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A Family Aggregation Study: The Influence of Family History and Other Risk Factors on Language Development

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Abstract

Substantial evidence continues to accrue for familial transmission of specific language impairment (SLI). The incidence in families with a history of SLI is estimated at approximately 20%–40%, whereas in the general population the estimated incidence is about 4%. Typical aggregation studies compare data on the speech and language status of parents and siblings of individuals with SLI (the probands) to similar data from family members of control individuals with no speech or language disorder history. In the present study, family aggregation of SLI was examined for a unique sample of children who were ascertained before 6 months of age and thus did not have SLI, but were born into a family with a positive history of SLI (FH+). No study to date has examined the pattern of affectance in families of children ascertained at such a young age. In addition, the ratio of boys to girls born into such families was investigated, as previous studies have suggested alterations in the expected gender ratios. Consistent with prior research, SLI was found to aggregate in families; the average affectance rate in FH+ families was 32%, with significantly more boys (41%) reported as having SLI than girls (16%). A comparison of FH+ and control families (FH−) on sociodemographic factors and medical history revealed differences in the overall rate of autoimmune diseases; FH+ families reported a significantly higher incidence (35%) compared to FH− families (9%). Finally, the 3-year language abilities of a subset of 32 children from FH+ families were compared with those of 60 children from FH− families. Children from FH+ families scored significantly lower on standardized measures of language and were more likely to fall below the 16th percentile (28%) than children from FH− families (7%). These results provide converging evidence that children from FH + families are indeed at greater risk of developing language delay compared to children from control families.

Keywords

specific language impairment; language; aggregation; learning impairments

Studies have shown that specific language impairment (SLI)[1] aggregates in families (Benasich & Spitz, 1999;Bishop & Edmundson, 1986;Bishop, North, & Donlan, 1995;Lahey & Edwards, 1995;Neils & Aram, 1986;Rice, Haney, & Wexler, 1998;Spitz, Tallal, Flax, & Benasich, 1997;Tallal et al., 2001;Tallal, Ross, & Curtiss, 1989a;Tomblin, 1989;Tomblin & Buckwalter, 1998). Although recent statistics estimate the incidence of SLI in the general population of 6-year-olds at approximately 4% (Tomblin, 1996), the incidence in families with a history of

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[1]Studies reviewed in this article use either *specific language impairment (SLI)*, *language impaired (LI)*, or *developmental language disorder* to describe their population. We use the term *SLI*, as this most closely describes the proband population. The affected individuals in this study are considered to have SLI because both inclusionary and exclusionary criteria for SLI were used to recruit families with a history of language impairment (FH+).

impairment is estimated at approximately 20%–40% (Lahey & Edwards, 1995;Neils & Aram, 1986;Tallal et al., 1989a;Tomblin, 1989). This study describes the family aggregation and demographic characteristics of a unique group of children who were born into families with a history of language impairment (LI) and who were followed prospectively from 6 months to 3 years of age. To our knowledge, this is the first study to examine patterns of familial affectance for children ascertained at such a young age. Further, as previous studies have suggested alterations in the expected gender ratios of children born into such families with a history of SLI (Tallal, Ross, & Curtiss, 1989b), the present study examines whether such an alteration exists in this sample. Given the lack of sampling bias as to the gender of the newborn within the recruited families, this was an ideal population in which to address this question.

Family aggregation studies obtain information about the extent to which language-based learning impairments run in families. Data on the speech and language status of parents and siblings of individuals with SLI are compared to similar data from family members of control individuals with no speech or language disorder history. Most often, such studies use a retrospective approach to collect family history information. Thus, after identifying a proband (the affected individual), parents or individual family members are asked to complete questionnaires on the language development and school performance of family members. The results of these studies have suggested a robust effect of familiality; approximately 40% to 60% of families with a pro-band with SLI report impairments in at least one other immediate family member (Bishop & Edmundson, 1986; Lahey & Edwards, 1995). In a review of 18 family aggregation studies of LI, Stromswold (1998) found that the incidence of LI in families with a history of LI ranged from 24% (Bishop & Edmundson, 1986) to 78% (van der Lely & Stollwerck, 1996; this study also included individuals with reading problems), with an average rate of 46%. In comparison, the incidence of LI in control families ranged from 3% (Bishop & Edmundson, 1986) to 46% (Tallal et al., 1989a), with a mean rate of 18%.

Studies using direct testing methods have reported similar rates of impairment (Felsenfeld, McGue, & Broen, 1995; Gopnik & Crago, 1991; Plante, Shankman, & Clark, 1996; Tallal et al., 2001; Tomblin, 1996; Tomblin & Buckwalter, 1994). For example, Tomblin and Buckwalter (1994) reported that of the 26 families tested, 42% of individuals diagnosed with LI (proband) had at least one other family member with a speech or language problem. Tallal et al. (2001) also used direct testing to assess the rate of LI in proband and control families and found that 52% of the proband children (ages 4–14 years) had affected first-degree family members compared to 15.4% of control children. Finally, using a prospective longitudinal sample, Spitz et al. (1997) demonstrated that children born into families with a history of SLI have significantly lower scores as toddlers (16–24 months) on both receptive and expressive language measures when compared to age-matched peers. In this small sample of children (10 family history positive [FH+] and 10 control), half of the FH+ children scored 1.5 *SD*s below the age-appropriate mean, compared to none of the control children (Spitz et al., 1997). These results support the notion that children from FH+ families are at higher risk for developing delays in language acquisition.

