

# Among perinatal factors, only the Apgar score is associated with specific language impairment

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## ABBREVIATION

SLI Specific language impairment

**AIM** The purpose of this study was to assess the relation of perinatal risk factors with later development of specific language impairment (SLI).

**METHOD** In a case-control study, 179 children attending special needs schools for SLI were matched with non-affected children attending mainstream schools. Both groups consisted of 134 males and 45 females (age range 4–13y; mean age 9y, SD 2y 4mo). Data on duration of pregnancy, birthweight, delivery complications, birth characteristics, and Apgar scores were collected from the Preventive Child Health Care files of the Municipal Health Service.

**RESULTS** The gestational age of the children with SLI (mean 39.6wks, SD 0.1wk) and for the comparison group (mean 39.4wks, SD 0.1wk) and the birthweight of children with SLI (mean 3330.4g; SD 41.4g) and for the comparison group (mean 3388.1g; SD 39.8g) were not statistically different; neither were other pregnancy and birth characteristics, with the exception of the Apgar scores (effect of group for Apgar score after 1min  $p=0.045$ ; after 5min  $p=0.001$ ). The difference in Apgar scores was larger for females than for males (effect of group  $\times$  sex for Apgar score after 1min  $p=0.049$ ; after 5min  $p=0.043$ ).

**INTERPRETATION** The relation between Apgar scores and SLI together with the influence of sex may be meaningful for predicting modelling and for understanding the causal pathway for SLI.

Specific language impairment (SLI) is an isolated developmental disorder.<sup>1–3</sup> By definition, this means that SLI is unrelated to other disorders such as hearing loss, low intelligence, a contact disorder, or acquired brain damage.<sup>3</sup> The reported prevalence of this disorder varies widely from 2 to 12% owing to differences in definition and methods of investigation. Very little is known about the aetiology of SLI and multicausality is probable. In studying twins, Bishop found obvious clues for a familial component, but there is also evidence for other factors such as perinatal hazards being involved.<sup>4</sup> In a systematic evidence review for the US Preventive Services Task Force, it was concluded that the most consistently reported risk factors for SLI include a family history of speech and language delay, male sex, and perinatal factors.<sup>5</sup>

From follow-up studies of preterm children,<sup>6,7</sup> it is known that these children have a high risk of multiple developmental disorders such as neurodevelopmental disorders and intellectual disability. De Kleine et al.<sup>6</sup> have shown that very preterm (<32wks and/or <1500g) children have more combined developmental disorders, whereas isolated language disorders are seldom found.<sup>8</sup> Most language problems are part of more complex developmental disorders. However, it

is conceivable that less complicated perinatal problems might cause a single developmental disorder such as SLI. Nevertheless, literature on this subject is scarce and shows contradictory results. Gestational age, very low birthweight, complications during delivery, delayed first antenatal care, and an Apgar score less than 6 at 5 minutes have been studied as potential perinatal risk factors for SLI.<sup>1,4,9–17</sup> In some of these studies one or more of these factors were identified as having an association with language delay or SLI, whereas in other studies such associations were not found. The contradictions are probably caused by differences in definition or age when language delay or SLI was diagnosed, insufficient study group size, or recall bias by using questionnaires for perinatal hazards long after birth and after the diagnosis SLI was already established.

We had the opportunity to perform a case-control study in which we used data collected shortly after birth, so recall bias could be avoided. The diagnosis of SLI was in this study independently established through a government-controlled programme for children with SLI to attend special needs schools at the age of 4 years or older.

The aim of our study was to assess the relations between the duration of pregnancy, birthweight, complications

