Contributions of Memory Brain Systems to First and Second Language

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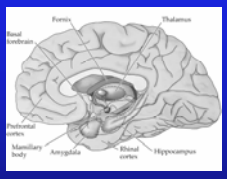
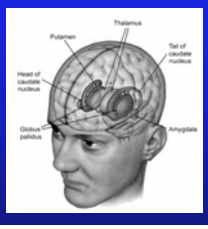
Funding
NIH: R01 MH58189; R01 HD049347; R03 HD050671
NSF: SBR-9905273; BCS-0519133; BCS-0001961
Defense: DAMD-17-93-V-3018/3019/3020, DAMD-17-99-2-9007
McDonnell Foundation
National Alliance for Autism Research
Mabel Flory Trust
Pfizer, Inc.

Declarative Memory System

- Learning & processing of facts, events
- Specialized for arbitrary relations
- Explicit and implicit knowledge
- Medial & lateral temporal-lobe; frontal regions (BA 45/BA 47, BA 10)
- Modulated by estrogen, acetylcholine
- Genes: BDNF, possibly others



Procedural Memory System



- Learning & control of cognitive and motor "skills" (e.g., riding a bicycle)
- Specialized for sequences and rules
- Implicit knowledge
- Left frontal (BA 44/premotor)-basal ganglia circuits; superior temporal cortex
- Modulated by dopamine
- Genes: possibly DAT, others

First Language (L1)

First Language

Declarative/Procedural Model

Declarative memory system

Procedural memory system

Lexicon
Memory store: ***(at least)***
all word-specific information:
-simple words (cat)
-irregulars: (dig-dug)
-complements (hit [direct object])

Language

Grammar
Rule-governed hierarchical and sequential (de-)composition of complex forms:
-syntax (the cat; NP VP)
-morphology (regulars: walk -ed)

First Language

Empirical Evidence

1. Psycholinguistic
   - Frequency effects
   - Similarity (neighborhood) effects
   - Priming effects
   - Working memory effects

2. Neurological
   - Aphasia
   - Neurodegenerative disease (AD, PD, HD, semantic dementia)
   - Developmental disorders (SLI, autism, other)

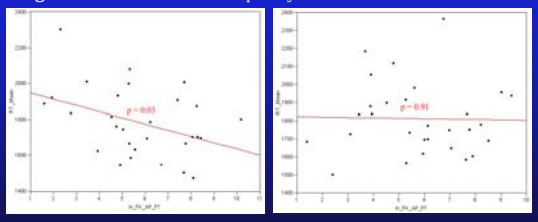
3. Neuroimaging
   - Electrophysiological: ERP
   - Hemodynamic: fMRI, PET

4. Molecular

First Language

Psycholinguistic

Frequency effects:
- **Irregulars:** Consistent frequency effects
- **Regulars:** No consistent frequency effects



Evidence Suggests:
- **Irregulars:** Retrieved from memory
- **Regulars:** Can be (de)composed in real time to/from their parts

First Language

Neurological: Aphasia

Posterior Aphasia

Lesions: Left temporal regions
Behavior:
- Impaired at content words, conceptual knowledge, irregulars
- No agrammatism, no difficulty with regulars, no motor problems

Anterior Aphasia

Lesions: Left inferior frontal and basal ganglia structures
Behavior:
- Agrammatism, problems with regulars, motor deficits
- Relative sparing of content words, irregulars, conceptual knowledge

Compensation: Storage of complex forms (eg, walked) in lexical memory

(Goodglass, 1993: Alexander, 1997; Ullman, et al., 1997; Ullman, Pancheva, et al., in press)

First Language

Neurodegenerative Diseases

Alzheimer's Disease

Degeneration: Temporal > frontal (Broca's/premotor)/basal-ganglia
Behavior:
- Impaired at learning new, using old content words, facts, irregulars
- Sparing of motor & cognitive skills, regulars, maybe syntax

(Arnold et al., '91; Beatty et al., '94; Nebes, '97; Ullman et al., '97; Ullman, '99; Ullman, in press; Walenski et al., under revis.)

Parkinson's Disease

Degeneration: Primarily frontal/basal-ganglia
Behavior:
- Impaired at motor & cognitive skills, syntax, regulars
- Relatively spared: learning new, using old content words, facts, irregulars

(Dubois et al., '91; Lieberman et al., '92; Young & Penney, '93; Ullman et al., 1997; ; Ullman, 1999; Ullman, in press; Estabrooke & Ullman, in prep.)

