Lateralisation in language

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Outline

- Optic aphasia
- What does the right hemisphere do?
- How does the brain become specialised?
- Side-of-damage effects in early brain damage

Anomia according to sensory modality

- Rare occurrences of naming difficulty in single sensory modality
  - Optic aphasia (visual) – picture naming
  - Auditory aphasia – naming from definition
  - Tactile aphasia – naming from handling object
- Patient must have some knowledge of object to exclude agnosia
  - e.g., be able to describe object's use and where found

Optic aphasia

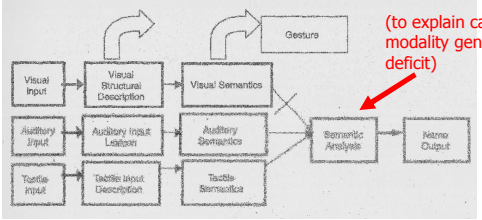
- Patients better at naming objects when handled or verbally defined than when visually presented
- Often associated with left occipital lesion (left posterior cerebral artery)
- Can co-occur with right hemianopia, colour anomia, alexia
- Similar to visual associative agnosia but…
- …patients can show knowledge of meaning by miming the object's use through gesture

Optic aphasia

- Riddoch & Humphreys (1987): miming may be possible from structural knowledge (physical analysis) of object without true object meaning
- Shallice (1988) proposed multiple semantic subsystems based on:
  - Modality-specific priming in patients, e.g. prime: pharaoh (picture or word) => target name: pyramid
  - Patient dissociations, e.g., EM more successful in naming with pictures, AB more successful with auditory description

Optic aphasia

- Disorder produced by disconnection?



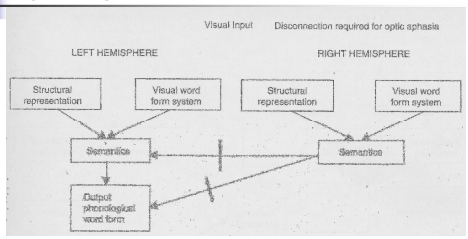
Optic aphasia

- But how come residual semantic knowledge (structural or otherwise) can drive gesture but not naming?
- Coslett & Saffran (1991): case MP, features reminded authors of response of right hemisphere in split brain patients
  - 1. Lack of awareness of the visual stimuli input
  - 2. Inability to express in language what has been seen
  - 3. Ability to comprehend high-imagery common nouns
  - 4. Failure to process syntax in terms of suffixes (e.g., to recognise *tigered* is incorrect)

Optic aphasia

- MP also showed within-category, word-picture matching errors – coarse semantic analysis of right hemisphere? [cf. deep dyslexia]
- **Proposal** – optic aphasia = disconnection between two hemispheres and a large lesion within left occipital region
- Residual semantic processing from right hemisphere expressed through miming
- Object not named because visual access to left language hemisphere denied

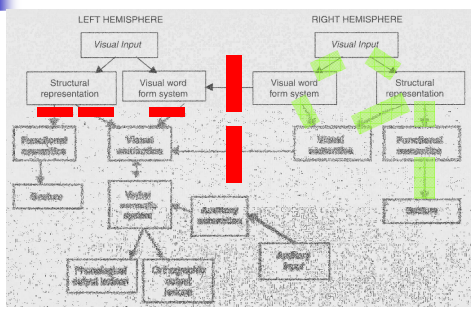
Optic aphasia



- Implies knowledge is <u>not</u> fully intact – optic aphasia is a milder form of visual object agnosia
- Intactness of knowledge may relate to pre-morbid use of right hemisphere for semantic analysis (testability?)

Optic aphasia

- How is knowledge expressed through mime?
- Appeal to distinction between "what" and "where" channels
- "Where" = pathway for analysing object location and visually guided manipulation
- Runs dorsally from visual cortex and relies on occipital-parieto-frontal structures
- Mime = non-verbal representation of object using coarse right hemisphere semantic analysis and the "where-action" pathway for expression



Optic aphasia

- Suggestion, then, of less precise or coarser representation of semantics in RH
- What else does the RH contribute to language processing and what is the origin of this lateralisation?
- There are indications RH involved in non-literal language processing

Right hemisphere language processing

- Evidence from right handed adults with damage confined to right hemisphere
- Cerebrovascular accidents rather than traumatic brain injury (TBI) or Alzheimer's
- Right hemisphere damage (RHD) leaves phonological and syntactic functioning essentially unimpaired
- Most RHD patients have middle cerebral artery occlusions - but little work on lesion-behaviour correspondences

Methodological difficulties

- Interactions of left and right hemisphere in language processing unknown
- Deficits in RHD may not reveal normal function of RH
  - e.g. if L-R effects are inhibitory, damage may release inhibition
- Task difficulty and specificity of effects
  - Nonliteral language processing is harder
  - Typically assessed with off-line tasks requiring meta-linguistic knowledge
  - Deficits could just be due to general attentional / working memory limitations

Methodological difficulties

- Task difficulty and specificity of effects (cont.)
  - LHD-RHD comparisons difficult: the LHD patients still able to do the experimental tasks may have less severe damage than RHD patients
- No detailed processing models of discourse / nonliteral language available
  - Makes it hard to construct on-line tasks

