J Inherit Metab Dis (2008) 31:524–532
DOI 10.1007/s10545-008-0877-y

ORIGINAL ARTICLE

Correlates of language impairment in children with galactosaemia

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Received: 18 January 2008 / Submitted in revised form: 30 April 2008 / Accepted: 19 May 2008 / Published online: 12 July 2008

Summary
Purpose This study describes risk factors associated with language impairment in children with classic galactosaemia.
Method Thirty-three 4–16-year-old participants with classic galactosaemia and a history of speech sound disorders completed a battery of cognitive and language measures and their parents completed a family history questionnaire.
Results Nine of the sixteen (56%) participants with typical cognitive development and 15 of the 17 (88%) with borderline-low cognitive development had language impairments. Participants with typical cognitive development more often had an expressive language disorder, whereas those with borderline-low cognitive development more often had a mixed receptive-expressive language disorder. Participants with Q188R/Q188R genotypes had increased risk for both cognitive and language impairments. The IQs of younger siblings who did not consume milk postnatally were 10–56 points higher than the IQs of their older siblings with galactosaemia who had consumed milk postnatally. However, 4 of 5 younger siblings who were lactose-restricted from birth had language impairments. Typically-reported risk factors for language disorder, including parental history of speech/learning problems and low parental education level, were not significantly associated with cognitive or language impairments in the present sample of children with galactosaemia.
Conclusions Children with galactosaemia and speech disorders have a 4–6 times greater risk for language impairment than children with early speech disorders of unknown origin. Early dietary lactose may increase the risk for cognitive and language impairments; however, the lack of significant associations of language impairment with days of milk consumption, and other familial and educational risk factors, is consistent with prenatal causation.

Communicating editor: Peter Burgard

Competing interests: None declared

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Abbreviations

CAS	childhood apraxia of speech
CELF-R	Clinical Evaluation of Language Fundamentals-Revised
CWG	children with galactosaemia
GAL-1-P	galactose-1-phosphate

GALT	galactose-1-phosphate uridyl transferase
GFTA-2	Goldman-Fristoe Test of Articulation-2
KBIT-2	Kaufman Brief Intelligence Test, Second Edition
OWLS	Oral and Written Language Scales
SD	speech delay
SSD	speech sound disorder
ST	speech-language therapy
WISC	Wechsler Intelligence Scale for Children

Introduction

Classic galactosaemia is an autosomal recessive inborn error of metabolism that results in an inability to metabolize the milk sugar *galactose* due to a deficiency of galactose-1-phosphate uridyl transferase (GALT), an enzyme needed to convert galactose-1-phosphate (GAL-1-P) to glucose-1-phosphate (Segal and Berry 2001). GALT enzyme deficiency places children with galactosaemia at risk for neurodevelopmental disorders, likely due to accumulation of toxic metabolites. Studies have estimated that 38–65% of children with galactosaemia have neurodevelopmental speech disorders (Nelson 1995; Nelson et al 1991; Robertson et al 2000; Segal 1998; Waggoner et al 1990; Waisbren et al 1983; Webb et al 2003). Of the children with galactosaemia who have speech disorders, more than 90% have been reported to have co-occurring language disorders, which include vocabulary and word retrieval deficits (Waggoner et al 1990; Waisbren et al 1983).

Speech sound disorders in children with galactosaemia

Children's speech sound disorders (SSDs) may be divided into a common form termed speech delay (SD) and a rarer form associated with motor speech impairment termed childhood apraxia of speech (CAS). The presence and persistence of SSDs observed in some children with galactosaemia have frequently been classified as meeting criteria for CAS. A major constraint on the findings from such research reports is the inclusionary criteria used to classify children's speech error patterns as CAS. Over 50 definitions of CAS were identified in a recent Technical Report on this disorder by the American Speech-Language-Hearing Association (2007), and a number of speech tasks and checklists have been used to attempt to differentiate CAS from the far more prevalent SD subtype of SSD. At present, there is no validated list of diagnostic features that differentiate CAS from other types of SSD. The present data do not address the hypothesis of CAS in children with galactosaemia, the topic of a larger ongoing study from which the present data were obtained.