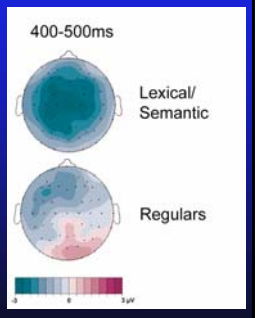
First Language

Event-Related Potentials (ERPs)

ERPs are the EEGs following stimuli (e.g., words).

Lexical/Semantic processing:
- Central Negativity (N400)
  - Temporal lobe

Grammar processing difficulties:
- Left Anterior Negativity (LAN)
  - Left frontal
- Central/posterior positivity (P600)
  - Basal ganglia



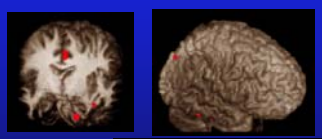
(Friederici et al. 1993, 1996, 1998; Kutas & Hillyard, 1980; Neville et al., 1991; Kotz et al., 2003; Osterhout & Holcomb, 1992)

First Language

Hemodynamic Neuroimaging: fMRI, PET

- Measure changes in blood oxygenation/flow in the brain.
- Changes correlate with changes in neural activity.

Lexical processing:
- Temporal lobe regions; BA 45/47 for retrieval



Grammatical processing:
- Broca's (especially BA 44); basal ganglia (caudate nucleus); superior/anterior temporal cortex

(Damasio et al., 1996; Embick et al., 2000; Indefrey et al. 1999; Moro et al., 2001; Newman et al., 2001; Ni et al., 2000; Stromswold et a. 1996; Friederici, 2002, 2004)

First Language

Data Suggests That in L1

Language	Lexicon	Grammar
Computation	Associative memory	Rule-governed composition
Brain Systems	Declarative Memory	Procedural Memory
Non-Language	Facts, Events	Motor, Cognitive skills
Specialized for	Arbitrary relations	Sequences
Anatomy	Medial & lateral temporal cortex; BA 45/47, BA 10	Left BA 44/premotor-basal ganglia circuits; superior temporal
Molecular	Estrogen; acetylcholine	Dopamine
Genetic	BDNF	DAT?

(for reviews and discussion, see Ullman et al., 1997; Ullman, 2001a, b, 2004, 2005; Ullman & Pierpont 2005)

Late-Learned Second Language (L2)

Second Language

Declarative/Procedural Model: Low L2 Experience

Declarative memory system

Procedural memory system

Lexical/Declarative Memory

-All word-specific information
-Stored complex structures (walked)
-Declarative memory based rules

Language

Grammar

Little or nothing learned and processed here

Second Language

Declarative/Procedural Model: High L2 Experience (L1-Like)

Declarative memory system

Procedural memory system

Lexicon

Memory store: (*at least*)
all word-specific information:
-simple words (cat)
-irregulars: (dig-dug)
-complements (hit [direct object])

Language

Grammar

Rule-governed hierarchical and sequential (de-)composition of complex forms:
-syntax (the cat; NP VP)
-morphology (regulars: walk -ed)

Second Language

Frequency Effects

Lower L2 experience (Brovetto and Ullman, 2001)
- Subjects: L2 Learners of English (mean of 6 years exposure)
- Results: Frequency effects for irregulars *and* regulars
- Suggests: Regulars and irregulars *both* stored

Higher L2 experience (Birdsong and Flege, 2001)
- Subjects: L2 Learners of English (10 to 16 years of exposure)
- Results: Frequency effects for irregulars but *not* regulars (L1-like)
- Suggests: Irregulars stored, *not* regulars (i.e., like in L1)

Second Language

Neurological: Focal lesions, Alzheimer's & Parkinson's

Temporal-lobe damage (herpes simplex, Alzheimer's)
- L2 worse than L1, including syntax

Frontal or basal-ganglia damage (left focal lesions, Parkinson's)
- Grammar: L1 *and* highly-practiced L2 worse than less-practiced L2
- Lexicon: No L1/L2 difference

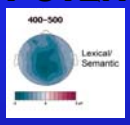
(Ku, Lachmann, & Nagler, 1996; Fabbro & Paradis, 1995; Ullman, 2001c; Zanini et al, 2004)