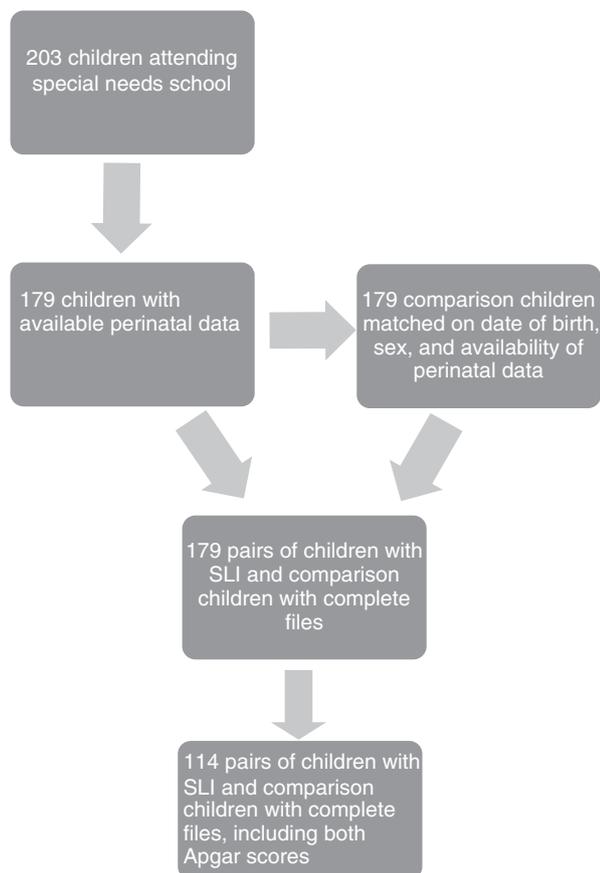
during delivery, and Apgar scores after 1 minute and 5 minutes, with later diagnosed SLI.

## METHOD

### Population and design

The study was designed as a case-control study. Figure 1 shows information on the study population. The group with SLI was recruited in 2008 from 203 pupils attending a special needs school, who were born between 1994 and 2003, having an age range of 4 to 13 years. These children met the following strict criteria for special needs education formulated by the Dutch Department of Education:<sup>18</sup> a score of more than 1½SD below normal for two or more tests on auditory processing, speech production problems, grammatical problems, and/or lexical-semantic problems; in addition, the disorder should not be caused by limited cognitive skills or hearing impairment. Children were diagnosed with SLI by a multidisciplinary team of specialists with an audiologist, a psychologist, a didactic specialist, and a speech therapist. Subsequently, their report was examined by an independent, government-controlled committee.

Exclusion criteria for the SLI group were missing or lack of perinatal data ( $n=20$ ) or adoption ( $n=4$ ), leaving 179



**Figure 1:** Flow chart of inclusion in the study. SLI, specific language impairment.

### What this paper adds

- It provides insight into perinatal risk factors associated with SLI.
- Children with SLI tend to have lower Apgar scores.
- The difference between Apgar scores is larger for females than for males.
- Other data for pregnancy and birth did not show a relation with SLI.

children to be included. Files were missing ( $n=4$ ) or incomplete ( $n=16$ ) mostly because of the child moving from another region. The comparison group was a random sample from the same region consisting of 179 children attending mainstream schools, representing those with normal cognitive abilities. They were matched with the included children of the affected group by date of birth and sex.

Children with SLI and the comparison group were recruited from schools situated in the service area of the Municipal Health Service of Nijmegen. Informed consent for anonymous use of filed data was given by the parents at their first contact with the Preventive Child Health Department of the Municipal Health Service. The Central Committee on Research Involving Human Subjects did not consider that their approval was needed.

### Data collection

The Preventive Child Health Department care files were obtained for both groups and the data concerning pregnancy and birth were studied. These data included duration of pregnancy, birthweight, complications during delivery, and the Apgar scores at 1 minute and 5 minutes after birth. Data on complications during delivery consisted of duration of the delivery and the expulsive phase of labour, whether spontaneous delivery occurred, and whether meconium-stained amniotic fluid was discharged. These data were prospectively acquired shortly after birth at the first visit from the Preventive Child Health Department. Kloosterman curves, as assessed in 1970, were used to determine whether the children were dysmature, normal, or heavy in weight for the duration of the pregnancy. Data on all the children in the SLI and comparison groups were analysed.

