Because the excluded counties had experienced unusually high population growth due to immigration during the past 12 years, it was less likely that the children in the school districts were born in the same county. Of the 33 county school systems that met the aforementioned criterion, 28 provided data. The counties that did not provide data were scattered throughout the region. Also, rates of free-lunch participation (an index of the socioeconomic status of the students in the county school system) were known for each of the 33 counties. A comparison of the percentage of children receiving a free lunch between the 5 counties that did not provide data and the 28 counties that provided data demonstrated no significant difference. Thus, there appeared to be no ascertainment bias.

Standardized achievement scores were available for 9,674 children in the fifth grades of the 28 school districts from which children with SLD were selected. Of the total sample, 6,292 were European Americans who did not self-identify as Hispanic (referred to hereafter as White) and were at the appropriate age for fifth grade. That is, children who had been retained and were now in the fifth grade or who had been advanced and were now in the fifth grade were excluded from the main achievement analysis. However, 1,103 students who had been retained and were now in the fifth grade were studied in a separate analysis.

Data were obtained from the 2000 assessment using the *Iowa Test of Basic Skills* (ITBS). Fifth-grade achievement was thought to be a defensible measure of general achievement patterns in these schools, and representative of those grades from which the children with SLD were drawn, because the data were obtained in late elementary school at about the midpoint of primary and secondary education.

Procedure

Children with an SLD Diagnosis. During the 2000–2001 school year, the director of special education in each school district was contacted by the principal investigator by phone and subsequently by mail. Each school district was asked to supply a listing of students receiving special education services in their county. The names of the students, teachers, and schools attended were not provided, to protect the privacy of the students, parents, and school personnel. The listing of students included information on gender, race, birth date, and primary diagnosis. This report involves only those children for whom a diagnosis of SLD was assigned. If special education services were provided based on more than one diagnosis, only the primary diagnosis was considered.

Standardized Achievement Data. Data were obtained from the Spring 2000 standardized achievement testing in the State of Georgia by the Test Scoring and Reporting Service (TSARS) unit of the University of Georgia. This unit is contracted to score and produce reports for the school districts of Georgia based on several statewide assessments. Permission was obtained for the use of these data from appropriate representatives of the State Department of Education and TSARS, with the understanding that all student identification information was eliminated from the data set prior to its being given to our research team. Acquisition of achievement data and listings of students with SLD was approved by the Institutional Review Board policies of the University of Georgia.

Results

ITBS Performance by Month of Birth

The traditional method of determining if season of birth or relative age within grade is associated with standardized achievement scores is to calculate the mean scores for each month (or group of months) of birth and determine if significant differences between months occur. This approach, however, overlooks the fact that during the first few years of schooling, a number of children are advanced or retained based typically on one of two related procedures. One procedure occurs when children are failed or advanced one grade based on achievement and the recommendations of educational personnel. A second common procedure occurs when a child is academically redshirted or held back in grade based on parental concern that the child is not ready physically, socially, or academically to participate fully in instruction at the next level. If the children who are advanced, failed, or redshirted are not randomly distributed throughout the age range, the achievement scores obtained from those who remain in the grade that matches their age may not reflect the achievement patterns of their age–grade cohort. Thus, in the current study, we sought to determine the season-of-birth distribution of children who were overage (due to failure or redshirting) and to take this into account when associating season of birth with achievement.

Frequencies of overage students were obtained by referencing birth date information for the fifth-grade ITBS assessment. The total enrollment for the sixth-grade class, the initial class placement of the vast majority of the retained students, was estimated to be 1.2% lower than the current fifth-grade enrollment based on data available from the Georgia State Department of Education. This number and the birth rates of White children per month in Georgia were used to estimate the frequency of the total enrollment who were born during each 3-month period. These estimates were adjusted for the unequal number of days per month to render the comparisons more interpretable. These data are presented in Table 1. Of all children in the sixth-grade birth cohort, 15.03% were retained or redshirted. The number of fifth-grade children who were overage was dramatically higher if they were born during June, July, or August than if they were born during any other 3-month period; 44% of all retained or redshirted children were born during this period. Furthermore, of the estimated enrollment in the sixth grade who had birth dates during June, July, or August, 25.4% were either retained or redshirted. This birth pattern across 3-month intervals was not significantly different for White boys and girls who were retained in this sample. However, a larger percentage of the children retained were boys (64.1%).