Heritability of Language-Based Learning Disorders: Twin Studies

In addition to family aggregation studies, behavioral-genetics research has also shown that SLI has a highly heritable component (for review, see Leonard 1998; for review of methodology and genetics of language, see Brzustowicz, 1996). These studies report that monozy-gotic twins show a higher concordance rate for language-based learning disorders compared to dizygotic twins (Bishop et al., 1995; Lewis & Thompson, 1992; Tomblin & Buckwalter, 1998). For example, Bishop et al. (1995) found higher concordance rates for monozygotic male twins (70%) on articulation and language disorders compared to dizygotic twins (46%). Similarly, Tomblin and Buckwalter (1998) reported higher rates of concordance for poor language

achievement in monozygotic twins (96%) than in dizygotic twins (69%). Finally, Dale et al. (1998) showed that the more impaired the child, the greater the genetic contribution.

Factors Associated With LI

Although family history of SLI has been shown to be the most robust predictor of language outcomes in children, research has shown that gender, prenatal and perinatal factors, and family history of autoimmune diseases are also associated with SLI (Benasich, 2002; Bishop, 1997; Stein, 2001; Tallal et al., 1989b; Tomblin, 1989, 1996, 1997).

Gender—One of the most consistent risk factors for developmental speech and langu0age problems is gender. Many studies report higher rates of SLI in males compared to females; the ratio of affected males to females is approximately 2:1 to 3:1 (Bishop, 1997; Flax et al., in press; Lahey & Edwards, 1995; Lewis, 1992; Rice et al., 1998; Shriberg, Tomblin, & McSweeny, 1999; Tallal et al., 1989b; Tomblin, 1989, 1996, 1997; Tomblin & Buckwalter, 1994; Tomblin, Hardy, & Hein, 1991). For example, in a nonclinical sample, Tomblin (1996) found that approximately twice as many males were impaired compared to females. In a more recent study, Flax et al. (in press) assessed the family aggregation and comorbidity of LI and reading impairments (RI) by directly testing the immediate and extended family members of SLI probands. The authors report that the incidence of LI and RI for males was significantly higher than for females (LI = 45% in males vs. 18% in females; RI = 37% vs. 19%, respectively). Interestingly, Tallal et al. (1989b) found that the male-to-female ratio reported in SLI populations was altered only in families in which more than one individual was affected. Moreover, an affected mother seemed to have a disproportionate influence on the gender ratio skew, such that affected mothers had three times as many male children as female, and nearly five times as many sons with SLI as daughters. We were particularly interested in examining these hypotheses in our sample, as the issue of ascertainment bias by gender (e.g., that boys with SLI are more likely to be diagnosed than girls with SLI; Shaywitz, Shaywitz, Fletcher, & Escobar, 1990) was not a concern in this group of normal, healthy, preverbal infants who were recruited because they had a sibling or parent diagnosed as having SLI.

Autoimmune Disease—Recent research seems to indicate that SLI may co-occur with certain types of health-related problems. Associations among autoimmune disorders, left-handedness, and learning disability were originally proposed by Geschwind and Behan (1982, 1984) and since then have been vigorously investigated (see Bryden, McManus, & Bulman-Flemming, 1994; Gilger et al., 1998). Specifically, a number of studies have reported a higher incidence of language-related disorders in individuals with autoimmune disorders (Geschwind & Behan, 1982, 1984; Gilger, Pennington, Green, Smith, & Smith, 1992; Wood & Cooper, 1992). Other studies have suggested a higher incidence of autoimmune disorders in individuals with language disorders (Hugdahl, Synnevag, & Satz, 1990; Pennington, Smith, Kimberling, Green, & Haith, 1987). Such relations, however, have not been consistently found across studies and remain highly controversial (e.g., Biederman et al., 1995; Bryden et al., 1994; Flannery & Liederman, 1995). Theories have been put forth by Stein (2001) and Gilger et al. (1998) to attempt to explain these reported relations, by suggesting a maternal effect on the fetus that modifies the offspring's immunological profile, thus invoking the possibility of a neural–immune interaction. Interestingly, a recent study that suggests that children born into families with a history of autoimmune disease may be at higher risk for delayed language development supports this interpretation (Benasich, 2002). As the Benasich research was a pilot study that examined a small subset of infants ($n = 11$), we were interested in investigating this phenomenon in a larger, more heterogeneous sample.

