Language comprehension

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Outline
- Words vs. sentences
- Sentence comprehension
  - What's involved?
  - Difficulties with the syndrome approach
    - Syndromes not homogeneous with regard to syntactic deficits
  - Theoretical models of sentence comprehension
  - How patterns of breakdown inform these models
  - Neural substrate revealed by brain imaging

Comprehension
- Individual words
  - Sounds (Pure word deafness)
  - Meanings (Wernicke’s aphasia)
- Sentences (Broca’s aphasia)
- Intended meaning (Right hemisphere)

In this lecture we will focus on sentence comprehension

Sentence comprehension
- Use syntactic information to understand meaning
  - Structure building
  - Checking agreement
  - Mapping thematic roles
  - Complexity

Sentence Comprehension
(1) Structure building
- Combining words into larger units based on word-category information + grammatical rules
  - E.g. ‘cat’ + ‘the’ + rule [det+noun=legal noun phrase] => “the cat” (and not ‘cat the’)

Newspaper headline:
ENRAGED COW INJURES FARMER WITH AXE

______ COW ______ ENRAGED ______ INJURES
FARMER WITH AXE ______ WITH AXE
Sentence Comprehension

(2) Checking agreement
- e.g. marking for number, case, gender

the daughters of the colonel who were killed
the daughters of the colonel who was killed

(3) Mapping thematic roles
- map roles such as agent (‘do-er’) and patient (‘do-ee’) onto certain positions in the sentence

John loves Mary ≠ Mary loves John
- Not always easy: agent does not always precede patient

The dog was chased by the cat

P(s) A

(4) Complexity
- sentence is more complex if order of noun phrases that receive thematic roles deviates from usual agent-before-patient order
- patient-first imposes larger burden on working memory

Simpler: the reporter who attacked the senator
Complex: the reporter who the senator attacked

Comprehension and aphasia

Broca’s aphasics - difficulty comprehending syntax-driven meaning
- E.g. reversible passive sentences

The brown dog is chased by the white horse

The Wernicke-Geschwind model

Broca’s area = seat of syntax?
Problems with the syndrome approach

- Broca’s aphasics don’t show uniform syntactic problems
  - degree of agrammatic speech not correlated with degree of asyntactic comprehension
  - comprehension deficits on reversibles – worse on passives than actives
  - working memory problem?

- Some of our own data...

  Sentences > scrambled
  Reversible > not

Problems with the syndrome approach

- grammaticality judgement preserved in patients with agrammatic speech and asyntactic comprehension
- morphological deficits dissociate from word order problems
- morphological deficits associated with damage to anterior temporal lobe, not Broca’s area

Problems with the syndrome approach

- Attempt to tie some type of syntactic processing deficit to clinical category of Broca’s aphasia has not proved fruitful
- Case studies showing dissociations have proved more useful

Main findings from behavioural and imaging work

1. Behavioural: Semantics and syntax are independent, dissociable systems
2. Behavioural: Semantic and syntactic systems interact
3. Behavioural: Operation of combining semantic constraints (thematic roles) and syntactic structure may be selectively impaired
4. Behavioural: There may be separate working memories for phonological information, lexical-semantic information, and syntactic information
5. Behavioural: No clean loss of specific syntactic operations. Specific syntactic rules/operations may be differentially impaired, but parsing theory not well enough advanced to explain current data - Better cognitive level theory required
6. Imaging ERP: Temporally, syntax processing is initially autonomous (modular?) but later interacts with semantic processing
7. Imaging FMRI/PET: No syntax processing module (for comprehension) is apparent in the substrate. Network of areas, different areas recruited for different tasks

Sentence processing theories

1. Serial / syntax-first model
   - syntactic structure derived autonomously based on word-class information, prior to semantic information (e.g. Frazier, 1987)
Sentence processing theories

(2) Interactive / constraint satisfaction model
- all types of information interact at each stage of language comprehension (e.g., Marslen-Wilson & Tyler, 1980)

Interactivity does not rule out independent structures for different types of knowledge

Boland's concurrent model (1997)

Sentence processing theories

Evidence from cognitive neuropsychological approach (patient case studies)
- Dissociation between semantic and syntactic knowledge (Hodges et al., 1994; Ostrin & Tyler, 1995)
- Interactions between syntax and semantics (Saffran, Schwartz, & Lisleberger, 1998)
- Mapping between grammatical and thematic roles (Breedin & Martin, 1996)
- Working memory (Martin & Romani, 1994)
- Differential loss of syntactic operations (Caplan & Hildebrandt, 1987)

Semantic vs. syntactic knowledge
- Selective preservation of syntax in presence of semantic disruptions in Alzheimer's dementia & progressive aphasia
- Patient PP (Hodges et al., 1994): no sensitivity to semantic violations in word monitoring

Options

The evidence examined...
- The woman examined...
- The horse examined by...
(NB importance of frequency)
**Semantic vs. syntactic knowledge**

Examples of word monitoring materials used by Tyler and colleagues (from Hodges et al., 1994 and Tyler, 1992) with target word in capitals.