### Statistical analyses

Data from children with SLI and the comparison group were analysed as pairs. The percentage of pairs with missing values per variable varied considerably between 0% (duration of pregnancy and birthweight) and 36% (Apgar score after 1min). To solve the problem of missing data, multivariate imputation by chained equations in R was performed.<sup>19</sup> Five imputed data sets were created, in line with Rubin, who stated that 5 to 10 imputed data sets are enough to achieve high efficiency.<sup>20</sup>

Continuous variables were inspected for normality, and skewed variables (i.e. both Apgar scores) were log-transformed. Differences between the two groups were examined with a McNemar test (for categorical variables) and dependent  $t$ -tests for continuous variables. As a measure of effect size, Cohen's  $d$  was computed.<sup>21</sup> A  $d$  value of

0.20, 0.50, and 0.80 was considered as small, medium, and large respectively.<sup>21</sup> To control for sex, a repeated-measures analysis was performed, with the group as the within-factor variable and sex as the between-factor variable. Analyses used SPSS, version 20.0 (SPSS Inc, Chicago, IL, USA). The mean of the five imputed data sets was used as the final point estimate per group. Furthermore, if possible, the results of pooled tests were reported. For all tests, a two-tailed significance level of  $\alpha=0.05$  was used.

## RESULTS

Our sample consisted of 179 pairs of children with SLI and non-affected children, 134 (75%) pairs of males, and 45 (25%) pairs of females. The mean age of all children was 9 years (SD 2y 4mo). There was no difference in socio-economic status between the children with SLI and the comparison group as determined by analysis of postal area codes.

Also, for duration of pregnancy, birthweight, percentage of preterm births, dysmaturity, and delivery characteristics, we found no differences between the affected and comparison groups (Tables I and II). However, the Apgar score 5 minutes after birth showed a significant difference between children with and without SLI (Table III). The

estimated effect size (Cohen's *d*) indicated that the difference was small (Table III). Table IV shows the results of repeated-measures analysis using group (children with SLI or comparisons) as within factor and sex as between factor. After controlling for sex, a significant difference between children with and without SLI was found for both Apgar scores. In addition, an interaction effect was found between group and sex. This effect implies that for females the difference in Apgar scores between the SLI and comparison groups is significantly larger than for males. The estimated effect sizes (Cohen's *d*) were small for males and medium for females (see Table III).

## DISCUSSION

In the present study we found no relation between the duration of the pregnancy, preterm birth, dysmaturity, birthweight, and complications during delivery and later development of SLI. However, children with SLI tended to have lower Apgar scores 5 minutes after birth. In addition, the difference in Apgar scores between both groups was larger for females than for males.

The distribution of females (25%) and males (75%) in our study is somewhat different from other community cohorts.<sup>1,2,5</sup> In most studies males are in the majority, but

**Table I:** Pregnancy characteristics for the specific language impairment (SLI) and comparison groups ( $n=179$ )

Characteristic	SLI group	Comparison group	<i>p</i>	Cohen's <i>d</i>
Gestation, wks	39.6 (0.1)	39.4 (0.1)	0.34 <sup>a</sup>	0.10
Birthweight, g	3330.4 (41.4)	3388.1 (39.8)	0.30 <sup>a</sup>	-0.10
Preterm birth,%	7.8	8.4	1.00-1.00 <sup>b</sup>	
Dysmaturity,%	2.8	1.7	0.73-0.73 <sup>b</sup>	

Values are displayed as means (standard error) or percentages, averaged over the five imputed data sets. Cohen's *d*, standardized mean difference between the groups (for continuous variables only). <sup>a</sup>Pooled results are given of the dependent *t*-tests for the five imputed data sets. <sup>b</sup>The range of the *p* values is given for the McNemar tests for the five imputed data sets.

**Table II:** Delivery characteristics for the specific language impairment (SLI) and comparison groups ( $n=179$ )

Characteristic	SLI group	Comparison group	<i>p</i>	Cohen's <i>d</i>
Duration of labour, h	10.1 (0.8)	10.0 (0.9)	0.90 <sup>a</sup>	0.01
Expulsion, min	29.9 (3.2)	29.0 (2.3)	0.83 <sup>a</sup>	0.03
Non-spontaneous birth, %	38.8	36.1	0.53-0.67 <sup>b</sup>	
Meconium staining, %	20.6	20.9	0.44-1.00 <sup>b</sup>	

Values are displayed as means (standard error) or percentages, averaged over the five imputed data sets. Cohen's *d*, standardized mean difference between the groups (for continuous variables only). <sup>a</sup>Pooled results are given of the dependent *t*-tests for the five imputed data sets. <sup>b</sup>The range of the *p* values is given of the McNemar tests for the five imputed data sets.