Goals of the Current Study

The purpose of the present study was to describe the aggregation of SLI in families using a prospective early onset model. Further, in order to detect potential mediators of later language abilities, FH+ and control families (FH−) were compared on factors shown to be associated with language ability (e.g., demographic indicators, gender, prenatal risk, and family medical history). We were also very interested in exploring the possibility of altered gender ratios within families with one or more SLI individuals (cf. Tallal et al., 1989b), as a majority of our FH+ families included two or more children. Language outcomes for a subset of children who had reached their 3-year assessments were also examined to provide support for the observation that the language abilities of children from FH+ families are lower as a group when compared to children from control families. Further, nonverbal reasoning abilities were also assessed in order to ascertain whether FH+ and FH−control children differed only in the language domain. Finally, children from both FH+ and FH− families whose performance on a standardized language assessment was below the 16th percentile (low-language group) were compared to children whose scores were above the 16th percentile cutoff (normal-language group) on factors such as gender, demographic indicators, and family history of asthma and autoimmune disorders to determine the contribution of such factors to 36-month language ability.

The data presented in this article are a synthesis across several ongoing longitudinal studies, and the uniqueness of this report arises from the methodology and criteria used for the recruitment of FH+ children. Children in these studies were ascertained early in the first year of life (by 6 months of age) and were born into families with a history of SLI (FH+). The criteria used for selecting FH+ families were considered to be conservative and more rigorous than those used in previous aggregation studies; probands (i.e., a sibling or parent of the study child) were required to provide confirmatory external reports of an LI and normal general cognitive abilities. As yet, we do not know what proportion of the infants recruited into these studies will eventually be diagnosed as having SLI and what proportion will develop normal language. However, the opportunity is presented to compare those children whose language acquisition, at 3 years of age, is below average compared to those whose skills are within the average range, irrespective of family history, for both family aggregation and gender distribution. We can also compare gender ratios within the family, as the sex of the proband was not considered in ascertaining this sample.

Method

Participants

One hundred thirty-six infants from 112 families were included in these analyses. Families were recruited from New York City, Newark, and surrounding New Jersey suburbs and were assigned to one of two groups on the basis of parental report of family history of SLI: the FH + or the FH− group. The FH+ group consisted of 42 infants from 37 families in which at least one nuclear family member (the proband) was diagnosed with SLI. The FH− group consisted of 94 infants (75 families) with no reported family history of SLI or of dyslexia, attention deficit disorder, pervasive developmental disorder, or autism.

The “pooled” sample used in this study comprised children who were participating in several longitudinal studies examining the association between early processing of auditory information and language development. Although children received different experimental protocols across studies, the standardized language assessments administered were consistent across the different study protocols. Thus, we only examined the familial aggregation issues described above. The results of the main hypotheses regarding changing linguistic performance across time and concerning rapid auditory processing as a predictor of subsequent outcome are presented elsewhere in more detailed formats (Benasich & Spitz, 1999; Benasich & Tallal,

1998, 2002). Although prematurity and/or low birth weight (LBW) are considered risk factors for SLI, in this sample prematurity and/or LBW were exclusionary criteria. Moreover, comparison of the FH+ and FH− groups included here on birth weight and gestational age revealed no group differences (see Table 1). Hence, birth weight and gestational age are not included in any of the analyses presented here.

Selection Criteria for FH+ Group

Infants from FH+ families were recruited from local (New York City, Newark, and New Jersey suburbs) obstetric and pediatric practices. In order to be classified as FH+, families provided clinical reports of expressive and receptive language scores and a general cognitive score for at least one affected child or parent (the proband). If the language scores for the proband were at least 1 *SD* below the age-appropriate mean and if performance on standardized tests of general cognitive ability was within the normal range, the family was recruited into the FH+ group. A parent was considered to be a proband if he or she met the inclusionary and exclusionary criteria for SLI; clinical or school evaluations of school-aged language and cognitive skills were provided and the diagnosis was reviewed and verified by speech-language pathologists at our laboratory. Families in which the proband had a diagnosis of pervasive developmental disorder or autism were not included in these analyses. Families with children who received a primary diagnosis of attention deficit disorder or families with children who had LIs because of hearing loss, neurological disorders, or oral motor impairment were not included in this sample. Control families reported no known history of LIs or learning impairments in the nuclear or the extended family (grandparents, aunts, and uncles). Seventy-six percent (28 of 37) of families identified a child as the proband, and significantly more male children (70%) were identified as SLI probands than were female children (30%), $\chi^2 = 7.00$, $p < .05$. For 24% (9 of 37) of the families, a parent(s) was identified as the proband; four mothers, three fathers, and (in two families) both parents were identified as probands.

Measures

Demographic Data—At study induction, parents were asked to complete a 24-item questionnaire. From this questionnaire, basic demographic information (parental age, marital status, education, and income) and details of the enrolled infant's pre- and postnatal development (e.g., prenatal complications, gestational age, birth weight, otitis media, hospitalizations, and developmental complications) were obtained. The mother was the primary informant in most cases; however, both parents were asked to report on family medical history (allergies, asthma, and autoimmune diseases such as juvenile onset diabetes, lupus erythematosis, multiple sclerosis, rheumatoid arthritis, Crohn's disease, hypothyroidism, etc.), and to provide information on language and learning problems in the nuclear (mother, father, and siblings) and extended (grandparents, aunts, uncles, and cousins) family. Questionnaire items used to query family history of language and learning disabilities and family medical history are presented in the Appendix.