- **Early Target Position**
  - Normal Prose: He said the BUS always left on time and he didn’t want to miss it.
  - Ambiguous Prose: It until the BUS always left on time, and he didn’t want to miss it.
  - Somewhat Prose: The said he BUS and went left always he so didn’t it time wise to.

- **Late Target Position**
  - Normal Prose: Apparently in the middle of the night some thieves broke into the CHURCH and stole a golden crucifix.
  - Ambiguous Prose: Apparently in the distance the wind some ants pushed around the CHURCH and forced a new hym.
  - Somewhat Prose: Of middle apparently the some the into the broke night in thieves CHURCH and crucifix stole a golden.

**Ostrin and Tyler (1994):** case JG marked disruption to all syntactic abilities + relatively preserved lexical-semantic abilities

- Sentence-picture matching: asyntactic comprehension (fails if agent and object are reversed, succeeds if distracter is a lexical substitution)
- Word monitoring: insensitive to grammatical violations
- Normal semantic priming in lexical decision task

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**Interim conclusion 1**

- Semantics and syntax are independent, dissociable systems

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**Interactions between syntax and semantics**

- Pit constraints of syntax against those of semantics
- After damage to syntax, patient may show stronger effects of semantic constraints
- When no strong semantic constraints, effects of weakened syntax should still emerge
- Saffran, Schwartz, and Linebarger (1998) => evidence for such an interaction between syntax and semantics

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**Saffran, Schwartz, and Linebarger (1998)**

- Verb constrained sentences (strong semantic constraint)
  - The cat barked at the puppy
- Proposition based sentences (weaker semantic constraint)
  - The insect ate the robin
Saffran, Schwartz, and Linebarger (1998)

- Subjects: five Broca’s aphasics, one conduction aphasic, one transcortical motor aphasic
- Task: Detect implausible sentences!

Tasks: "Is this sentence plausible?"

- Patients: ‘Plausible!’ (E) - relying on semantics and not syntax
- Patients: ‘Implausible!’ (C) - now using syntax

Error rate for judging plausibility of sentences

Interim conclusion 2

- Semantics and syntax interact!

Mapping between grammatical and thematic roles

- Difficulty discriminating between verbs that have similar semantic representations but different mapping between grammatical and thematic roles
  - Could discriminate e.g. lend from distribute
  - but not lend from borrow

Mapping between grammatical and thematic roles

- Elisabeth is in white top with white hair band
  - Which of (a) and (b) is Elisabeth lending?
  - Which of (b) and (c) is Elisabeth distributing?

- "The cat looked at the mouse"
- "The mouse was caught by the cat"
- "The boy who caught the mouse"

- "Which of (a) and (b) is Elisabeth lending?"
- "Which of (b) and (c) is Elisabeth distributing?"

(a) (b) (c)
Interim conclusion 3

- Operation of combining semantic constraints (thematic roles) and syntactic structure may be selectively impaired

Working memory

- Phonological working deficit does not cause difficulties in processing syntactically complex sentences
- Syntactic + semantic info abstracted as you go, words not kept in mind
- Martin and Romani (1994): dissociations can be found between
  - phonological working memory deficits (nonword repetition)
  - lexical working memory deficits (nouns + adjectives)
  - syntactic working memory deficits (grammaticality judgements)

Lexical working memory

Task: Plausibility judgement

- The rusty pail was lying on the beach [Distance 1]
- The rusty, old, red, pail was lying on the beach [Distance 3]
- The rusty, old, red swimsuit was lying on the beach
  [adjectives BEFORE noun - HARD]
- The pail was old, red, and rusty but she took it to the beach anyway [Distance 3]
- The swimsuit was old, red, and rusty but she took it to the beach anyway
  [adjectives AFTER noun - EASY]
- For BEFORE condition, you have to keep adjective meanings in mind until noun arrives and can be modified

Interim conclusion 4

- There may be separate working memories for phonological information, lexical-semantic information, and syntactic information

Can you lose specific syntactic operations?