When the numbers of overage children born in June, July, and August and those born in all other months of the year were compared to expected values based on estimated enrollment for typical children of their birth year, the resulting chi-square (goodness-of-fit test) was significant, $\chi^2(1, N = 1{,}103) = 186.5$, $p < .0001$. These data provide strong support for the idea that in the school districts studied, school retention and redshirting is disproportionately applied to summer-born children.

The next issue to be addressed was the extent to which season of birth was related to achievement. For selected achievement scores (Vocabulary, Reading Comprehension, Mathematics with Computation, Science, and Comprehensive Achievement Score), mean scores by month of birth were determined. These scores were standardized for the State of Georgia and reported in z-score form ($M = 0.0$; $SD = 1.0$). Mean scores for the counties studied in this sample were all above the mean because minority children and children in the southern part of the state, who tended to have lower achievement scores, were not included in the analysis. Scores were then submitted to a 4-level (month-of-birth groups) one-way analysis of variance. Initial tests for gender differences revealed some small gender differences in mean achievement level, but no gender by season of birth interaction, so gender was dropped from the analysis. This procedure was done twice—once with retained students included in the data set and once with these children excluded. In both cases, the small group of accelerated students was eliminated. Data are presented in Table 2.

This table reveals that achievement scores were significantly related to season of birth both when retained children were included and when they were excluded. Examination of effect sizes (maximum difference between birth periods/pooled standard deviation) revealed that the differences were small when retained students were excluded, ranging from .12 to .17 of a standard deviation. When retained students were included, the effect sizes ranged from .20 to .29, almost twice as large for most measures. This finding reveals that the achievement level of

TABLE 1
Number of Overage Children in the Fifth-Grade Cohort by Month of Birth

Month of birth	Frequency	% retained[a]	% born during period[b]	% enrolled[c]
September–November	161	14.6	8.84	2.19
December–February	206	18.7	11.52	2.81
March–May	250	22.7	13.76	3.41
June–August	486	44.0	25.44	6.62
Total	1,103	100.0		15.03

[a]Retention frequencies have been adjusted for the different number of days per month, to a constant 30 days per month. [b]Percentage of estimated White enrollment of the sixth-grade class who were born during each 3-month period and were retained or redshirted, adjusted for number of days per month. [c]Percentage of the total estimated White enrollment of the sixth-grade classes in the 28 school districts sampled.

TABLE 2
Achievement of Fifth-Grade Students on Selected ITBS Scales by Month of Birth

ITBS scale	Sep–Nov		Dec–Feb		Mar–May		Jun–Aug		
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*ES*[d]
Excluding retained students									
Vocabulary	.29	.87	.28	.89	.22	.85	.20	.83	.12
Reading[a]	.30	.99	.27	.93	.20	.94	.18	.91	.13
Mathematics[b]	.25	.95	.19	.92	.15	.92	.14	.89	.14
Science	.36	.95	.31	.93	.27	.92	.20	.93	.17
Total[c]	.30	.96	.24	.93	.20	.92	.17	.90	.14
Including retained students									
Vocabulary	.29	.87	.23	.92	.13	.90	.10	.89	.21
Reading	.30	.99	.20	.96	.09	.98	.05	.96	.26
Mathematics	.26	.95	.13	.95	.03	.96	.00	.95	.28
Science	.37	.95	.26	.95	.17	.95	.11	.97	.26
Total	.30	.96	.18	.96	.08	.97	.03	.95	.28

Note. Means and standard deviations are in *z*-score form, standardized for the children of Georgia. For all analyses of fifth graders with retained children excluded, chi-square comparing summer-born to those born in all other months, $p < .001$; for all analyses with retained children included, $p < .0001$. Sample size for all White fifth graders excluding retained children was 6,292 for the Mathematics scale, and slightly lower (< 2.2%) for other scales; for all White fifth graders including retained, sample size was 7,395 for the Mathematics scale, slightly lower (< 2.1%) for other scales. ITBS = *Iowa Test of Basic Skills* (Hoover et al., 1999).
[a]Reading Comprehension score. [b]Mathematics with calculation score. [c]Comprehensive Achievement score. [d]Effect size was calculated by subtracting achievement scores of children born June, July, and August from scores in the period of highest achievement (typically September, October, November) and dividing the result by the pooled standard deviation.

those retained was, on average, lower than that of their peers.