Language and Cognitive Assessments—At 3 years of age, children were administered a battery of standardized language and cognitive assessments. The Preschool Language Scale–3 (PLS-3; Zimmerman, Steiner, & Pond, 1992) yields standardized scores for both receptive and expressive language. The mean for the receptive, expressive, and total scores for the PLS-3 is 100 points, with a standard deviation of 15 points. Two subtests of the Clinical Evaluation of Language Fundamentals–Preschool (CELF-P; Wiig, Secord, & Semel, 1992), Sentence Structure and Word Structure, were also used to assess language skills. Sentence Structure evaluates comprehension of sentence formation rules, whereas Word Structure evaluates the child's use of morphological rules and forms. Both subtest standard scores have a mean of 10 points and a standard deviation of 3 points. A speech-language pathologist administered both of these assessments in the laboratory and was not aware of the child's family history.

The Stanford-Binet Intelligence Scale, 4th edition (SB-4; Thorndike, Hagen, & Sattler, 1986) was also administered; two subscales—verbal reasoning–vocabulary and verbal reasoning–comprehension—were also used to index children's language ability. The quantitative reasoning–quantitative subscale was used to index nonver-bal reasoning abilities. The SB-4 subscale scores have a mean of 50 points and a standard deviation of 8 points. This assessment was administered by trained psychologists who were blind to the group status of the child.

Results

Family Aggregation of SLI

The Rate of SLI in Families—On average, FH+ families consisted of 4.55 nuclear family members (including the "identified proband") and reported SLI in 1.65 individuals (32.26%). Twenty families reported that the proband was the only impaired member (20 of 37; 54%) in the nuclear and extended family. Eleven families reported 2 or more nuclear family members with SLI (11 of 37; 30%), and 6 families reported 2 or more members in the nuclear and the extended family with SLI (6 of 37; 16%). The average number of affected members in the multiply affected families was 2.2 individuals. Importantly, there were no differences in the size of the nuclear family for those reporting 1 affected individual ($M = 4.40$) and those reporting multiply affected individuals ($M = 4.76$), $F(1, 36) = 1.433$, $p > .20$.

Affected Family Members—Of the 56 affected family members in this study, there were significantly more impaired males ($n = 39$) than impaired females ($n = 17$), $\chi^2(1) = 8.64$, $p < .005$. Families reported that sons were most likely to be impaired (23 of 56; 41%), followed by fathers (10 of 56; 18%), daughters (9 of 56; 16%), mothers (6 of 56; 11%), and then extended family members (uncles = 2 of 56, 4%; grandfathers = 2 of 56, 4%; cousins = 4 of 56, 7%). In the following analyses, rates of affectance are presented only for nuclear family members.

Specific Patterns of Affectance Within Families—Although only 1 child in a family was identified as the proband (17 of 28, 61%), a number of families reported SLI in more than 1 child. Eight families reported SLI in 2 sons (28.6%), 1 reported SLI in 2 daughters (3.6%), 1 reported SLI in a son and a daughter (3.6%), and 1 reported SLI in 2 daughters and a son (3.6%). There were no differences in the family size for male and female probands (mean family size for males = 5.00, females = 4.62), $F(1, 28) = 1.29$, $p > .50$.

Of the 20 families within which a male child was identified as the proband, 10 families reported impairments in 2 or more children (50%). In contrast, of the 8 families with an SLI daughter, only 1 family reported impairments in 2 children (12.5%). A chi-square analysis revealed a significant association between the gender of the impaired proband and the number of affected children in the family, $\chi^2(1) = 3.68$, $p < .05$. Additionally, SLI males were significantly more likely than SLI females to have a male sibling with impairments, $\chi^2(1) = 5.31$, $p < .05$. Eight of the 11 siblings identified as impaired were boys (73%). There were no differences between SLI males and females with regard to rate of impairment for female siblings, $\chi^2(1) = 2.53$, $p = .29$.

In families where the parent was identified as the proband, most (7 of 9, 78%) reported only 1 parent with a history of SLI, and in these families only 1 child (1 of 7, 14%) had a language delay. In the 2 families where both parents were affected, only 1 child (1 of 2, 50%) was reported as affected. There were no associations between the gender of the impaired parent and the number of impaired children in the family, $\chi^2(1) = 0.97$, $p > .50$. However, because of the very small number of affected parents and children, any interpretations about the relationship between affected parents and offspring is speculative at best.

Gender Distribution in FH+ Families: Given reports of alterations in the male:female birth ratio in SLI families (Tallal et al., 1989b), we were interested in the relation between the gender of the SLI proband and the average number of male and female children in the family (irrespective of impairment). On average, male pro-bands had significantly more brothers (M = 1.45 brothers vs. 0.5 sisters), whereas female probands had significantly more sisters (M = 1.25 sisters vs. 0.25 brothers), $\chi^2(1) = 12.8$, $p < .05$.

The relationship between parent affectance and the gender distribution of children within the family (irrespective of impairment) was also assessed. The results revealed that although SLI fathers had approximately equal numbers of daughters (1.18) and sons (1.27), SLI mothers had significantly more daughters than would be expected (1.83 vs. 0.37), $t(5) = 3.953$, $p < .05$.