- Most studies of agrammatism use linguistic theory to generate hypotheses about locus of existing deficit
- Few studies of aphasia seek dissociations of specific linguistic rules based on existing theory
- Exception: Caplan & Hildebrandt (1987, & Evans, 1988): patient KG
- Analysed in terms of Chomskian theory
  - Surface vs. Deep structure of sentence
Can you lose specific syntactic operations?

- KG's performance broke down when several (linguistically defined) syntactic capacity demands were combined.
- Some evidence that comprehension of linguistic constructions may be differentially affected by brain damage.
- However, theories of parsing not well enough developed to explain findings.

Interim conclusion 5

- Specific syntactic rules/operations may be differentially impaired, but parsing theory not well enough advanced to explain current data.
- Better cognitive level theory required.

Neural substrate: Friederici (2002)

- Postulates areas of brain involved in auditory sentence processing based on imaging work.
- Autonomy of syntax assessed using ERP components.
- Claim => initial phase of syntactic processing is autonomous - modularity?

Time course: three phase theory

1. Initial structure building
   - ERP: ELAN
   - Independent of semantic processes
2. Semantic integration
   - ERP: N400
3. Late syntactic integration
   - ERP: P600 (patients can lose ELAN but still show P600)

- Syntactic violation = ELAN deflection
- Semantic violation = N400 deflection
- ELAN but no N400 when both syntactic and semantic violation
- Conclusion = syntactic violation prevents semantic stage, so it precedes it (and is independent/modular?)

Friederici & Kotz (2003)

- Damage to these areas = loss of ELAN
- Patients: Basal ganglia (sub-cortical) involved in late syntactic integration
- BG and posterior regions of STG dissociation from areas for phase 1
Interim conclusion 6

- Temporally, syntax processing is initially autonomous (modular?) but later interacts with semantic processing
- Does modular imply a special brain area...?

Neural substrate: Kaan & Swaab (2002)

- Sounds like there's a part of the brain dedicated to syntax processing?
- Broca's area?
- Kaan & Swaab (2002) summarise PET / fMRI data
- Results depend on contrasts used in subtraction method

Area for syntax

- Lots of pictures coming up
- Watch Broca's area
- Is it (and it alone) more activated when syntax is involved?

Activation differences: (1) Complex vs. simple sentences

- Syntactically simple
  The reporter who attacked the senator admitted the error
- Syntactically complex
  The reporter who the senator attacked admitted the error

Activation differences: (1) Complex vs. simple sentences
Activation differences:
(2) Sentences vs. word lists (no syntax)

- Sentences have syntax + semantic coherence, word lists have neither. Need non-semantic sentences to compare to word lists
- Jabberwocky
  The mumphy folofel fonged the apole trecon
- Syntactic prose
  The infuriated water grabbed the justified dream

Activation differences:
(3) Jabberwocky or syntactic prose vs. word lists (no syntax)

- Compare syntactic (no semantics) sentence to word lists (no syntax, no semantics)

Activation differences:
(3) Jabberwocky or syntactic prose vs. word lists (no syntax)

- Syntactic violations vs. correct or semantic violations or spelling errors [black blue green]
- Semantic violations vs. correct [red]

Trees can grow

vs

Trees can grow / Trees can eat / Trees can graw

vs

Trees can fly

(purple = pragmatic violations)

Activation differences:
(4) Syntactic violations

- Conclusion:
  - No one part of the brain is exclusively involved in syntax
  - Network of areas, different areas recruited for different tasks
  - In comprehension, Broca’s area appears to underlie something like working-memory-for-syntax (complexity)
  - (Production is generally more anterior and also involves Broca’s area)

Neural substrate: Kaan & Swaab (2002)
Interim conclusion 7

- No syntax processing module (for comprehension) is apparent in the substrate

Overall conclusions (1)

- Syndrome approach less useful than cog-neuro approach in using deficits to inform models of sentence comprehension
- Semantics and syntax appear to be dissociable but interacting functional systems
- Time course of interaction revealed by ERP work – suggests syntax initially autonomous
  - though must identify words as nouns, verbs, etc. first!

Overall conclusions (2)

- PET/fMRI – syntax comprehension involves network of areas, none entirely dedicated to syntax
- Functional modules realised by underlying distributed networks of neural areas
  - Cognitive modularity ≠ Substrate modularity
- Potential tension between cognitive neuropsychology, syndrome, and imaging approaches

Note on methodology

- Examples of tasks used to assess comprehension (potentially in the absence of production)
  - Sentence-to-picture matching
  - Grammaticality judgement
  - Plausibility judgement
  - Anomaly detection
  - Enactment
  - Word monitoring
  - Priming (e.g., in lexical decision task)
  - Passive listening to different materials (imaging)