For all of the achievement scores listed in Table 2, the one-way analysis of variance across four birth periods was significant, $p < .001$, whether retained children were included in the analysis or not. Post hoc analyses using the Scheffé test indicated that for all achievement areas analyzed, children born in June, July, and August had significantly lower achievement, $p < .05$, than children born in September, October, and November. For the analysis in which retained students were included, children born in May through August had significantly lower achievement scores than those born in September through November. These results indicate that summer-born children not only have higher rates of retention but also have lower rates of achievement, whether retained students are included in the analysis or not. The differences are particularly noteworthy if retained students are included.

SLD Analyses

Table 3 presents the number of children in Northeast Georgia who served as participants in the SLD analysis. The sample was limited to White children, as children in other ethnic groups constituted a small part of the population in this region of the country (25.6% in all minority groups; 18.8% African American) and constituted a small proportion of all students diagnosed with SLD (18.2%).

The sex ratio of SLD students was 2.64 (boys) to 1 (girls), a sex ratio that is similar to that found by many researchers in public school populations. For example, Diamond (1983) found a 2.59-to-1 ratio. A prevalence rate was calculated by comparing the enrollment in the 28 county schools at the end of the 2000–2001 school year to the total number of SLD students in these schools. All SLD students in these districts were included in this calculation, not just the students in fourth through ninth grade listed in Table 3. The mean prevalence rate of SLD per school district was 4.90% of all enrolled European American students. For girls, the prevalence rate was 2.70%, and for boys, 7.29%. These rates are similar to generally accepted prevalence rates (American Psychiatric Association, 1994).

Given that children born in June, July, and August are retained at higher rates than their peers, are more frequently redshirted by their parents due to various forms of perceived immaturity, and achieve lower even if not retained, we hypothesized that children born in June, July, and August would also be diagnosed with SLD at a higher rate than children born during other periods of the year. To test this hypothesis, the number of children with SLD who were born during each month of the 6 years under study (born from September 1984 through August 1990) was calculated. Based on the total number of children with SLD born during each 12-month period (September through August), the expected number of children born per month was calculated by multiplying the total number of children with SLD for a given year by the known percentage of White children born in Georgia per month. It was assumed that children coming into the school district who were not born in Georgia had the same percentage of births per month as those born in Georgia. In order to facilitate interpretation, these data were adjusted for the number of days per month, with all months standardized to a 30-day period. Because the number of children with SLD (particularly girls) born each month was small, the numbers of actual births and numbers of expected births were aggregated into four 3-month birth periods.

For descriptive purposes, the expected and observed frequencies for each 3-month birth period were compared. Because the relative difference between expected and observed frequencies per birth period were found to be nearly identical for boys and girls, gender-specific data were aggregated. Figure 1 presents the expected and observed frequencies of children diagnosed with SLD. It can be seen that for the children born in September through November and December through February, fewer children were given this diagnosis than would be expected from population data (–10.4% and –6.5%, respectively). For the birth periods March through May and June through August, more children than expected were given an SLD diagnosis (4.03% and 12.5%, respectively). To directly test the hypothesis that children born June through August would have a higher rate of SLD, expected and observed frequencies of births of children with SLD were compared using a goodness-of-fit chi-square test, with births in September through May compared to births in June through August. The results were significant, $\chi^2(1, N = 2{,}768) = 14.78$, $p < .001$. This result strongly supports the hypothesis that children born in June through August were receiving services for SLD at a higher rate than children born in the remaining months of the year.

An alternative view of the association between month of birth and probability of an SLD diagnosis can be obtained by correlating month of birth (ordered by relative school age) with the frequencies with which children with an SLD diagnosis are born during each month. This is the procedure used by Diamond (1983). For purposes of comparison to Diamond's findings, birth month was coded 1 through 12, with September being assigned 1 and August assigned 12. This index is scaled with higher numbers indicating younger students. Diamond had created her index in this manner, and this procedure aided the comparison between her data and the current data. The results are presented in Table 4. Table 4 reveals that from Grade 4 through Grade 9, there was a moderate to high correlation (.48 to .78) between relative age and percentage of students receiving a diagnosis of SLD by birth month. The highest correlation was at Grade 8. The data also reveal that the relation between relative age at school entry and SLD diagnosis is generally higher for boys than for girls.