Comparison of FH+ and FH− Families on Demographic Variables and Family Medical History—In order to identify potential mediators of later language abilities, FH+ and FH− families were compared on demographic variables (e.g., parental age, education, socioeconomic status, number and gender of children) and family history of medical disorders (e.g., autoimmune diseases and asthma). Table 1 presents the mean and standard deviations of the family characteristic variables by group.

Family Characteristics: At induction into the studies, FH+ families had older parents and more children than FH− families (see Table 1). These findings are an artifact of ascertainment and are compatible with the demands of the recruitment criteria: The majority of the FH+ families had at least 1 child with a diagnosis of SLI and a young infant. In contrast, control families could have only 1 child and be recruited into the study. Thus, as a group, FH+ parents tended to be older than FH− parents. There were no group differences in the level of maternal and paternal education: On average, both fathers and mothers had completed more than 3 years of education beyond high school. According to the Hollingshead Four Factor index of socioeconomic status (Hollingshead, 1975), families from both groups were classified as “major business people” or “professionals” (e.g., doctors, lawyers, business owners, etc.) and there were no between-group differences in socioeconomic status.

Family Medical History: The following analyses assessed whether there was a greater likelihood that FH+ families would report a familial history of asthma and autoimmune diseases (e.g., juvenile onset diabetes, lupus erythematosis, multiple sclerosis, rheumatoid arthritis, Crohn’s disease, hypothyroidism, etc.) than would FH− families (see Table 2). Overall, FH+ families were more likely to report a family history of autoimmune diseases, but not asthma, as compared to control families. Specifically, 35% of families at risk for SLI reported a history of autoimmune disorders as compared to 9% of control families, $\chi^2(1) = 11.22$, $p < .001$.

Language Abilities at 3 Years: Patterns Across and Within Groups

The following analyses examined data, across within-laboratory study groups, from the subset of children who had completed their 3-year follow-up language assessments (N = 92). First, differences between FH+ (n = 32) and FH− (n = 60) groups on language outcomes at 3 years of age were explored. The language measures used were the Expressive and Receptive scales of the PLS-3, the Sentence Structure and Word Structure subtests of the CELF-P, and the Verbal Vocabulary and Verbal Comprehension subscales of the SB-4. The quantitative reasoning subscale of the SB-4 was used to index nonverbal reasoning (see Table 3).

Difference Between FH+ and FH−Groups on 3-Year Language Measures—Results of a 2 (family history group) ×3 (language scales of the PLS) analysis of variance (ANOVA) show that although the mean scores for the FH+ and FH−groups fell within the normal range, the FH+ group earned significantly lower scores than the FH− group on both the Expressive

and Receptive subscales and on the total language scale of the PLS-3 (see Table 3). A similar 2 × 2 ANOVA with the CELF-P revealed that children from the FH+ group performed less proficiently on the Word Structure subtest but not on the Sentence Structure subtest. Finally, a 2 × 3 ANOVA was conducted using the Verbal Reasoning–Vocabulary, Verbal Reasoning–Comprehension, and Quantitative Reasoning–Quantitative subscales of the SB-4. Overall, FH + children's performance on the Comprehension and Vocabulary subscales was significantly lower than that of FH− children. The data revealed no group differences in performance on the nonverbal quantitative reasoning subscale (see Table 3).

Although we did not have speech sample data for children at age 3 years, parents completed the MacArthur Language Inventory (Fenson et al., 1993) at 24 months and from it we coded the mean sentence length (MSL) and mean sentence complexity. Comparison of FH+ and FH − children on both of these measures at 2 years showed that FH+ children had significantly shorter MSL (M = 3.23 vs. 4.85) and used less complex sentence structures (M = 5.23 vs. 10.37) than FH− children (see Table 4).

The Association Between Language Ability and Family History of SLI—For the following analyses, children were classified into either a low-language group or a normal-language group on the basis of their performance, at age 3 years, on the Expressive and Receptive language scales of the PLS-3. Children who scored below the 16th percentile, irrespective of family history, were classified as having low language scores. The two groups were well separated by PLS-3 scores, with the means for the low-language group (expressive = 78.53, SD = 10.39; receptive = 80.07, SD = 14.81; total = 77.15, SD = 13.17) being significantly lower ($p < .001$) than the means for the normal-language group (expressive = 107.21, SD = 14.75; receptive = 112.40, SD = 14.68; total = 110.94, SD = 14.97). Thirteen of the 92 children (14.5%) had language scores below the 16th percentile on the PLS-3. Nine of these children were from FH+ families. A chi-square analysis showed that children from FH + families were more likely to be in the low-language group than children from FH families (28% vs. 7%), $\chi^2(1) = 7.720$, $p < .005$.

The means and standard deviations for the low- and normal-language groups for the SB-4 and CELF-P are presented in Table 5. An ANOVA revealed that children placed in the low-language group, on the basis of their PLS-3 scores, scored lower at age 3 than did children in the normal-language group on all other standardized measures of language, but not on the nonverbal quantitative-reasoning measure. Moreover, at 2 years of age, the low-language group had significantly shorter MSL (M = 2.25 vs. 4.71) and less complex sentence structures (M = 17.50 vs. 53.68), as coded on the MacArthur Language Inventory, than did children in the normal-language group (see Table 6).

