Developmental disorders

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Outline

- Types of developmental disorder
- Explanatory frameworks
- Developmental language deficits
- The example of Williams syndrome
- The relation of genes to cognition

Types of developmental disorder

1. Disorders caused by well-understood genetic abnormalities (e.g., Down syndrome, Williams syndrome)
2. Disorders defined by behavioural deficit (e.g., dyslexia, SLI, autism)
3. Developmental disability of unknown aetiology
4. Disorders caused by environmental factors (e.g., impoverished environment, Foetal Alcohol syndrome)

Genetic syndromes

- Alagille syndrome
- Angelman syndrome
- Apert syndrome
- Beddington-Wiedemann syndrome
- Bloom syndrome
- Branchio-oto-renal syndrome
- Cri du chat syndrome
- Creutzfeldt syndrome
- DiGeorge syndrome
- Down syndrome
- Ehlers-Danlos syndrome
- Fragile-X syndrome
- Jackson-Weiss syndrome
- Joubert-Lange-Nelken syndrome
- Kallmann syndrome
- Kearns-Sayre syndrome
- Langer-Giedion syndrome
- Lesch-Nyhan syndrome
- Li-Fraumeni syndrome
- Marfan syndrome
- Miller-Diecker syndrome
- Nijmegen breakage syndrome
- Prader-Willi syndrome
- Phenylhabton syndrome
- Romano-Ward syndrome
- Rubinstein-Taybi syndrome
- Smith-Magenis syndrome
- Stickler syndrome
- Treacher Collins syndrome
- Usher syndrome
- Waardenburg syndrome
- Williams syndrome

(Shinchan & Read, 1999)

Explanatory frameworks

- Static classical cognitive neuropsychology (e.g., Temple, 1997)
- Neuroconstructivist (e.g., Karnioloff-Smith, 1998)
For disorders with uneven cognitive profiles (e.g., in adulthood), use selective deficits to inform normal structure (general deficits less interesting...)

Temple (1997):
- "The objective of case studies in cognitive neuropsychology is not to produce a clinical taxonomy, but to propose selective deficits of a common modular architecture of a developmental system"
- "It may be common for children to have problems with several components of the system, but the most informative child, in terms of revealing the structure of the system, will be the child who has selective difficulty with a particular element and therefore a dissociation of skills"

Temple (1997):
- "Downstream effects do not mean that a developing system cannot have a modular organisation, but they may make the appearance of the classical double dissociations, which are the hallmark of cognitive neuropsychology, difficult to attain within developmental disorders"
- "If the brain reorganised and generated new modules then abnormal performance would not necessarily reflect a normal system minus those components that are disrupted, which is a basic assumption of cognitive neuropsychology (Saffran, 1982)"
- "From the perspective of cognitive neuropsychology, which has little interest in the issue of biological localisation, it is of no consequence whether language develops in the right or the left hemisphere, provided that the functional architecture of the language system is the same in both cases"

Problems with static approach
- Use of static models eliminates the developmental process, a core causal element
- Functional modules are an outcome of the developmental process, not a precursor
  - in domains such as language, face processing, executive function, imaging studies show increasing selectivity, localisation, and lateralisation of activity with age
- Behavioural impairments = outcome of a process of development involving a long history of interaction with the environment

Problems with static approach
- Coarse standardised test scores showing performance in the normal range cannot reveal if underlying processes are atypical
- Gene expression in the developing brain is typically widespread
- Developmental process involves compensation and interaction - unlikely that deficit in one module will not affect others during development ("Residual Normality")
- Selective deficits often explained using non-developmental models

Reading

Developmental Phonological Dyslexia
Static models

- Static models (usually adult) - not bad place to start to generate hypotheses about source of developmental deficits
- But final explanation must be in terms of way specialised components develop
  - e.g., modules of reading system - how do they know what to do? Reading is not even innate


- Disorders are the result of development guided by atypical neurocomputational constraints from embryogenesis onwards
- Causes will be in terms of low-level neural properties + developmental process
  - e.g., firing properties of neurons or local connectivity

Neuroconstructivist approach: Karmiloff-Smith (1998)

- Approach predicts both strengths and weaknesses in behavioural outcome
  - Small differences in initial start state can lead to divergent behavioural outcomes
  - Apparently normal behaviour in a disorder may have different cognitive processes underlying it

Neuroconstructivist approach: Karmiloff-Smith (1998)

- Rejects innate modularity - “different domain-relevant mechanisms become domain-specific through ontogeny”
- Empirical approach traces back developmental trajectories to infancy
- Uses sensitive measures to explore nature of underlying processes
- Takes developmental computational neuroscience perspective
  - Includes brain imaging data
  - Employs developmental computational modelling

Problems with Neuroconstructivism

- Risks rejecting possibility that anything can develop normally in a genetic developmental disorders
- Not much empirical evidence that developmental disorders show radically different modular structure (though methodological issues here)
- Difficulty of assessing functional significance of atypicalities in brain structure / metabolism / processing