Discussion

This study has demonstrated a statistically and practically significant association between season of birth and schooling outcomes. In particular, children born from June through August were more frequently retained or redshirted, performed lower on standardized achievement tests, and were more frequently diagnosed with SLD. The associations between season of birth and these outcomes were similar for boys and girls, although more boys were retained or redshirted and more boys were given an SLD diagnosis.

The overall effect on the children born June through August was enormous. Approximately 25% of these children were retained, and an additional 5% to 10% were placed in classes for children with SLD. This latter percentage is difficult to estimate, as it depends on the number of children with SLD who were retained or redshirted, and these data were not available for this sample. These data indicate that approximately one third of the children born in June through August are removed from the typical learning experience of their age-mates, with the proportions being higher for boys. From another perspective, these children are using the resources of the school district at a much higher rate than their peers. It is noteworthy that even when children in special education or children who were retained are excluded from the analysis, achievement levels of summer-born children are lower than those of their peers.

The pattern of results obtained in this study raises many important theoretical issues. With regard to the diagnosis of SLD, the most critical issue is to determine if the same factors that contribute to retention, redshirting, and poorer academic achievement in the general population of summer-born students also contribute to placement in special education under a diagnosis of SLD. This research was not designed to address this question directly. However, retentions (due to failure or redshirting), achievement patterns, and rates of diagnosis for SLD had the same pattern of association with period of birth. Specifically, chil-

TABLE 3
Number of European American Children Born Each Year in a Northeast Georgia Sample Who Received Special Education Services for SLD

Year of birth	Grade level	Boys	Girls	Total
1984–1985	9	293	105	398
1985–1986	8	325	123	448
1986–1987	7	339	130	469
1987–1988	6	349	146	495
1988–1989	5	354	146	500
1989–1990	4	347	111	458
Total		2,007	761	2,768

Note. SLD = specific learning disabilities.

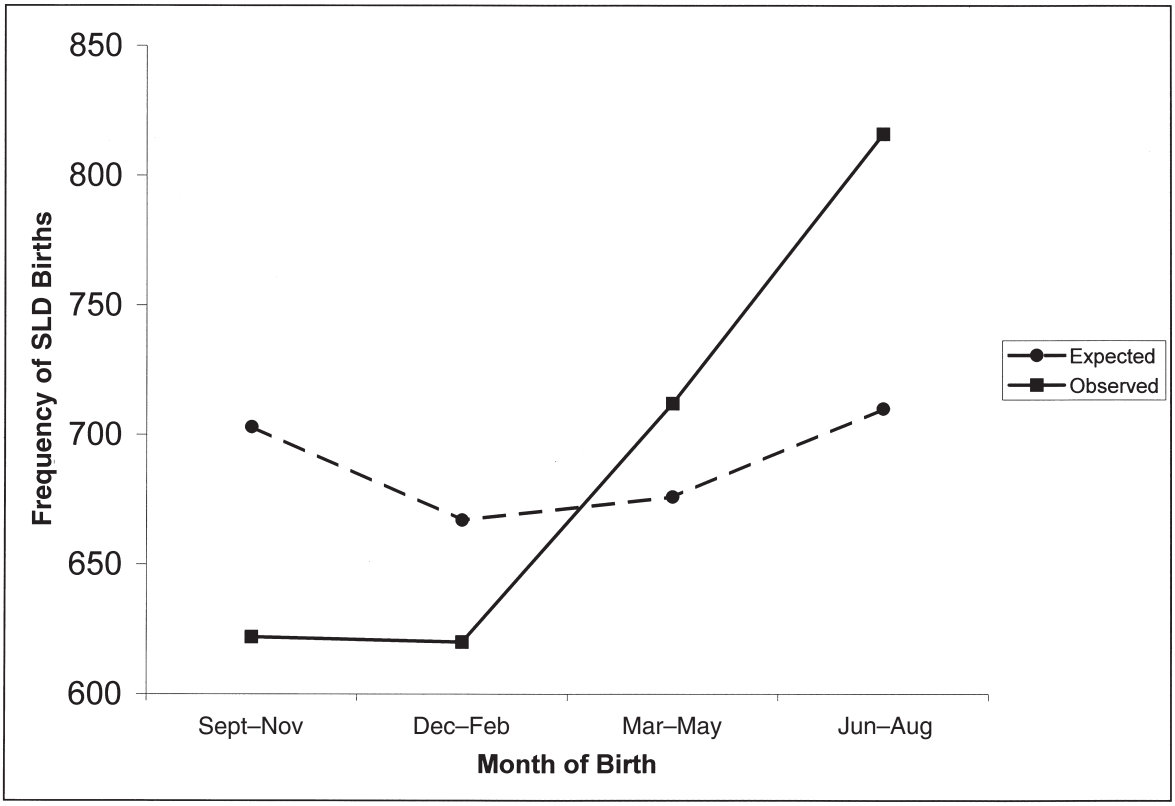

FIGURE 1. Comparison of observed and expected frequencies of children with specific learning disabilities (SLD) by period of birth.