Gender Distribution of Low- and Normal-Language Children by Family History of SLI—The 36-month subsample comprised 44 males and 48 females. There were no differences in the gender distribution between the low-language and normal-language groups, $\chi^2(1) = 0.28$. However, boys from the FH+ group were more likely to perform below the 16th percentile than were boys from control families, $\chi^2(1) = 5.45$, $p < .05$ (see Table 7).

Reported Rates of Autoimmune Diseases or Asthma as a Function of Group Status—Chi-square analyses were conducted to examine the distribution of children from low-language and normal-language groups on family medical history variables (autoimmune diseases and asthma). Results revealed a significant association between language-group status at 3 years of age and reports of autoimmune disease within the family. Forty-six percent of children from the low-language group also had a family history of autoimmune diseases, whereas only 20% of children from the normal-language group had such a history, $\chi^2(1) =$

4.55, $p < .03$ (see Table 7). No differences were seen in the rates at which familial history of asthma were reported for this subgroup of children.

Discussion

The purpose of these analyses was to describe family aggregation of SLI in a unique population of children who were born into FH+ families and ascertained early in the first year of life. Issues regarding possible alteration of gender ratios within SLI families were examined (Tallal et al., 1989b), as were questions regarding higher incidence of SLI being diagnosed in boys compared to girls (Shaywitz et al., 1990). This was an ideal group within which to address such issues, as our sample comprised a group of normal, healthy, preverbal infants who were recruited because they had a sibling or parent diagnosed as having SLI. Moreover, sampling bias could not have affected the gender of the newborn within the recruited families. We also explored whether differences in the expression of SLI in FH+ and FH− families were associated with family environment (demographic and parental factors) and/or family history of medical disorders (autoimmune disorders and asthma). Then, using a prospective early-onset research design, the language skills of a subset of these children at age 3 were examined and potential predictors of poor language abilities, such as family history of SLI, family medical history, socioeconomic status, and parental education, were explored. Although this was primarily a descriptive study, some very interesting patterns emerged.

Consistent with previous research (Bishop, 1997), we found that SLI did, in fact, aggregate in families and that there were no differences between FH+ and FH− families on basic environmental risk factors such as socioeconomic status or level of parental education. With regard to family medical history, both FH+ and FH− families reported first-degree family members with asthma and autoimmune disease. However, the overall rate of autoimmune diseases in FH+ families was significantly higher than that reported by FH−families.

This study also demonstrated that at 3 years of age, children from our FH+ families were much more likely than FH− control children to have lower scores on measures of language comprehension and expression. As a group, children from FH+ families earned lower scores on the Expressive and Receptive scales of the PLS-3, the Word Structure subtest of the CELF-P, and the Verbal Comprehension and Vocabulary scores of the SB-4. This appears to be a specifically targeted effect, as there were no differences between the two groups on quantitative (nonverbal) reasoning. Thus, our findings suggest that the differences observed in our sample at this age are limited to the language domain and cannot be attributed to a more generalized deficit. In the following section, we discuss these findings in more detail.

Family Aggregation of SLI and Specific Patterns of Impairment

The affectance rate of 32% reported in this study is comparable to rates reported in earlier aggregation studies (Beitchman, Hood, & Inglis, 1992; Bishop & Edmundson, 1986; Lahey & Edwards, 1995; Rice et al., 1998; Tallal et al., 1989a, 2001; Tomblin, 1989). Consistent with previous reports, we found that nearly half of the families enrolled in the study reported only one SLI-affected member. These findings concur with studies that have shown that a large proportion of SLI families report a single affected individual (i.e., isolates; Tallal et al., 1989a; Tallal, Townsend, Curtiss, & Wulfeck, 1991; Tomblin, 1989). For example, Tallal et al. (1991) reported that 35% of their LI probands did not have immediate or extended family members with any form of language-based learning disorders. In an earlier study with the same participants, a bimodal distribution of the number of relatives affected was reported such that most families had impairment rates of 0 or greater than 0.32; either only the proband was affected or several non-proband family members were affected (Tallal et al., 1989a). A similar distribution existed in our population. The average FH+ family consisted of 3.6 members, excluding the proband, and in approximately half of the families where only one affected

member (the proband) was identified, the average impairment rate was 0 (excluding the proband). In the other half of the families, the affectance rate was 48%, suggesting that at least two other family members, excluding the proband, were also affected (see Tomblin, 1989, for discussion of simplex and multiplex families).

