

# THE NEUROBIOLOGY OF SPECIFIC LANGUAGE IMPAIRMENT (SLI)

Richard Webster MBBS, MSc, FRACP  
Paediatric Neurologist  
Children's Hospital Education Research Institute (CHERI)  
The Children's Hospital at Westmead

## INTRODUCTION

- **SLI is one of the commonest causes of childhood developmental disability**
  - 7.3% of kindergarten children have SLI (*Tomblin 1997*)
  - Ongoing social, language and academic impairment.
- **A cause for language impairment is not usually identified**
  - 72 preschool aged children with language impairment
  - Aetiology identified in 1 child (2 hearing impairment) – GDD 55%
  - *Shevell et al J. Peds 2000*
- **What is known about the biology of SLI?**

## SLI A DEFINITION

- **SLI: an impairment in language which is greater than impairments in other non-language domains**
- A **significant** discrepancy between language and non-verbal cognitive performance
- **Exclusions:**
  - Autism or ASD, hearing impairment, neurological disease, severe oral dyspraxia
- **SLI is a description of a phenotype and probably has multiple biological causes**

## THE NEUROBIOLOGY OF SLI

1. Language processing and location
2. Deficits in sound processing and memory
3. **SLI is not specific**
  - Clues from a broader phenotype
4. **Genes and SLI**
5. **Environmental factors and SLI**
6. **Lesions producing SLI**
7. **Morphometric MRI in SLI**

# 1. LANGUAGE PROCESSING

- Language processing occurs in **real time**
  - Sentences 2-3 seconds
- Phonological analysis
  - Critical changes in frequency occur in very short periods of time 40/1000 second
  - Information is stored, encoded and processed
- Meaning is inferred/ nonsense options are discarded
- Words are predicted
  - You know the word I am going to finish this sentence ....
  - To be or no to ...
- Responses are formulated ...

# 1. SPEECH AND LANGUAGE

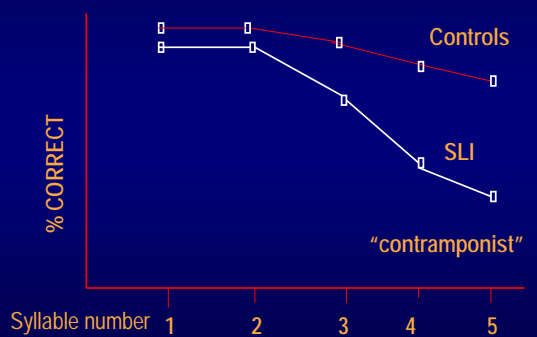
- Speech is one of the fastest and most complex motor/cognitive function humans perform
  - For most children this is learnt only with the aid of environmental input
- Where does this go wrong in children with language impairment?
  - Why is there a discrepancy between language and non-verbal cognitive function?

# 1. LANGUAGE LATERALISATION

- Adult aphasia
  - 96% of adults with infarcts and aphasia have an insult to their left hemisphere
- Geschwind & Levitsky 1968
  - Found that the planum temporale is larger on the left in 65% of brains
  - It was larger on the right in 11% of brains
  - This difference is present in neonates
  - Is asymmetry of the planum temporale the structural correlate of language lateralisation?
- Could abnormal structural asymmetry of be a causal factor in SLI?

# 2. DEFICITS IN SOUND MEMORY

## NON-WORD REPETITION



## 2. NON-WORD REPETITION

- Tests perception, coding of sound, **sound memory** and articulation
- Poor non-word repetition seems to be a core deficit in SLI
- Evidence suggests children with SLI have problems storing sound signals in memory
  - Limitations in the memory for sounds may be a major factor in SLI ? Storage ? Encoding?

## 2. ELECTRICAL CORRELATES OF AUDITORY PROCESSING

Ors M et al (2002). Auditory event-related potentials in children with specific language impairment. *Eur J Paed Neurol*. 6: 47-62

Studied: SLI CHILDREN (10)/ CONTROL CHILDREN (10)

**Event related brain potentials (ERP):** Average of responses to recurrent stimuli. puss (non-target)/ buss (target) - asked to identify the odd stimulus.

Children with SLI worse at discriminating.