**Table III:** Apgar scores 1 minute and 5 minutes after birth for specific language impairment (SLI) and comparison groups ( $n=179$ ) and for males and females

	SLI group	Comparison group	<i>p</i>	Cohen's <i>d</i>
After 1min				
Total ( $n=179$ )	8.2 (0.2)	8.6 (0.1)	0.17 <sup>a</sup>	-0.20
Males ( $n=134$ )	8.4 (0.2)	8.5 (0.1)		-0.06
Females ( $n=45$ )	8.2 (0.4)	8.6 (0.1)		-0.55
After 5min				
Total ( $n=179$ )	9.3 (0.1)	9.6 (0.1)	0.01 <sup>a</sup>	-0.24
Males ( $n=134$ )	9.4 (0.1)	9.5 (0.1)		-0.12
Females ( $n=45$ )	9.3 (0.2)	9.6 (0.1)		-0.57

Means (standard errors) are shown, averaged over the five imputed data sets (for the non-transformed scores). Cohen's *d*, standardized mean difference between the SLI and comparison groups. The *t*-tests were performed for the total group only. The results adjusted for sex are given in Table IV. <sup>a</sup>Pooled results are given of the dependent *t*-tests for the five imputed data sets, using the log-transformed scores.

**Table IV:** Results of repeated-measures analysis using group as within factor and sex as between factor

Apgar score	Within factor: group (SLI vs comparisons)		Interaction group × sex	
	<i>F</i> (df1, df2)	<i>p</i>	<i>F</i> (df1, df2)	<i>p</i>
After 1min	6.02 (1, 177)	0.045	5.08 (1, 177)	0.049
After 5min	12.91 (1, 177)	0.001	4.91 (1, 177)	0.043

Pooled results of the *F*-tests are given for the five imputed data sets, using the log-transformed scores. SLI, specific language impairment.

not as high as in ours. We have no explanation for this result.

Our findings that gestational age has no influence on SLI is in line with most other studies, although published data are scarce. Stanton-Chapman et al.<sup>1</sup> performed a population study of perinatal risk factors in children with SLI identified at school. The study group consisted of approximately 250 000 children, of whom almost 6000 (2.4%) had SLI. No relation with gestational age less than 37 weeks was established. Bishop<sup>4</sup> performed a study with homo- and heterozygote twins with and without SLI. Eighty-four twins, one or both with SLI, were compared with 36 twins with no history of speech-language difficulties. She found no relation with gestational age in her small study group. In the study by Luoma et al.,<sup>12</sup> 55 children born preterm at no more than 32 weeks' gestational age were examined at the age of 5 years for speech and language skills and compared with children born at term. Although they found significant differences in several language measures between both groups of children, SLI was not more frequent in the preterm group. Also, in the Victoria Study of Reilly et al.,<sup>15</sup> no significant relation was found between preterm birth and low language status or SLI at the age of 4 years in approximately 1500 children. In contrast, in an Australian study of nearly 5000 children of 4 to 5 years old, a relation was found between preterm birth and later attendance at speech-language pathology services.<sup>10</sup>

We found no difference in birthweight between children with SLI and the comparison group. Our results are in line with the findings of some studies.<sup>9,10,15,17</sup> However, others<sup>1,14</sup> did find low birthweight as a risk factor for language developmental problems. Tomblin et al.<sup>16</sup> interviewed parents of 177 children with SLI and 925 comparison children and did not find this relation for children with a low birthweight (<2500g). Also Aram et al.,<sup>9</sup> who studied 249 children with very low birthweight (<1500g) and 363 comparison children with a normal birthweight, did not. They also found no relation between a very low birthweight and speech and language disorders, after excluding the children with major neurological abnormalities. In the large population study of Stanton-Chapman et al.,<sup>1</sup> very low birthweight and medium low birthweight (1500–2499g) were established as risk factors for SLI, whereas gestational age was not an influence. Recently, Prathanee et al.<sup>14</sup> have published a study of 3125 Thai children of whom 12% were identified with an early language delay at 2 years old. They found birthweight as a risk factor for early language delay. It should be noted that language delay at the age of 2 years is not predictive of later SLI.<sup>22</sup> In the study by Keegstra et al.<sup>11</sup> a relation between low birthweight and parental concern about the language skills of the child was recorded. They investigated 240 children between 2 years and 5 years of age, of whom 35% had adequate language development. This group was compared with the group of children with a subnormal score at the language tests. Neither group differed in birthweight. Also, in the study of Marschik et al.,<sup>17</sup> there was no relation

between birthweight and delayed word production at the age of 18 months. Here also, delayed word production at the age of 18 months did not imply SLI later on.