Gender Distribution in SLI Families

Consistent with previous research, FH+ families reported more males with SLI, and most of the affected individuals were sons (Bishop, 1997; Flax et al., in press; Lahey & Edwards, 1995; Lewis, 1992; Rice et al., 1998; Shriberg et al., 1999; Tallal et al., 1989b, 2001; Tomblin, 1989, 1996, 1997; Tomblin & Buckwalter, 1994; Tomblin et al., 1991). Further, the 3-year-olds' language scores also show that boys born into FH+ families were more likely to score below the 16th percentile than were boys born into FH− families. Recent epidemiologically based studies have not found a differential distribution of SLI based on gender (Rice et al., 1998; Shaywitz et al., 1990). One reason often given for the differences observed between clinically referred and epidemiological samples is ascertainment bias, that is, the contention that boys, rather than girls, are much more likely to be referred for clinical services for related behavioral and attentional issues (Shaywitz et al., 1990). This may indeed be the case; however, we identified the children in this sample as normal, healthy infants. Although ascertainment biases might explain the gender differences (a preponderance of males) observed for the SLI probands, the finding that more male siblings of the proband had poorer early language attainment cannot be explained by ascertainment bias. Moreover, although it is possible that parental bias could inflate the reporting of language delay in brothers of the SLI proband, it is unlikely that the higher rate of language delay we identified by direct testing in the FH+ boys at 3 years of age can be explained in this way. Thirty-five percent of FH+ boys were classified as language delayed, compared to 20% of the girls. The gender distribution of impaired children in FH− families was more proportionate (8% for boys vs. 6% for girls). Further, recent research using direct testing methods reports an even greater sex ratio difference between boys and girls (Tallal et al., 2001). Taken together, these findings suggest that when SLI aggregates in families, there is a higher rate of impairment in males born into FH+ than there is for females or males born into FH− families.

Finally, the issue of male-to-female gender alternation in FH+ was also explored. Previous studies (Tallal et al., 1989b) have reported that mothers with LI had 3 times as many sons as daughters and nearly 5 times as many sons with SLI as daughters with SLI. The current study was not able to replicate these findings, and in fact found that affected mothers were more likely to have daughters. One potential explanation of these findings may be the small sample size of affected mothers ($n = 4$). In general, issues of affected parents and alterations in the gender ratios of offspring could not be adequately addressed given the very few affected parents in this group. Thus, examination of an epidemiological sample with sufficient power to examine subsets is necessary to further explore this issue.

Association Between Family History of SLI, Demographic Factors, and Family Medical History

There were no differences between FH+ and FH−families on demographic variables such as socioeconomic status or parental education. Moreover, at the 3-year longitudinal assessment point, lower language skills were not related to any demographic variables. These results support previous retrospective studies that show that the occurrence of SLI in families is unlikely to be a consequence of differences in environmental factors (Bishop, 1997).

Interestingly, however, we were able to show that, overall, families with a history of SLI were significantly more likely to report autoimmune diseases than were FH− families. We also found that children whose language abilities were below the 16th percentile at age 3 were more likely

to have a family history of autoimmune problems if they had a family history of SLI. Although these findings must be interpreted with caution because of their preliminary nature, it is possible that autoimmune disorders covary with a particular phenotype of SLI and that there may be a core deficit that leads to the expression of both disorders. One interesting theory suggests that maternal prenatal mechanisms and/or possible neural–immune interactions might directly, or perhaps through genetic mediation, affect the developing fetus (Gilger et al., 1998; Stein, 2001). Our findings provide some support for that theory; however, as in the case of patterns of parental–offspring affectance, a large well-controlled epidemiological study is needed to address the questions raised (see Benasich, 2002, for a discussion of these issues).

Conclusions

The study reported here shows that SLI does in fact aggregate in families and that the risk for developing SLI is significantly higher for children born into families with a history of such disorders. This pattern of results was seen within a sample of infants that were identified by virtue of being born into families at high risk for SLI and then included in a prospective longitudinal study. These aggregation results echo, support, and extend previously reported findings using retrospective techniques. Additional support is provided for the premise that there is a gender specificity to SLI, as more boys than girls were affected among the probands. More important, within our carefully ascertained infant sample, children who were performing poorly on measures of language at 3 years of age were more likely to be FH+ boys than FH− boys, or girls of either background (FH+ or FH−). A provocative finding concerns the higher reports of autoimmune disorders within the families of children already at high risk due to family history of SLI. The present study is one of the first to prospectively examine familial aggregation and the incidence of language impairment from infancy and to determine the shifting patterns of deficits across early development and acquisition of language skills. Continued prospective assessment and analysis of the patterns of morbidity in these children and their families will allow relations between early deficits and subsequent SLI to be better defined.

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Appendix. Language History Questions

Is there a history of delayed language (e.g., late-talking) or reading/learning impairment in your immediate family (please include both parents, siblings, grandparents, aunts and uncles)?

YES NO

If yes, please identify family member(s), specify type of impairment and also state whether the impairment(s) has been diagnosed by a physician or specialist, and if so, when:

Family member?

Type?

Diagnosed?

When?

Did she/he receive any type of intervention (speech therapy, special education)?

YES NO

If yes, please specify the type of support, when support was given, and the frequency and duration for which it was received.

Family History of Autoimmune Disorders

Is there a history of autoimmune diseases (e.g., rheumotoid arthritis, juvenile diabetes mellitus, lupus, Crohn's disease, Grave's disease, Guillain-Barré syndrome, ideopathic thromb-ocytopenia purpura (ITP), multiple sclerosis, myasthenia gravis, etc.) in your immediate family?