TABLE 4
Correlations Between Age in Grade and Proportions of Births Per Month of Students with SLD by Grade Level

		Boys		Girls	
Grade	Total	Current	Diamond[a]	Current	Diamond[a]
4	.62	.59	.69	.33	.54
5	.53	.46	.85	.33	.39
6	.57	.49	.85	.51	.79
7	.55	.47	.62	.30	.61
8	.78	.46	.68	.59	.40
9	.48	.58	.82	.39	.19

Note. SLD = specific learning disabilities. All correlations for the current study were significant, $p < .01$.
[a]Data extracted from Diamond (1983) for purposes of comparison.

dren born in September through November were retained less, achieved at a higher level, and were diagnosed with SLD at a lower rate than their peers. Children born in June through August had the opposite outcome. This outcome at least raises the possibility that similar processes are at work.

A number of explanations of this pattern of results seem possible. The findings of this study are perhaps most easily interpreted as supportive of the *maturity hypothesis.* This hypothesis asserts that less neurologically mature children perform lower in school than their older peers and, thus, have a greater chance of receiving a diagnosis of SLD. There is clear evidence that the brain continues to mature during the elementary school years, with some areas not reaching full maturity until late adolescence. The region that matures most slowly is the frontal cortex (Bradshaw, 2001). This portion of the brain is involved in maintaining attentional control, controlling impulses that might interfere with learning, engaging in planful behavior, forming concepts, making abstractions from perceptual experience, and manipulating ideas (Pennington & Ozonoff, 1996). Thus, the most biologically immature children would be expected to have difficulty in learning to work independently, directing their behavior when a goal is remote or abstract, being able to search memory systematically, focusing or sustaining attention, and inhibiting responses when appropriate (Bradshaw, 2001). All these functions affect such behaviors as learning to read and to perform in an academic setting. Thus, it is possible that the neurological immaturity of children relative to their peers would account for the youngest children being more likely to have SLD.

This interpretation is strengthened by two findings. It is known that the maturation of some executive functions progresses more slowly in boys than in girls. For example, the ability to control gross motor activity is strongly related to chronological age and neurological maturity (Eaton, 1994). It is also known that the inhibition of this activity is related to the functioning of the frontal cortex and is slower to develop in boys than in girls (Castellanos, 1999). Thus, the maturity hypothesis would predict that the relationship between age in grade and rates of SLD diagnosis would be stronger for boys than for girls, and this result was indeed obtained. Furthermore, the finding that the Diamond (1983) study (with a cutoff date of January 1 for school entry) and the current study (with a cutoff date of September 1) obtained similar results provides strong support for the maturity hypothesis.

The results could also be considered supportive of the *self-concept hypothesis.* This hypothesis posits that children who are less mature in a broad sense (physically, emotionally, and cognitively) have more difficult social interactions with teachers and peers in school and, as a result, have a higher probability of internalizing feelings of social inadequacy. These feelings and social experiences may, in turn, result in less attention and planful behavior, resulting in lower achievement and higher retention rates. The factors subsumed under this hypothesis could exacerbate performance difficulties, resulting in higher teacher referral rates, which in turn could result in an enhanced probability of SLD diagnosis. This may be a particularly strong effect for boys, with the emphasis placed on physical strength, size, and athletic ability in elementary and middle school that is strongly associated with chronological age. This could result in lower social integration in school activities. Research by Carroll (1992) seems to support this hypothesis. He found that summer-born children (youngest in their grade) had the lowest school attendance, and fall-born children (oldest in their grade) had the highest school attendance rates. School attendance may, in part, be a function of liking school and feeling socially comfortable in the school environment.