Low amplitude and abnormal waveform of ERP associated with identifying the target stimulus (P3 potential)

P3 is the response to an odd stimulus may reflect updating of memory. ? impaired speed of classification and allocation of attention

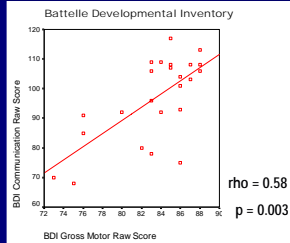
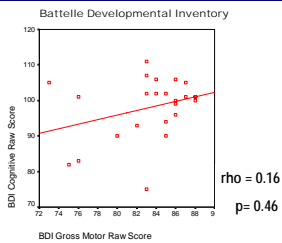
## 2. DEFICITS IN SOUND PROCESSING

- Children with SLI have an acoustic decoding problem
  - Eg consonant vowel combinations /ba/ and /da/
- Difficult discrimination if:
  1. Rapid transitions in frequency
  2. Separated by very short intervals
  3. Improved if the sound was slowed down or if the interval between sounds was lengthened
    - Tallal & Piercy (1973, 1974, 1975, 1976)
- Children with SLI improve if trained with acoustically modified sound
  - Controversial study (Fast Forward)
    - Tallal & Merznich (1996)

## 3. SLI IS NOT SPECIFIC

- **Associated problems**
  1. **Dyspraxia** (Hill 2000)
    - High incidence of clumsiness in children with SLI
    - Motor sequencing problems
  2. **Attention Deficit Disorder** (Tannock & Brown 2000)
  3. **Non-verbal cognitive impairment** (Johnson 1994)
    - Impaired performance on tests which purely assess visuo-spatial tasks
  4. **Abnormal neurological examination**
    - Brisk reflexes/ mirror movements (Trauner 2000)

### 3. MOTOR FUNCTION IN SLI



GM scores more closely correlated with communication scores than with non-verbal cognitive scores

Webster, Majnemer, Platt, Shevell. J.Pediatrics Jan 2005

### 3. OTHER IMPAIRMENTS

- Reaction times of children with SLI for a range of non-linguistic and linguistic tasks are slower than children with normal language
  - Miller et al J. Speech Language and Hearing Research 2003;44: 416-433.
- The fact that a lot of children with SLI have evidence of impairment of other systems suggests that SLI is a more general problem
- Language is the most severely affected function ..... why?
  - Conceivably language requires the most rapid processing

### 4. GENES AND SLI

- The X chromosome
  - Boys more commonly have SLI
  - Reported male to female ratio 1.3 - 5.9:1
    - Stromswold K. Hum. Biol 1998;2:297-324.
- Increased familial incidence of language impairment
  - Bishop (1995): 25-75% of children with SLI have first degree relative with LI
  - Is this environmental or genetic?
- Bishop (1995)
  - SLI concordance (70 %) identical vs non-identical twins (46%)
  - 90% concordance among identical twins with SLI if a broader phenotype of language impairment

### 4. THE KE FAMILY

- An inherited speech and language disorder
- Initial phenotypic descriptions focussed on impairments in morpho-syntax
  - Eg Gopnik & Crago Cognition 1991;39:1-50.
- Broader phenotype
  - Articulatory impairment
  - Verbal dyspraxia/ orofacial dyspraxia
  - Non-verbal cognitive impairment
- Structural brain abnormalities
- Mutation in FOXP2 gene (Lai 2001 Nature 413:519-23)
  - FOX genes encode transcription factors (regulators of protein synthesis)
  - Strongly expressed in fetal human brain

## 4. GENOME SCREENS

- Linkage reported to several chromosomal regions:
  - **13q21**: Nonword reading impairment - *Bartlett 2002* – this region has also been reported as an area of linkage in autism
  - **16q24**: Nonword repetition *The SLI Consortium 2002*
  - **19q13**: expressive language impairment *The SLI Consortium 2002*

## 5. BRAIN INJURY AND SLI

- **Perinatal risk factors and SLI**
  - Florida study of SLI
    - 5862 children with SLI/ 244,619 controls
  - Factors significantly associated with SLI
    - APGAR score less than 3 at 5 minutes
    - Birth weight less than 2500g
    - High birth order
      - *Stanton Chapman Res. Dev. Dis 2002:390-405.*
- **Maternal cocaine exposure**
  - An independent risk factor for language impairment
- **Premature birth and bronchopulmonary dysplasia**