YES NO

If yes, please explain which disorder and specify the family member(s) affected.

Table 1

Mean differences between FH+ and FH− groups on demographic characteristics.

Characteristic	FH+ (*n*= 37)		FH− (*n*= 75)		*t*	*p*
	M	*SD*	*M*	*SD*		
Maternal age	34.62	3.60	31.74	4.85	−3.37	.001
Paternal age	36.77	4.35	33.73	4.89	−3.08	.003
Maternal education	3.83	0.43	3.76	0.48	−0.33	.740
Paternal education	3.74	0.62	3.63	0.64	−0.91	.362
Hollingshead Four Factor Index (SES)	56.70	8.99	55.89	9.02	−1.27	.204
Number of children	2.54	.95	1.98	0.87	7.56	.007
Number of sons	1.41	1.14	1.07	0.91	−1.59	.115
Number of daughters	1.13	0.94	0.92	0.86	−1.46	.148
Birth weight	3,421.22	762	3,241.19	776	−1.25	.210
Gestational age	39.00	2.90	38.50	2.30	−1.02	.312

Note. FH+ = positive family history of specific language impairment (SLI); FH− = negative family history of SLI; SES = socioeconomic status.

Table 2

The distribution of FH+ and FH− families by family history of autoimmune diseases and asthma.

	FH+ (*n*= 37)		FH− (*n*= 75)			
Disease/ condition	***n***	***%***	***n***	***%***	χ^2	***p***
Autoimmune diseases						
Yes	13	35	7	9		
No	21	57	61	81		
Unknown	3	8	7	9		
					11.22	.001
Asthma						
Yes	4	11	10	13		
No	21	57	33	44		
Unknown	12	32	32	43		
					1.63	.44

Table 3

Mean language scores of FH+ and FH− groups at 3 years of age.

Measure	FH+ (*n* = 32)		FH− (*n* = 60)		*F*	*p*
	M	*SD*	*M*	*SD*		
Preschool Language Scale–3						
Expressive language	94.41	15.51	107.83	6.58	14.29	.001
Receptive language	98.78	19.78	112.67	15.92	13.36	.001
Total standard score	96.31	19.77	111.43	16.62	15.59	.001
Stanford–Binet (4th ed.)						
Verbal vocabulary	52.92	6.07	55.66	5.79	6.76	.011
Verbal comprehension	51.03	5.98	54.70	6.31	4.25	.043
Quantitative reasoning	50.41	12.40	52.64	9.24	0.72	.390
CELF-P						
Word structure	7.87	3.62	10.52	3.78	8.01	.010
Sentence structure	10.21	2.27	10.73	3.28	0.46	.490

Note. CELF-P = Clinical Evaluation of Language Fundamentals–Preschool.

Table 4

Mean sentence length and sentence complexity on the on the MacArthur Language Inventory for FH+ and FH− groups at 2 years of age.

	FH+ (*n*= 31)		FH− (*n*= 63)			
Variable	***M***	***SD***	***M***	***SD***	***t***	***p***
Mean sentence length	3.23	1.61	4.85	2.22	3.61	<.001
Mean sentence complexity	5.23	6.78	10.37	9.58	2.67	<.01

Table 5

Mean language scores for low- and normal-language groups at 3 years of age.

Measure	Low-language group (n = 13)		Normal-language group (n= 79)		F	p
	M	*SD*	*M*	*SD*		
Stanford–Binet (4th ed.)						
Verbal vocabulary	47.12	4.64	55.62	5.54	13.74	.001
Verbal comprehension	46.12	4.29	54.34	6.09	10.84	.001
Quantitative reasoning	49.83	4.70	52.86	8.68	.67	.410
CELF-P						
Word structure	7.12	7.37	10.01	3.23	4.06	.040
Sentence structure	6.87	2.23	11.01	2.78	16.38	.001

Table 6

Mean sentence length and sentence complexity on the MacArthur Language Inventory for low-language and normal-language groups at 2 years of age.

Variable	Low- language group (*n*= 10)		Normal- language Group (*n*= 72)		*t*	*p*
	M	*SD*	*M*	*SD*		
Mean sentence length	2.25	1.13	4.71	2.17	−3.506	.001
Mean sentence complexity	17.50	12.30	53.68	26.36	−4.258	<.001

Table 7

The distribution of 3-year-old children from low-language and normal-language groups by family history of SLI, gender, and family medical history.

Variable	Low- language group (*n*= 13)	Normal- language Group (*n*= 79)	χ^2	*p*
	Family history			
FH+ (*n* = 32)	9	23		
FH− (*n* = 60)	4	56	7.92	.01
	Gender			
	Male (*n* = 44)			
FH+ (*n* = 17)	6	11		
FH− (*n* = 27)	2	25	5.45	.02
	Female (*n* = 48)			
FH+ (*n* = 15)	3	12		
FH− (*n* = 33)	2	31	2.15	.14
	Autoimmune disease			
Yes	6	15		
No	7	64	4.55	.03
	Asthma			
Yes	2	10		
No	9	47	0.00	.96