RHD language deficits

- Prosody
- Lexical-semantic deficits
- Discourse processing

Prosodic deficits

- Melody of language
- RHD patients can lose melody and produce monotone / robotic speech (though semantically and syntactically correct)
- Prosody involves larger scale computations over whole sentences

Lexical-semantic deficits

- Results contradictory across different tasks
- Types of proposal: general vs. specific deficits in lexical-semantic processing after RHD
- Specific: does RHD impair processing of specific meaning domains?
  - nonliteral words
  - emotional words
  - concrete words
- Important to equate processing difficulty across domains - or results could be due to general processing limitations

Lexical-semantic deficits

- RH may be particularly involved in concrete word processing
  - split visual field experiments in normals
  - RHD: relative concrete word processing deficit?
- PET study of normals has suggested no specific role for RH in concrete vs. abstract words
- Conflicting ERP evidence

Lexical-semantic deficits

- Hypothesis: RH activates weak associates of lexical items (Beeman, 1998) – less inhibitory network?
- RHD disrupts activation of metaphoric meanings or subordinate interpretations
  - SHARP - intelligent
  - BANK - river
- Hypothesis: LH quickly selects dominant / context appropriate meaning, RH maintains activation of subordinate meanings and remote associates
  - RHD should not have access to nondominant / alternative interpretations

Lexical-semantic deficits

- Overall, definitive evidence still lacking
- Persistent issue of matching stimulus sets / experimental tasks to rule out general processing deficit account

Discourse processing

- RHD language disorders particular evident in pragmatics: context-appropriate social use of language
- Growing literature suggests impairments in building, extracting, or applying mental structures that guide discourse processing

Discourse processing

- Tasks involve nonliteral forms and intentions
  - selecting punchlines for jokes
  - recognising conversational irony and its implications
  - determining connotative meanings of words
  - interpreting idioms
  - processing indirect requests
- RHD does not seem to affect activation or representation of nonliteral intended meanings
  - Knowledge intact but not accessed
- Some deficits interpreted with reference to deficits in reasoning from a Theory of Mind

Discourse processing

- Particular problems when RHD must
  - revise mental models to update or repair initial interpretations
  - construct a coherent model by linking multiple or disparate representations of text elements, internal knowledge, and external contexts
- A problem with effortful integration and inferencing, social cognition, and/or suppression of contextually inappropriate alternatives
- A problem 'bringing it all together'

Discourse processing

- Suppression deficit hypothesis
  - 'Discourse comprehension difficulties result from tendency to activate and hold on too long to interpretations that become contextually irrelevant' (Tompkins et al., 2000)
- Suppression account provides principle foundation for common treatment practices
  - e.g. working with RHD adults to distinguish central or relevant info from peripheral / irrelevant info

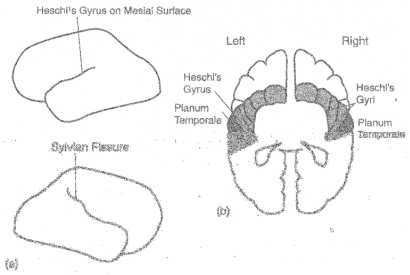
Fodor's nightmare

- Traditional cognitive neuropsychology predicated on assumption of modularity
- Fodor's notion of module was about low-level processing (fast, local, automatic, encapsulated)
- RH language processing is slow, effortful, global, and context-sensitive - everything that a module isn't
- RH language processing: part of Fodor's Central System?

The origin of lateralisation

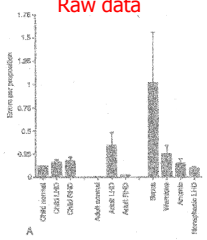
Where does L-R specialisation come from?

Adult brain

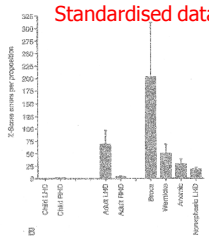


Adult vs. child brain damage

Raw data



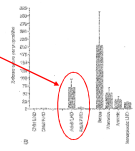
Standardised data



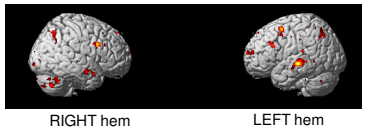
- Adults show sub-types depending on location of damage, children don't

Deficits after damage versus normal function

- Only left-sided damage produces deficit
- FMRI indicates bilateral activations (L>R), e.g., during comprehension
- What is the right side doing?



Auditory words > reversed



RIGHT hem LEFT hem

Where does L-R specialisation come from?

- Three theories of origin of specialised structures
  - Equipotentiality

(how does it explain uniformity of outcome?)

  - Irreversible determinism

(how does it explain flexibility after early damage?)

  - Emergentism

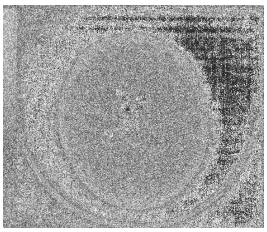
(yeah, but what does this really mean?)

Redundancy?