Developmental disorders of language

- Importance of plasticity illustrated by fact that children who experience same brain damage as adult aphasics end up with no symptoms of aphasia (Bates & Roe, 2001)
- Whatever is wrong in the developmentally disordered brain, plasticity cannot overcome it
- Doesn’t imply plasticity isn’t trying… plasticity itself may be atypical
Landau-Kleffner syndrome (Acquired Epileptic Aphasia)
- profound receptive language impairment (may extend to total disappearance of auditory verbal comprehension)
- Onset 18 months - 13 years (peak incidence 4 years)
- 80% cases also seizure disorder with bilateral EEG abnormality
- disruption of processing of auditory input to Wernicke's area?
- no evidence of deafness - failure of words to be associated with meanings
- knock-on effects in development of syntax
- later the onset, better final language development (established knowledge)

Semantic disorders
- children with word finding difficulties
- semantic but not phonological errors in naming
- slow naming times
- impoverished word definitions

Grammatical disorders
- SLI - esp. errors of morphology (differ across languages)
- KE family (motor deficits too - FOXP2 gene)
- grammatical SLI - restricted to difficulties with representational dependencies within syntactic constructions

Developmental dyslexia
- Problems in forming phonological representations exist prior to literacy (e.g., revealed by phoneme discrimination, onset-rhyme knowledge)

Pragmatic disorders
- Language difficulties overlap with wider social communicative difficulties (autistic spectrum)
Other disorders

- Williams syndrome - language relative strength compared to visuospatial skills
- Downs syndrome - language development much delayed (esp. syntax), poor phonological working memory
- Autism - varying levels of language development, particular pragmatic impairment

<table>
<thead>
<tr>
<th>Other disorders</th>
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</thead>
<tbody>
<tr>
<td>Non-Verbal Learning Disability (Rourke, 1987, 1989) - widespread brain damage causes recurring pattern:</td>
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<tr>
<td><strong>Relative weaknesses</strong></td>
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<tr>
<td>bilateral tactile-perceptual deficits, more marked on the left side of the body</td>
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<tr>
<td>impaired visual recognition and discrimination</td>
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<td>impaired visuospatial organisation</td>
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<tr>
<td>bilateral psychomotor co-ordination problems, more marked on left</td>
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<td>difficulties managing novel information</td>
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<td><strong>Relative strengths</strong></td>
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<tr>
<td>simple motor skills</td>
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<tr>
<td>auditory perception</td>
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<tr>
<td>rote learning</td>
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<tr>
<td>selective and sustained attention for auditory-verbal information</td>
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<tr>
<td>basic expressive and receptive language</td>
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<tr>
<td>word reading and spelling</td>
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The example of Williams syndrome

- Rare genetic disorder (1 in 20,000 live births) caused by a deletion of ~25 genes on the long arm of chromosome 7 at q.11,23
- Clinical features:
  - Heart abnormalities - typically SVAS
  - Facial dysmorphology
  - Small stature
  - Hernias
  - Hoarse voice
  - Premature ageing of skin
  - Constipation
  - Hyperacusis
  - Abnormal gait

<table>
<thead>
<tr>
<th>Williams syndrome</th>
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<tbody>
<tr>
<td>Brain anatomy in WS</td>
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<tr>
<td>80% of normal brain volume</td>
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<tr>
<td>anterior regions and cerebrum:</td>
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<tr>
<td>small in proportion to other brain regions</td>
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<tr>
<td>limbic and frontal regions:</td>
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<tr>
<td>small, but proportionally normal to other brain regions</td>
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<tr>
<td>cerebellum:</td>
</tr>
<tr>
<td>large in proportion to other brain regions</td>
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<tr>
<td>malformations in dorsal regions</td>
</tr>
<tr>
<td>total grey matter reduced</td>
</tr>
<tr>
<td>abnormal layering, orientation, density and size of neurons in several brain regions</td>
</tr>
</tbody>
</table>
Brain chemistry in WS

- Normal ratios in cerebellum:
  - Cho/Cre
- Abnormal ratios in cerebellum:
  - Cho/NAA
  - Cre/NAA

Correlations with cognitive ability:
- Increase in cognitive performance associated with increase in NAA for all cognitive tasks (particularly general speed of processing)

Structure-function relationships?

"Brain volume, brain anatomy, brain chemistry, hemispheric asymmetry, and the temporal patterns of brain activity are all atypical in people with WS. How could the resulting cognitive system be described in terms of a normal brain with parts intact and parts impaired, as the popular view holds? Rather, the brains of infants with WS develop differently from the outset, which has subtle, widespread repercussions at the cognitive level." (Karmiloff-Smith, 1998)

- Quote illustrates neuroconstructivist perspective on importance of substrate
- Possible response is to argue only some of atypicalities have functional importance (ungrounded)

Early views

- Rossen et al. (1994): WS "presents a remarkable juxtaposition of impaired and intact mental capacities...[...]. Linguistic functioning is preserved in Williams syndrome while problem solving ability and visuospatial cognition are impaired"
- "Although their IQ is measured at around 50, older children and adolescents with WS are described as hyperlinguistic with selective sparing of syntax, and grammatical abilities are close to normal in controlled testing. This is one of several kinds of dissociation in which language is preserved despite severe cognitive impairments, suggesting that the language system is autonomous of many other kinds of cognitive processing." (Pinker, 1994)
- Pinker (1999): WS and SLI represent ‘genetic double dissociation’ arguing for the developmental independence of language from cognition (innate modularity)

Fractionation in Williams syndrome?