The *gestational hypotheses* cannot be eliminated from consideration by our results. It is possible that winter-related perturbations of the CNS that occur in early or mid-gestation could produce both clinical and subclinical problems in learning for children born from June through August. Such gestational factors could help explain the wide range of outcomes observed in this study. The primary piece of data from this study that appears to argue against gestational factors is that the youngest children in both Georgia and Hawaii had the highest rates of SLD, although the youngest children in Georgia were born from June through August, whereas the youngest in the Hawaii study (Diamond, 1983) were born from October through December. It remains possible that these two apparently different results could be explained by the same phenomenon. With regard to infection, the peak period of upper respiratory infections in the Hawaiian population in the 1980s is unknown to our research team. It is possible, however, that infections in the continental United States could be carried to Hawaii by travelers. For example, upper respiratory disease is most common in the continental United States in the winter. Infections of this type have been found to relate to neurodevelopmental illnesses such as mental retardation (Takei, Murray, et al., 1995) and schizophrenia (Mednick et al., 1988). If continental travelers to Hawaii carry these diseases to the islands in the late winter and spring, this could result in the same early- to mid-gestation infection rate of pregnant women and subsequent high rates of neurodevelopmental problems of children in the fall. This pattern is currently speculative, but it illustrates how the same mechanism might produce different effects in different environments.

Finally, it is possible that two or more of these factors may have the same temporal sequence but have different outcomes. It is possible that the summer upsurge in achievement problems is related to maturity, whereas the increase in SLD diagnoses is related to other factors.

The findings of this study raise many practical issues. If summer-born children are at increased risk of CNS perturbations, and if the youngest children in a class are at risk for CNS immaturity, a September or October cutoff date for school entry is a particularly bad policy. Such early-fall cutoff dates increase the risk of school failure by confounding these risks. Our findings raise other questions. How are teacher and parent beliefs about the association between maturity, attention, and behavioral control influencing referrals for psychological diagnosis and, in turn, affecting rates of diagnosis of SLD? What are the potential legal vulnerabilities of a school district in which a large correlation is found between retention rates, SLD rates, and age in grade? Could a parent object to retention or to an SLD diagnosis on the grounds that the child has simply not been offered the appropriate curriculum for his or her developmental level? As learning problems occur more frequently for the youngest in an age-graded classroom, and as there are large individual differences in neurological maturity, does this argue for elementary schooling to be presented in an ungraded format? Do the results of this study argue for continuous progress programs as opposed to annual evaluations of progress and annual placement adjustments? It is noteworthy that the arguments laid out in this article would not be supportive of later school entry (e.g., at age 7). The maturity, self-concept, and gestational hypotheses would all suggest that a *single* entry point at a later time would not solve the problem. However, the data and the hypotheses would be supportive of *double entry points* (perhaps one in August and one in January), with the later entry point being preferable for less mature children. However, consideration of the complex implications of such a system is beyond the scope of this article.

The theoretical and practical implications of this study must be interpreted in light of its limitations. The study was carried out in one region of the country, and the extent to which the results can be generalized to other regions is unknown. Regional differences in diagnostic practices, retention policies, or subcultural beliefs about the benefits of redshirting could alter the results. Furthermore, diagnostic practices in schools are subject to many influences (referral patterns) that do not occur in some research settings. Thus, the extent to which these results would be different if season of birth and rates of SLD diagnosis were studied in a rigorous laboratory setting is unknown. The results are also limited to southern White children in schools in which minority populations constituted a small proportion of the enrollment. Moreover, an effort was made to study a population that was stable, so that there was a higher probability that the children were born in the region in which they attended school. Although census data indicate that the counties studied have been relatively stable, the migration patterns of the individual families or children (e.g., city or state of birth) were not available.

The current results, and the body of evidence reviewed, strongly support the continued study of these phenomena. Further study of season-of-birth effects on other disabilities should be particularly helpful. If, for example, summer-born children were found to have higher rates of diagnosis of speech–language disabilities, but fall-born children showed higher rates of mental retardation, progress would have been made in eliminating some alternative explanations for these phenomena. Another type of research that would be particularly helpful is to replicate the current study in school districts in which the cutoff date for school entry is in late fall or at the beginning of the calendar year. This type of study will be critical in evaluating the maturity-related hypotheses.