Risk factors for persistent cognitive, speech, and language impairment in children with galactosaemia

There are conflicting views on the relationship between cognitive impairment in children with galactosaemia and the prevalence, severity, and persistence of speech-language disorders. Kaufman and colleagues (1995) concluded that speech and language deficits are part of a more global set of cognitive impairments. They reported that scores on standardized speech and language tests were concordant with scores on cognitive ability tests of children and adults with galactosaemia ($N = 45$). This perspective was not supported by the findings reported in Waisbren and colleagues (1983), who stated that language skills in children with galactosaemia were particularly poor relative to their other abilities. Waisbren and colleagues (1983) reported that more than half of their modest sample of children with galactosaemia with normal cognitive function ($N = 7$) and one with borderline-low cognitive function had language impairments. Similarly, based on one of the largest available surveys (350 cases) of children with galactosaemia, Waggoner and colleagues (1990) reported that language disorders were more prevalent in, but not limited to, children with borderline or low IQ scores.

Other possible risk factors for cognitive, speech, and language impairment in children with galactosaemia include genotype and early exposure to dietary lactose. There is agreement across most studies that the genotype Q188R/Q188R is a risk factor for cognitive and speech disorders. Robertson and colleagues (2000) reported that 47% of children with galactosaemia who were homozygous for Q188R had speech disorders, compared with 41–43% of children with galactosaemia who had other genotypes. Children with galactosaemia have IQ scores in the typical (85–115) or borderline-low (60–84) range, with considerable intersubject variability (Antshel et al 2004). Shield and colleagues (2000) found that IQ scores for children with galactosaemia with the Q188R/Q188R genotype were 20 points lower (74 vs 95) than in other genotypes. However, findings in two other studies did not support lower cognitive function in children homozygous for Q188R. Cleary and colleagues (1995) and Kaufman and colleagues (1995) reported that Q188R homozygous

participants had equivalent or slightly higher scores on cognitive tests than found in children with galactosaemia with other genotypes.

Few data are available on the effects of postnatal milk consumption and subsequent neonatal illness on cognitive and language outcomes. The available findings indicate that the prevalence of cognitive, speech, and language impairment is not significantly associated with age at diagnosis of galactosaemia, initiation of lactose-restricted diet, or dietary compliance (Antshel et al 2004; Bosch 2006; Nelson et al 1991; Waggoner et al 1990; Waisbren et al 1983). Findings differ among studies of older siblings with postnatal complications due to early exposure to dietary lactose and their younger siblings whose lactose was restricted from birth. Waggoner and colleagues (1990) reported that in IQ tests with 29 multiplex families the younger siblings averaged 12 points higher than their older siblings, whereas Fishler and colleagues (1980) reported that three of the younger siblings averaged 24 points higher and eight younger siblings averaged 10 points lower than their older siblings. Although none of the studies examining multiplex families have had sufficient power to detect significant between-group differences in the cognitive function of older and younger siblings, the spread in test scores suggests that early milk consumption may contribute to long-term cognitive complications.

Efficacy studies are inconclusive on the persistence of speech, language, and educational deficits in children with galactosaemia who have had early intensive intervention. Two papers reported that early speech therapy prevents future educational problems and allows children with galactosaemia to participate in normal behavioural development (Robertson et al 2000; Webb et al 2003). Other follow-up studies, however, report that impairments persist even with intervention (Nelson et al 1991; Schweitzer et al 1993; Waggoner et al 1990).

Statement of purpose

Research is unclear about risk factors for language disorder in children with galactosaemia, particularly the relationship between cognitive status and persistent language impairment. Among the studies cited, none has reported the language status of children with galactosaemia with average compared to those with below average intellectual function. The goal of the present study was to assemble findings on associations among cognition, receptive and expressive language status, and risk and protective factors in children with classic galactosaemia, with implications for early identification and appropriate intervention.