Second Language

Event-Related Potentials

Lexical/semantic processing

- Low *and* high proficiency L2:
  - N400s present



Grammatical processing

- Lower proficiency L2:
  - No LANs; sometimes N400-like negativities
  - P600s generally present
- Higher proficiency L2:
  - LANs (including in artificial language)
  - P600s

(Webber-Fox and Neville, 1996, 1999; Osterhout & McLaughlin, 2000; Hahne, 2000, 2001; Hahne and Friederici, 2001; Friederici, Steinhauer & Pfeifer, 2002, Ojima et al, 2005)

Second Language

Artificial Language: Explicit and Implicit Training

Work with Kara Morgan-Short, graduate student from Spanish and Portuguese Dept. (now Assistant Professor, Univ of Illinois, Chicago)

Explicit Training: The rules of the language are...
Implicit Training: Rapid auditory sentence presentation...

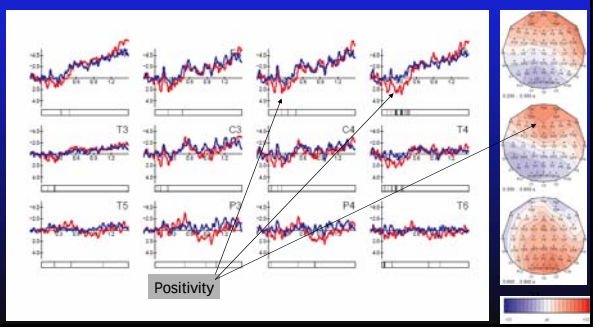
Results:

1) Behavioral: No differences between the training groups

2) ERP: ...

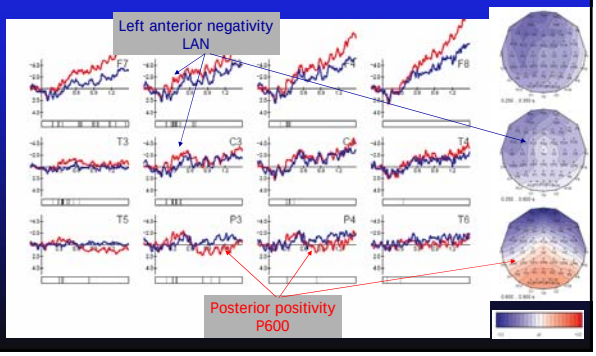
Second Language

Explicit Training: High Proficiency (Syntactic Violation)



Second Language

Implicit Training: High Proficiency (Syntactic Violation)



Second Language

Hemodynamic Neuroimaging

Lexical/semantic processing tasks:

- No L1/L2 differences in activation patterns
  (Chee et al 1999; Illes et al 1999; Klein et al 1999; Pillai et al 2003)
- Minimal L1/L2 differences (likely reflecting articulation, retrieval)
  (Klein et al 1995; Chee et al 2001; De Blesser et al 2003)

Sentence (syntactic) processing tasks:

- Greater activation in declarative memory structures in L2 than L1 – especially in lower proficiency L2 learners
  (Perani et al 1996; Perani et al 1998, Exp 1; Dehaene et al 1997; Opitz & Friederuci, 2002; Wartenburger et al 2003; Exp 1)
- Greater activation in procedural memory structures (left BA 44) in L2 than L1 - but only in higher proficiency L2 learners
  (Wartenburger et al 2003, Exp 2; Ruschemeyer et al 2005; Opitz & Friederuci, 2002)
- Artificial language learning, within-subjects (Opitz and Friederici, 2002)
  - low-proficiency: medial and lateral temporal activation
  - high-proficiency: activation in left BA 44

Overall Summary: L1 and L2

1. **Linguistic representations with arbitrary relations:**
   - *Always* seem to be stored in lexical/declarative memory – in L1 & L2.

2. **Rule-governed complex representations**:
   - **In L1, and in high experience L2:**
     Often (but *not* always) put together by the grammatical/procedural system
   - **In lower experience L2, and with disordered procedural memory:**
     Depend largely on lexical/declarative memory

Current & Future Directions

- **Individual differences in L1 and L2 learning:**
  - sex differences, endocrine effects, effects of age, handedness differences, genetic variability (e.g., BDNF polymorphisms), etc.
- **Improving L2 learning:**
  - selecting high-aptitude individuals
  - pharmacological manipulations
- **Therapeutic interventions for language disorders:**
  - behavioral and pharmacological manipulations of the memory systems