In our study there was no apparent difference between both groups in percentages of dysmaturity. As far as we know, dysmaturity has never been described in the literature in relation to SLI.

We found no difference between our groups for duration of delivery or the expulsive phase of labour, nor for the percentage of spontaneous delivery or meconium staining. None of the studies analysing complications during delivery and speech and language disorders found an association between these complications and SLI.<sup>1,16</sup>

We found low Apgar scores to be a risk factor for later SLI. The difference in Apgar scores was larger for females than for males. Study results on Apgar scores in relation to SLI are variable. Bishop<sup>4</sup> found no relation with the Apgar scores, but Stanton-Chapman et al.<sup>1</sup> did. It is interesting that Marschik et al.<sup>17</sup> describe an association between toddlers with a small word production at the age of 18 months and a low Apgar score 5 minutes after birth. Although this study was not about children with SLI and had only 15 toddlers and 15 comparison children, the results are in line with our findings. We found no study on the influence of sex on Apgar scores and having SLI.

Based on the results of the present study, we conclude that the relation between perinatal factors and subsequent SLI is restricted, which is in line with most studies.<sup>1,4,9–12,14–17</sup> Only the Apgar scores seem to be related to the later development of SLI in children, especially in females.

The Apgar score can be regarded as a measure of vitality shortly after birth.<sup>23</sup> It is conceivable that lower Apgar scores are an expression of reduced vitality. Recently, an association of cerebral palsy with an Apgar score 5 minutes after birth has been shown.<sup>24</sup> This relation was most obvious in children with a normal birthweight. The results of this study<sup>24</sup> and our findings suggest that this reduced vitality has an association with later developmental disorders, independent of birthweight and duration of pregnancy. Presumably, vitality and, therefore, the Apgar score can be seen as indicators of brain immaturity or impairment. SLI is a disorder that is more frequent in males. Females are presumably less 'vulnerable' to this disorder unless there is an additional problem like a lower Apgar score. Future research may reveal if the Apgar score can be useful as a prediction model for SLI and/or other developmental disorders, with other known risk factors for these conditions.

One of the strengths of our study is that most data were collected shortly after birth, so recall bias was avoided. Another strength was that the comparison group was a random sample from the same region as the children with SLI. In addition, the diagnosis of SLI was established by an independent committee based on strict criteria for special needs education at the age of 4 years or older. Our study also had some limitations. Not all Apgar scores were available. However, we have no reason to assume that

there is a relation between not registering the Apgar score and later development of SLI. In addition, the criteria we used for dysmaturity were the Kloosterman curves<sup>25</sup> for establishing whether a child was born dysmaturely. These curves originate from 80 000 deliveries in two Amsterdam clinics between 1931 and 1967, so may be somewhat out of date.<sup>26</sup> Because these criteria were used for both groups it is not likely that they influenced the results. We do not have data for the profiles of the children with SLI, so we cannot describe specifics about the SLI profiles of the individuals with a low Apgar score. This will be an item for further research. We found that for females the difference in Apgar scores was larger than for males. The fact that the number of females, especially females with low Apgar

scores, was small may have influenced this result. Further studies on this subject are necessary.

## CONCLUSION

Based on the results of the present study, we conclude that the relation between perinatal factors and subsequent SLI is restricted. Only the Apgar scores appear to be related to the later development of SLI in children. For females, the difference in Apgar scores was even larger. Further investigation of the relation of the Apgar score with isolated developmental disorders and the difference in sex can give us greater understanding of the causal pathway of these disorders. These results may also be useful in developing prediction tools for early detection of SLI.

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