Method

Participants

Participants were recruited from three sources as a part of a larger study on childhood apraxia of speech, including postal and e-mail announcements to the patients in the University of Wisconsin-Madison Biochemical Genetics Program and two parent support groups (Parents of Galactosemic Children and Galactosemic Families of Minnesota). Primary inclusionary criteria for the present study were a diagnosis of classic galactosaemia and a current or previous history of speech disorder, both by parental report. Exclusionary criteria included a first language other than English, bilateral hearing loss of greater than 40 dB at 1000, 2000, or 4000 Hz, and diagnosed structural anatomical disorders such as cleft palate. A total of 63 people volunteered to participate. Twenty-three were excluded on the basis of inclusionary/exclusionary criteria (were not within target age range ($N=6$); did not have a history of SSD ($N=7$); had a diagnosis of Duarte galactosaemia ($N=1$); first language was not English ($N=1$); had a cleft palate ($N=1$); had a significant hearing impairment ($N=2$); or did not live in the United States ($N=5$)). Of the 40 volunteers who met the inclusionary criteria; seven were unable to be scheduled because of family illnesses, death, time conflicts, or geographic location. The final group of 33 participants included 22 male and 11 female subjects, aged 4–16 years. Twenty-two of the participants were the only child in their family with galactosaemia and 11 were from five multiplex families in which two and three of the siblings had galactosaemia. Thirteen of the participants (39%) had a Q188R/Q188R genotype, 11 (33%) had Q188R/other genotypes, and 9 (27%) had unknown genotypes. All participants had hearing that was within normal limits with the exception of one child who had a mild (20–35 dB) bilateral sensorineural hearing loss. Parental report indicated that all of the participants had been on a galactose-restricted diet since their diagnosis of galactosaemia.

Procedures

The examiner (first author) was an experienced speech-language pathologist who tested the participants in their homes. All parents signed an informed

consent form granting permission for their children to participate in the study and all participants over age 11 years signed assent forms, both of which were approved by a University of Wisconsin-Madison institutional review board. Parents (most typically the mother) completed a case history questionnaire that included a detailed family history.

The test battery administered to all participants included a hearing screening at 25 dB HL for 1000, 2000, and 4000 Hz, the Listening Comprehension Scale (receptive language measure) and Oral Expression Scale (expressive language measure) from the Oral and Written Language Scales (OWLS; Carrow-Woolfolk 1995), and the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman and Kaufman 2004).

Psychometric information for the standardized tests

Reliability and validity estimates for the OWLS Listening Comprehension subtest include an internal reliability of 0.84 (range 0.75–0.89), inter-rater reliability of 0.95, test–retest reliability of 0.73–0.80, and a standard error of measure of 6.1 points; coefficients for the Oral Expression subtest include an internal reliability of 0.87 (range 0.76–0.91), inter-rater reliability of 0.95, test–retest reliability of 0.77–0.86, and a standard error of measure of 5.4 points (Carrow-Woolfolk 1995). In criterion validity studies, Carrow-Woolfolk (1995) reported receptive language coefficients of 0.80 for the OWLS Listening Comprehension subtest with Clinical Evaluation of Language Fundamentals-Revised (CELF-R) scores and 0.85 for the OWLS Oral expression with the CELF Expressive Language sub test (Semel et al 1987).

Psychometric estimates for the K-BIT-2 include an internal reliability for the IQ composite of 0.93 (range 0.89–0.93), test–retest reliability range of 0.88–0.89, and a standard error of measure of 4.3 points (Kaufman and Kaufman 2004). The K-BIT-2 has acceptable correlations with the WISC-III for diverse populations including children with learning disabilities and with typical development ($r = 0.87$; Canivez et al 2005; Wechsler 1991), economically disadvantaged minorities (Grados and Russo-Garcia 1999), and gifted students (Levinson and Folino 1994).