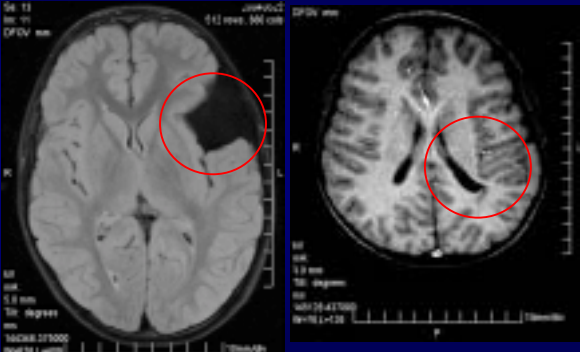
## 6. DOES UNILATERAL BRAIN DAMAGE EXPLAIN SLI?

- **Bates (1997) – 53 children with damage to right or left hemisphere before 6 months**
  - Brain damage transiently delays language development but this usually resolves by five years
  - Right hemisphere
- **Children (<5 years) with damage to the left brain can move language to the right brain**
  - *Basser (1962)* – hemispherectomy

## 6. LESION CAUSING SLI

- **Landau 1960**
  - Boy of 10 years, severe language impairment but normal intelligence
  - Bilateral loss of brain tissue around the Sylvian fissures and the insula
- **Preis 1996**
  - Twins with SLI, bilateral abnormal organisation of language cortex
- **Trauner 2000**
  - MRI increased incidence of white matter abnormalities
  - Abnormal asymmetry of ventricles
- Left temporal arachnoid cyst/ ischaemia

## LESIONS CAUSING SLI



Left temporal arachnoid cyst

Temporo-parietal gliosis and volume loss

## 6. MRI STUDIES IN SLI

Author	Region	Asymmetry
Plante (1991)	Perisylvian asymmetry in 6/8 boys with SLI (8 boys)	R>L
Jernigan (1991)	Pre-frontal asymmetry Superior parietal (20 children)	R>L L>R
Gauger (1997)	Planum temp. + posterior ascending ramus	R>L
Bollich (2002)	Primary auditory cortex [Heschl's gyrus] (17 children)	Abnormal asymmetry
Preis (1998)	Surface area of the planum temporale and parietale	Normal asymmetry

## 6. VOLUMETRIC MRI

- **Herbert MR et al. MGH**
- Boys 5.7 - 11.3 years
- 15 Language Impaired, 16 Autistic, 15 controls.
- Normal non-verbal IQ
- Language impairment defined as:
  - Language score > 1SD below non verbal IQ
  - Mean Length of Utterance more than 1 SD below the mean

## 6. WM VOLUME GREATER IN DLD AND AUTISM THAN CONTROLS

Compared white matter volumes of children with **Developmental Language Disorders, Autism (high functioning)** and controls.

**Children with Developmental Language Disorders and children with Autism have significantly greater volumes of white matter in the frontal lobes when compared to control children.**

*Herbert et al 2004*

## 6. ABNORMAL CORTICAL PATTERNS OF ASYMMETRY

- Similarities between ASD and SLI (*Herbert et al. 2004*):
  - Cortex showed **widespread** patterns of abnormal asymmetry
  - 1. Loss of asymmetry of some language areas
  - 2. Increased asymmetry of other language areas (inc. L Planum Temporale!)
  - 3. Abnormal asymmetry of areas of assoc. cortex
- Hypothesis:
  - Language because of increased reliance on association cortex is **most vulnerable** to the diffuse disturbance in development

## 10. CONCLUSIONS

- **SLI is a phenotype not a diagnosis**
  - It results from multiple different causes
- **SLI is not Specific**
  - Motor, attention and social impairments are important co-morbidities
  - May also be involved in the same process
- **Genetic and environmental factors are important aetiological factors**
- **Abnormalities of grey matter and associated white matter tracts may lead to language impairment**

## ASSESSMENT IN SLI

- 1. Hearing assessment
- 2. Look for co-morbidity - motor, attention and non-verbal cognitive assessment
- 3. Reading
- 4. EEG
  - BRE and language impairment
  - Probably not useful unless language regression
- 5. MRI
  - No complete series
  - Unclear what the yield is
  - Unlikely to alter management