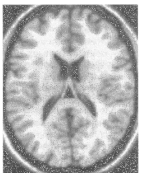
Early child brain damage

- Children recover from early damage due to greater plasticity
- Plasticity view contrasts with early vulnerability view (Anderson et al., 2001)
- Depends on nature of damage
  - Larger / bilateral damage in children often leads to children *growing into* their deficits
  - Adults may recover better following this kind of damage - structures already in place
- Bilateral damage – better outcome if damage in adulthood
- Focal damage – better outcome if damage in childhood
- Damage at different ages often not comparable

Case study: Jessica (3;11)

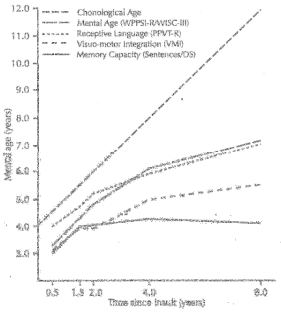


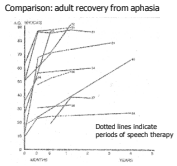
Normal



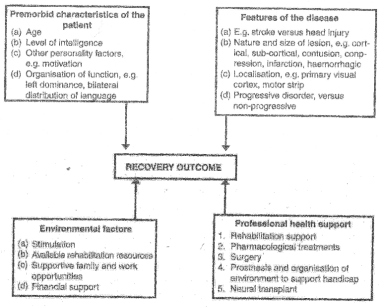
(Anderson et al., 2001)

Case study: Jessica





Factors determining recovery



Early brain damage: When recovery is over

- Bates, Vicari & Trauner (1999)
  - 43 English-speaking children (29 LHD 15 RHD), 33 Italian-speaking children (18 LHD 15 RHD) tested cross-sectionally 3-14 years
  - Mean IQ in low-normal range (94-97) though wide range (4-140)
  - No differences LHD vs. RHD in full-scale, verbal or non-verbal IQ

Early brain damage: When recovery is over

- Italian sample: PPVT, Boston Naming, TROG, semantic fluency
  - Brain injured children significantly below normal controls (except TROG)
- No evidence for difference between LHD and RHD on any measure
  - (see also Kempler and colleagues, 1999, for similar findings)

Early brain damage: When recovery is over

- Conclusions
  - Brain damage causes language delay
  - Plastic reorganisation takes place prior to 5-7 years of age
  - In contrast to adults, no side-of-damage effects by this stage

The process of recovery

- Bates et al. (1997)
  - CDI data, free speech used to assess early language development
  - 53 children 10-40 months of age: 36 LHD, 17 RHD

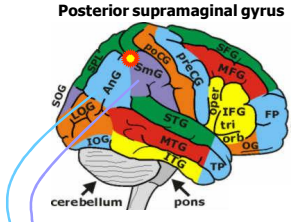
Epoch 1 10-17 months N=26	**Epoch 2** 19-31 months N=29	**Epoch 3** 20-44 months N=30
▪ Receptive greater delay for RHD ▪ Expressive greater for LHD but only for posterior (temporal) damage – compare to adults!	▪ Expressive worse for LHD (grammar, vocab) but only for posterior (temporal) damage ▪ LHD =RHD for anterior ▪ RHD frozen phrases, grammar deficit	▪ MLU of LHD temporal damage lower than normal ▪ LHD = RHD anterior damage shows non-sig. delay

Explanation?

- Bates et al:
  - Right temporal regions initial required to 'crack the code' of perceiving language
  - Left temporal region has superior ('domain-relevant') ability of analysing fine perceptual detail
  - Perceptual detail essential to drive eventual language production
  - Left = detail Right = global may be domain-general difference between hemispheres
    - E.g., for both language and visuo-spatial processing

Some unpublished data: structural MRI (VBM)

Posterior supramaginal gyrus

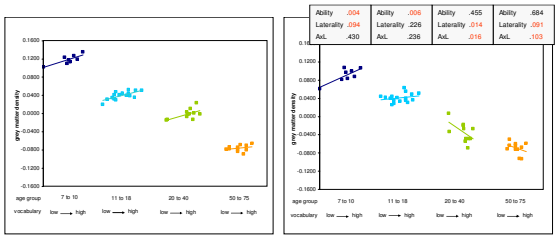


Richardson, Price & Thomas (unpub.)

Anterior supramaginal gyrus
associated with phonological processing

Anterior angular gyrus
associated with semantic processing

Results



Left

x = -52, y = -54, z = 44

Right

x = 60 y = -54, z = 44

A possible story

- Specialisation is caused by initial computational biases
- Final structure emerges across development - earlier bilateral stages may leave redundant structures which are progressively pruned / taken over by other functions
- Different hemispheres / regions may play different roles at different stages in development
- Right hemisphere functional structure still to be clarified (as are details of nonliteral language processing) + interactions between hemispheres

A possible story

- Left hemisphere ends up more modular, automatic and encapsulated, right hemisphere more global and effortful (domain-general difference?)
- Many developmental disorders have features of right hemisphere deficit ("non-verbal learning disorder")
  - its job (integration) may just be harder

Conclusion

- Individual differences in lateralisation
- Brain imaging reveals bilateral activation