Statistical methods

Between group differences were assessed using analysis of variance. Pairwise Pearson correlations were used to test for relationships among variables. The Fisher exact probability procedure was used to test

Table 1 Age, genotype, IQ standard scores (SS), language SS, language impairment classification, and current speech-language therapy status for participants divided by cognitive status

Group	Mean age Median age (range) in years	Genotype (*N*, %)	IQ Mean SS Median SS (range)	Receptive language Mean SS Median SS (range)	Expressive language Mean SS Median SS (range)	Classification and type of language impairment (*N*, %)	Currently receiving speech-language therapy *N* (%)
A Typical IQ ($N = 16$)	8.2 7.8 (4.6–13.2)	Q188R/Q188R (4, 25%) Q188R/other (9, 56%) Unknown (3, 19%)	99 100.5 (86–111)	91 88 (69–113)	88 84.5 (73–118)	Language impaired (9, 56%) Expressive only (6, 38%) Mixed receptive-expressive (3, 18%)	10 (63%)
B Borderline-Low IQ ($N = 17$)	9.3 8.7 (4.8–16.1)	Q188R/Q188R (9, 53%) Q188R/other (3, 18%) Unknown (5, 29%)	74 76 (40–84)	71 71 (40–89)	73 75 (40–99)	Language impaired (15, 88%) Expressive only (2, 12%) Mixed receptive-expressive (13, 76%)	15 (88%)

for difference in proportions. Significance was set at $p < 0.05$.

Results

Correlates of language impairments

Participants were divided into two groups based on their full-scale IQ scores using DSM-IV-TR classifications (American Psychiatric Association 2000). Table 1 shows number of participants, genotypes, IQ scores, receptive and expressive language standard scores, prevalence and type of language impairments, and current speech therapy status by group membership. Group A participants ($N = 16$; 11 male, 5 female, mean age 8.2 years, median age 7.8 years) had standard scores for IQ in the typical range (85–115). Group B ($N = 17$; 11 male, 6 female, mean age 9.3 years, median age 8.7 years) had standard scores for IQ in the borderline-low range (84 and below). Group A included one female subject diagnosed with Asperger syndrome and Group B included one male subject diagnosed with ataxic cerebral palsy.

Proportionally more group B than group A participants were homozygous Q188R (53% and 25%, respectively), but the difference in proportions was not significant (Fisher exact probability = 0.157). As indicated in Table 1, group A participants had a mean IQ standard score of 99 (range = 86–111) and group B participants had a mean IQ standard score of 74 (range = 40–84). There were no significant differences between the verbal and performance IQ standard scores within group A ($p = 0.17$) or group B ($p = 0.15$). WISC IV scores (Wechsler 2003) were available for 4 of the 33 participants. Their full-scale IQ standard scores on this measure were two points lower to 7 points higher than their KBIT-2 IQ composite standard scores but did not change cognitive group membership.

As indicated in Table 1, group A participants had higher receptive language standard scores ($F_{1,31} = 19.23$, $p < 0.001$) and expressive language standard scores ($F_{1,31} = 10.92$, $p < 0.01$) than those in group B. Using −1.25 SD or below as the criterion for determining language impairment, either expressive language disorder or mixed receptive-expressive language disorder, group B had a greater number of participants with mixed receptive-expressive language disorders ($F_{1,31} = 15.59$, $p < 0.01$) than group A. Age ($p = 0.13$) and sex ($p = 0.81$) were not significantly associated with IQ scores.

Risk factors

Genotype

As indicated in Table 1 and as reorganized in Table 2, genotypes were available for 25 (76%) of the 33 participants. A total of 13 (52%) of the 25 known genotypes were Q188R/Q/188R, and 12 (48%) were Q188R/other. As shown in Table 2, the subgroup of 25 participants with known genotypes was compared on measures of IQ, receptive and expressive language, and the presence and type of language disorder. In this sample, participants with the Q188R/Q/188R genotype had lower IQ ($F_{1,23} = 7.46$, $p < 0.05$) and expressive language ($F_{1,23} = 6.42$, $p < 0.05$) scores but did not have lower receptive language scores than the participants with the Q188R/other genotypes ($p = 0.10$).