WS language: More recent research

- Overall profile
  - Delayed language development (~ 2 years)
  - Usually MA / DS comparison groups - No independence from general cognition
- Precursors
  - Delayed pointing, impaired triadic interactions
  - Delay in using labels to aid categorisation
- Speech processing
  - Anomalous auditory ERPs
  - Lexical segmentation delayed
  - Phonological STM relative strength

More recent research suggests:

- Vocabulary acquisition
  - Vocabulary spurt doesn’t coincide with usual semantic markers
  - Lexical constraints different? (whole object, taxonomic)
  - Difficulty in spatial, perhaps ‘relational’ vocabulary
- Semantics
  - Poorer / slower but not atypical in its underlying dynamics
  - Integration with syntax may be anomalous
  - Knowledge remains more perceptually-based and insufficiently abstract
More recent research suggests:

- **Relation of grammar to vocabulary**
  - Initially MLU predicts grammatical complexity
  - Complex structures apparently mastered
  - Grammar generally behind vocabulary (TROG vs. BPVS)
  - Exaggerated difficulty with complex structures
  - Atypical errors found in Italian, Spanish gender agreement, morphology, preposition use

- **Pragmatics**
  - Persistent deficits, e.g. in non-literal language (despite usage of this language), advance theory-of-mind reasoning (despite hypersocial personality profile)

**Overall picture in WS**

- **Different lexical constraints**
- **Subtle grammatical impairments**
- **Atypical balance of semantics/phonology**
- **Language is relatively good but develops atypically**
  - Notably good compared to individuals with Down syndrome matched for IQ - but maybe that tells us more about DS?
- **However, some researchers still prefer static view**
  - "The linguistic performance of [individuals with] WS can be explained in terms of selective deficits to an otherwise normal modular system" (Temple & Clahsen, 2003)
  - E.g., inflectional morphology debate

**Comparison of disorders**

- Comparison of developmental disorders may be informative about constraints acting on normal language development
  - e.g., importance of various information sources

**Comparison of disorders**

- McDonald (1997): routes to acquire linguistic structure
  - Prosodic and/or phonological information used to segment input into meaningful units
    - [I scrambled the eggs] = [I scrambled + ed the egg + s]
  - Analysis of distributional and co-occurrence patterns of linguistic elements

**Comparison of disorders**

- Two types of information from patterns:
  - Function words - mark syntactic structure; fast automatic use associated with emergent left lateralisation of language (ERP marker)
  - Morphological analysis of words into component parts
    - [I scrambled the eggs] = [I scramble + ed the egg + s]

**Comparison of disorders**

- Successful: Disrupted Input, OK; Not developed; OK; More structure than input
- Down's syndrome
  - OK; OK; Some problems; Delayed, some problems in pragmatics
- Autism (High functioning)
  - OK; ?; ?; Problems in pragmatics

<table>
<thead>
<tr>
<th>Successful</th>
<th>Phonology</th>
<th>Function words</th>
<th>Morphological decomposition</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disrupted Input</td>
<td>OK</td>
<td>Not developed</td>
<td>OK</td>
<td>More structure than in input</td>
</tr>
<tr>
<td>Williams syndrome</td>
<td>OK</td>
<td>OK</td>
<td>Some problems</td>
<td>Delayed, some problems in pragmatics</td>
</tr>
<tr>
<td>Autism (High functioning)</td>
<td>OK</td>
<td>?</td>
<td>?</td>
<td>Problems in pragmatics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unsuccessful</th>
<th>Late L1 learners</th>
<th>Problems</th>
<th>?</th>
<th>Problems</th>
<th>Persistent problems, slow developing =&gt; high working memory load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late L2 learners</td>
<td>Problems</td>
<td>Do not show native ERP patterns</td>
<td>Some persistent problems (e.g., gender agreement)</td>
<td>Delayed, L2 better than L1 (larger DPA for cognit)</td>
<td></td>
</tr>
<tr>
<td>Down's syndrome</td>
<td>Problems</td>
<td>Short MLU</td>
<td>?</td>
<td>Problems with morphology and agreement</td>
<td></td>
</tr>
</tbody>
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## Conclusions

- Developmental deficits in language not due to brain damage analogous to adult case
- Genetic developmental disorders can show auditory, semantic, grammatical, and pragmatic deficits
- Competing explanations in terms of
  - (1) selective modular damage
  - (2) atypical neurocomputational constraints on developmental process
- Detailed testing required establish normal/delayed/atypical
- Computational modelling may be required to reveal role of developmental process
- Importance of input?
- Use of non-developmental models still widespread - can play role