ABOUT THE AUTHORS

Roy P. Martin, *PhD, is a professor in the Educational Psychology Department of the University of Georgia. His current interests include pre- and perinatal factors contributing to exceptionality and child temperament.* ***Patricia Foels,*** *MA,* ***Greg Clanton,*** *MEd, and* ***Kathryn Moon,*** *MEd, are graduate students in the Department of Educational Psychology, School Psychology Program, of the University of Georgia. Address: Roy P. Martin, 325 Aderhold Hall, Department of Educational Psychology, University of Georgia, Athens, GA 30602.*

REFERENCES

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Badian, N. A. (1984). Reading disability in an epidemiological context: Incidence and environmental correlates. *Journal of Learning Disabilities, 17,* 129–136.

Barkley, R. A. (1998). *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment.* New York: Guilford Press.

Barr, C. D., Mednick, S. A., & Munk-Jorgensen, P. (1990). Exposure to influenza epidemics during gestation and adult schizophrenia: A 40 year study. *Archives of General Psychiatry, 47,* 869–874.

Bergund, G. (1967). A note on intelligence and season of birth. *British Journal of Psychology, 58,* 147–151.

Bickel, D., Zigmond, N., & Strayhorn, J. (1991). Chronological age at entrance to first grade: Effects on elementary school success. *Early Childhood Research Quarterly, 6,* 105–117.

Bookbinder, G. E. (1967). The preponderance of summer-born children in ESN classes: Which is responsible, age or length of infant schooling? *Educational Research, 9,* 213–218.

Bradshaw, J. L. (2001). *Developmental disorders of the frontostriatal system.* Philadelphia: Taylor and Francis.

Carroll, H. C. (1992). Season of birth and school attendance. *British Journal of Educational Psychology, 62,* 391–396.

Castellanos, F. X. (1999). The psychobiology of attention-deficit/hyperactivity disorder. In H. C. Quay & A. E. Hogan (Eds.), *Handbook of disruptive behavior disorders* (pp. 179–198). New York: Kluwer Academic.

Castrogiovanni, P., Iapichino, S., Pacchierotti, C., & Pieraccini, F. (1998). Season of birth in psychiatry: A review. *Neuropsychobiology, 37,* 175–181.

Dalen, P. (1975). *Season of birth: A study of schizophrenia and other mental disorders.* Amsterdam: Elsevier.

Davis, B. G., Trimble, C. S., & Vincent, D. R. (1980). Does age of entrance affect school achievement? *The Elementary School Journal, 80,* 133–143.

DeMeis, J. L., & Stearns, E. S. (1992). Relationship of school entrance age to academic and social performance. *The Journal of Educational Research, 86,* 20–27.

Diamond, G. H. (1983). The birthdate effect—A maturational effect? *Journal of Learning Disabilities, 16,* 161–164.

DiPasquale, G. W., Moule, A. D., & Flewelling, R. W. (1980). The birthdate effect. *Journal of Learning Disabilities, 13,* 234–238.

Drabman, R. S., Tarnowski, K. J., & Kelly, P. A. (1987). Are younger classroom children disproportionately referred for childhood and behavior problems? *Journal of Consulting and Clinical Psychology, 55,* 907–909.

Eaton, W. O. (1994). Temperament, development and the five-factor model: Lessons from activity level. In C. F. Halverson, G. A. Kohnstamm, & R. P. Martin (Eds.), *The developing structure of temperament and personality from infancy to adulthood* (pp. 173–188). Hillsdale, NJ: Erlbaum.

Erion, R. J. (1986–1987). Chronological age, immaturity, and the identification of learning disabilities. *Educational Research Quarterly, 11,* 2–7.

Eyles, D., Brown, J., Mackay-Sim, A., McGrath, J., & Feron, F. (2003). Vitamin D3 and brain development. *Neuroscience.*

France, N., & Wiseman, S. (1966). An educational guidance program for the primary school. *British Journal of Educational Psychology, 36,* 210–226.

Garner, R. (1991). Children's use of strategies in reading. In D. F. Bjorklund (Ed.), *Children's strategies: Contemporary views of cognitive development* (pp. 245–268). Hillsdale, NJ: Erlbaum.

Glezen, W. P., & Couch, R. B. (1997). Influenza viruses. In A. S. Evans & R. A. Kaslow (Eds.), *Viral infections of humans: Epidemiology and control* (4th ed.; pp. 473–506). New York: Plenum.

Graue, M. E., & DiPerna, J. (2000). Redshirting and early retention: Who gets the 'gift of time' and what are its outcomes? *American Educational Research Journal, 37,* 509–534.