Postnatal milk consumption

Participants in groups A and B did not differ on age at diagnosis of galactosaemia or number of days consuming milk prior to diagnosis. The average age of diagnosis for group A was 8.87 (range 0–35 days) and for group B was 8.35 (range 0–18 days). The average number of days consuming milk prior to diagnosis was 7.62 (range 0–35 days) for group A and 7.1 (range 0–18 days) for group B. The number of days consuming milk prior to diagnosis was not significantly associated with IQ ($r = 0.09$, $p = 0.60$), expressive language

Table 2 Mean and range of IQ, receptive language, expressive language standard scores (SS) and percentage with language impairment for the subgroup of 25 participants with known genotype

Genotype	IQ Mean SS Median SS (range)	Receptive language Mean SS Median SS (range)	Expressive language Mean SS Median SS (range)	Mixed receptive-expressive language impairment (%)	Expressive language impairment (%)
Q188R/Q188R ($N = 13$)	80 81 (57–100)	76 75 (57–113)	75 74 (55–101)	54%	77%
Q188R/other ($N = 12$)	94 98.5 (72–111)	87 82 (69–113)	88 83.5 (75–118)	42%	55%

($r = 0.28$, $p = 0.11$), or receptive language ($r = 0.09$, $p = 0.58$).

Table 3 provides descriptive information for participants in the five multiplex families. In each family, the oldest child consumed milk prior to diagnosis of galactosaemia (range 4–17 days). In one multiplex family the second child consumed milk for 4 days prior to diagnosis; in the other four families the younger children were placed on a nondairy-based formula at birth. As indicated in Table 3, all five younger siblings in these latter four families had higher full-scale IQ scores than their older siblings (average IQ standard score difference 25.2, range 10–56, $F_{1,8} = 5.72$, $p < 0.05$). However, there were no significant differences in the receptive language ($p = 0.31$) and expressive language ($p = 0.53$) comparisons completed for these small subgroups of older compared to younger siblings. Descriptively, four of the younger siblings had higher and one had equivalent receptive language scores compared to their older sibling. Two of the younger siblings had higher expressive language scores than their older siblings and three had equivalent scores.

Parental educational level and history of learning/speech disorders

The educational levels of parents of participants in subgroups A and B did not differ on the highest educational level of either parent ($p = 0.22$). Mean years of paternal education were 14.9 (range = high school graduate–PhD) for group A and 14.9 (range = 10th grade–Master's degree) for group B. Mean years of maternal education were 16.1 (range = high school graduate–PhD) for group A and 15.2 (range = high school graduate–Master's degree) for group B. Moreover, the parents' highest educational level did not correlate with their child's IQ ($p = 0.77$), receptive language ($p = 0.89$) or expressive language ($p = 0.14$) standard score. The groups did not differ in history of parental learning or speech disorders, with one group A parent having a history of a speech disorder and one group B parent having a history of reading disabilities.

Early intervention

Speech-language services are generally viewed as protective factors for persistent speech-language disorders. All participants in the current sample of children with galactosaemia began speech-language therapy (ST) prior to age 4 years (mean = 2.7, range = 9 months–3 years of age), with no significant difference between groups A and B on age of initiation of ST ($p = 0.41$). Thirty-two of the participants received direct ST (working directly with a speech-language pathologist) and one child received indirect ST (the speech-language pathologist worked with the child's parents who in turn worked with the child). Typically, the participant's individualized education plan included speech, receptive language, and expressive language goals per parental report. At the time they were assessed for the present study, 25 (76%) of the 4–16-year-old participants were still receiving ST, with no significant statistical difference in the percentage of participants in each cognitive level group ($p = 0.06$).