Hoover, H. D., Hieronymus, D. A., Frisbie, D. A., Dunbar, S. B., Oberley, K. R., Bray, G. B., et al. (1999). *Iowa test of basic skills: Interpretive guide.* Itasca, IL: Riverside Publishing.

Jinks, P. C. (1964). An investigation into the effect of date of birth on subsequent school performance. *Educational Research, 11*(1), 220–225.

Jones, M. M., & Mandeville, G. K. (1990). The effect of age at school entry on reading achievement scores among South Carolina students. *Remedial and Special Education, 11*(1), 56–62.

Livingston, R., Balkozar, B. S., & Bracha, H. S. (1993). Season of birth and neurodevelopmental disorders: Summer birth is associated with dyslexia. *Journal of the American Academy of Child and Adolescent Psychiatry, 32,* 612–616.

Machon, R. A., Mednick, S. A., & Huttunen, M. O. (1997). Adult major affective disorder after prenatal exposure to an influenza epidemic. *Archives of General Psychiatry, 54,* 322–328.

May, D. C., & Welch, E. (1986). Screening for school readiness: The influence of birthdate and sex. *Psychology in the Schools, 23,* 100–105.

McGrath, J. (2001). Schizophrenia linked to mother's lack of sunlight. *New Scientist, 21,* 38.

Mednick, S. A., Machon, R. A., Huttunen, M. O., & Bonett, D. (1988). Adult schizophrenia following prenatal exposure to an influenza epidemic. *Archives of General Psychiatry, 45,* 413–421.

Miller, P. H. (1991). The development of strategies in selective attention. In D. F. Bjorklund (Ed.), *Children's strategies: Contemporary views of cognitive development* (pp. 157–184). Hillsdale, NJ: Erlbaum.

Mouridsen, S. E., Nielsen, S., Rich, B., & Isager, T. (1994). Season of birth in infantile autism and other types of childhood psychoses. *Child Psychiatry and Human Development, 25,* 31–45.

Nesby-O'Dell, S., Scanlon, K. S., Cogswell, M. E., Gillespie, C., Hollis, B. W., Looker, A. C., et al. (2002). Hypovitaminosis D prevalence and determinants among African American and White women of reproductive age: Third National Health and Nutrition Examination Survey, 1989–1994. *American Journal of Clinical Nutrition, 76,* 187–192.

Pellegrini, A. (1992). Kindergarten children's social-cognitive status as a predictor of first-grade success. *Early Childhood Research Quarterly, 7,* 565–577.

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37,* 51–87.

Pumfrey, P. D. (1975). Season of birth, special educational treatment and selection procedures within an LEA. *Research in Education, 14,* 55–76.

Siegler, R. S. (1991). *Children's thinking.* Englewood Cliffs, NJ: Prentice Hall.

Spitzer, S., Cupp, R., & Parke, R. D. (1995). School entrance age, social acceptance, and self-perceptions in kindergarten and first grade. *Early Childhood Research Quarterly, 10,* 433–450.

Takei, N., Murray, G., O'Callaghan, E., Sham, P. C., Glover, G., & Murray, R. M. (1995). Prenatal exposure to influenza epidemics and risk of mental retardation. *European Archives of Psychiatry and Clinical Neuroscience, 245,* 255–259.

Takei, N., Sham, P. C., O'Callaghan, E., & Glover, G. (1995). Early risk factor in schizophrenia: Place and season of birth. *European Psychiatry, 10,* 165–170.

Tarnowski, K. H., Anderson, D. F., Drabman, R. S., & Kelly, P. A. (1990). Disproportionate referrals for child academic/behavior problems. *Journal of Consulting and Clinical Psychology, 58,* 240–243.

Thompson, D. (1971). Season of birth and success in the secondary school. *Educational Research, 14,* 56–60.

Wallingford, E. L., & Prout, H. T. (2000). The relationship of season of birth and special education referral. *Psychology in the Schools, 37,* 379–387.

Williams, P. (1964). Date of birth, backwardness, and educational organization. *British Journal of Educational Psychology, 34,* 247–255.

Zill, N., West, J., & Lomax, J. (1997). *The elementary school performance and adjustment of children who enter kindergarten late or repeat kindergarten: Findings from national surveys.* Washington, DC: National Center for Educational Statistics.