Within group A, IQ was significantly negatively associated with receptive ($r = 0.53$, $p < 0.05$) and expressive ($r = 0.62$, $p < 0.01$) language, but IQ was not significantly associated with current enrolment in ST ($p = 0.09$). Within group B, IQ was also significantly negatively associated with receptive ($r = 0.70$, $p < 0.01$)

Table 3 Birth order, age at diagnosis, number of days consuming milk prior to diagnosis of galactosaemia, IQ standard scores (SS), receptive language SS, and expressive language SS for the five multiplex families

Family	Child's birth order	Age at diagnosis in days	Number of days on milk	IQ (SS)	Receptive language (SS)	Expressive language (SS)
1	1	7	4	80	71	77
1	2	7	0	104	110	89
2	1	10	10	87	72	78
2	2	0	0	97	113	78
3	1	9	4	40	40	40
3	2	5	0	96	83	103
4	1	17	17	65	65	70
4	2[a]	0	0	84	79	75
4	2[a]	0	0	82	64	68
5	1	4	4	103	84	108
5	2	4	4	109	94	98

[a] Twins

and expressive ($r = 0.54$, $p < 0.05$) language impairment, but these participants were not more likely than participants in group A to be receiving ST ($p = 0.65$). Therefore, although IQ and language scores were moderately correlated, neither was significantly associated with current enrolment in ST.

Discussion

Cognition and language

The children with galactosaemia in this sample had a higher prevalence of co-occurring language disorders than would be predicted by the earlier literature on children with speech sound disorders. At preschool age, 46% of children with average cognitive function and a speech sound disorder of unknown origin are estimated to have co-occurring language delay, falling to 11–15% by 6 years of age (Lewis et al 2006; Shriberg et al 1999). In the present study, more than half (56%) of the participants with average cognition (mean age 7.9 years) and most (88%) of the participants with borderline-low cognition (mean age 8.8 years) had co-occurring speech and language disorders. These findings suggest that that compared to children with speech sound disorders of unknown origin, children with galactosaemia have a 4- to 6-fold greater relative risk for co-occurring language disorders.

Language disorders were clearly associated with low cognitive function in this sample of children with galactosaemia, but more than half (56%) of the children with average cognition had language impairment and two (12%) participants with borderline-low cognition had typical language development. Type of language disorder was also associated with cognition. Mixed receptive-expressive language disorders were more prevalent in participants with borderline-low cognition (76%) than in children with galactosaemia with average cognition (19%). Expressive language disorders were more prevalent in participants with average cognition (37%) than those with borderline-low cognition (12%). These findings support those of Waisbren and colleagues (1983) described previously, based on a sample of 8 children with galactosaemia.

Our finding of an association between cognition and receptive and expressive language status is consistent with the emphasis on language-based items in the K-BIT-2, the WISC-IV, and other measures of IQ. Of interest, however was the lack of significant differences between the verbal and performance IQs for participants in typical versus those in the borderline-low cognitive groups. This dissociation between cognitive and language scores is consistent with multifactorial theories in which both genetic and environmental factors may have prenatal effects in both domains.

Genotype and language

The genotype findings in the present study are consistent with the proposal by Shield and colleagues (2000) that children with galactosaemia with the Q188R/Q/188R genotype are at greater risk than participants with Q188R/other genotypes for lower IQ and language impairment. Two constraints on this interpretation are that all children included in the present study had a history of speech sound disorders and the limited sample of children with known genotypes. Genotype was not limited during subject recruitment for the larger study, which is concerned with possible associations between galactosaemia genotype and apraxia of speech. An additional limitation

Table 4 Comparison of parental educational levels of children with galactosaemia (CWG) in the present study compared to participants with average cognition and language and participants with average cognition and language impairment from Tomblin et al (1997)

Parental education	CWG (%) $N = 33$	Language-impaired comparison group (%) $N = 177$	Typically developing comparison group (%) $N = 925$
Maternal education			
Completed college	66.7	15.3	28.1
Not complete college	24.2	33.9	36.3
Completed high school	9.1	40.1	29.8
Not complete high school	0.0	10.7	5.7
Paternal education			
Completed college	48.5	17.5	32.9
Not complete college	24.2	25.4	25.9
Completed high school	24.2	41.8	32.2
Not complete high school	3.0	15.3	9.0

in both the study of Shield et al (2000) and the present study is that the Q188R/other groups comprised more than six different genotypes.

Other risk factors and language

Many parents in the present study reported that family members, educators, and physicians had suggested that parents may be attributing their child's disabilities to correlates of galactosaemia when not all problems may necessarily be due to the disease. Findings in the present report suggest that, at least for children with galactosaemia and persistent speech disorders, neurodevelopmental correlates of galactosaemia are strongly associated with persistent language impairment. Notably, children with galactosaemia in both the typical and borderline-low cognitive groups did not have the risk factors for language impairment (parental education, family history of learning disabilities) found in children with speech and language impairment of unknown aetiology (Campbell et al 2003; Tomblin et al 1997).

Table 4 provides additional information on the above interpretation. In a study of 177 children with language impairment and 925 controls, Tomblin and colleagues (1997) reported that the most significant risk factors for language impairment were low parental educational level (incomplete high school) and parental history of speech problems, learning disabilities, and mental retardation. In the present study, the parents of children with galactosaemia were more educated and had fewer speech and learning disabilities than the parents of the children with language disorders and the parents of the control children in the Tomblin et al (1997) study (Table 4). The high level of parental education in the present study was likely due to sampling bias, whereby more educated parents were more likely to volunteer to participate in this study. Note that such a bias might also lead to an underestimate of the prevalence of language disorders in children with galactosaemia and speech disorders as a decrease in the prevalence of parental risk factors would likely decrease the prevalence of language disorder.

There is great interest in whether the complications from galactosaemia are due to prenatal factors or to exposure to dietary galactose after birth. Two factors support findings from previous studies (Holton 1995; Manis et al 1997) suggesting that most damage occurs during the prenatal period: (1) the presence of speech and language disorders in children with galactosaemia who did not consume milk after birth, and (2) the lack of an association of the severity of the IQ deficit and language disorder with days of milk consumption prior to diagnosis of galactosaemia.

Speech-language intervention and persistent language impairment

The present findings might be interpreted to suggest that the prognosis for children with galactosaemia is not as hopeful as implied by the statement of Webb and colleagues (2003) that early speech intervention would allow children with galactosaemia to participate in normal mental and behavioural development. The major limitation on generalizations for this question is that a primary inclusionary criterion for participation in the current study was persistent speech disorder. Limiting generalization to such participants, we note that of the 97% of children with galactosaemia in the present study who received direct speech therapy beginning in their preschool years, most (76%) continued to receive speech therapy at the time of testing. Although all of the parents reported that their child continued to make measurable gains in speech therapy, more than half (56%) of the participants in typical group and 88% of participants in the borderline-low cognitive group had persistent language impairments.

Conclusion

The results of the current study indicate that the majority of children with galactosaemia and a history of speech sound disorders have persistent language disorders that are related to, but not the direct result of, low cognition. Children with galactosaemia with speech disorders and average cognition are more likely to have expressive language disorders only, whereas children with galactosaemia with speech disorder and borderline-low cognition are more likely to have mixed receptive-expressive language disorders. These language impairments appear to arise in the absence of familial risk factors and to persist even with early speech-language intervention. Findings suggest that prenatal factors contribute to cognitive and language disorders and underscore the need for future longitudinal and sibling studies to examine the effect of postnatal exposure to dietary galactose.

Acknowledgements We wish to express our appreciation to the children and their families who so generously agreed to participate, to our laboratory colleagues at the University of Wisconsin-Madison, including Jane McSweeney and Heather Lohmeier, and to the graduate students at Washington State University-Spokane and Eastern Washington University for

their assistance and contributions at various stages of this project. This research was supported by National Institute on Deafness and Other Communication Disorders (NIDCD) grant DC000496 (L. D. S., principal investigator) and by a core grant (HD03352) to the Waisman Center from the National Institute of Child Health and Development.

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