

## CONTRIBUTIONS OF MEMORY BRAIN SYSTEMS TO FIRST AND SECOND LANGUAGE

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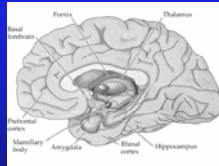
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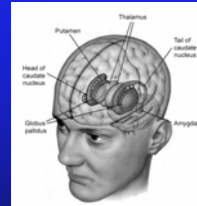
## DECLARATIVE MEMORY SYSTEM

- 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)

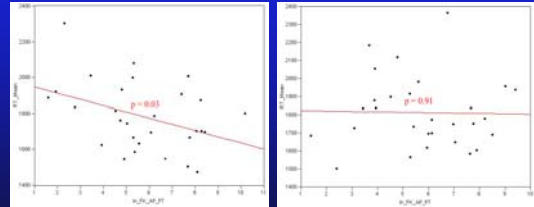
## EMPIRICAL EVIDENCE

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

## 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

## 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)

## 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.)

## EVENT-RELATED POTENTIALS (ERPs)

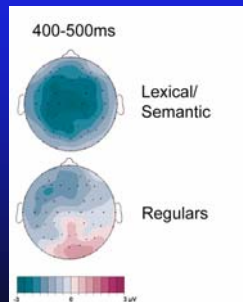
ERPs are the EEGs following stimuli (e.g., words).

### Lexical/Semantic processing:

- Central Negativity (N400)
  - Temporal lobe

### Grammar processing difficulties:

- Left Anterior Negativity (LAN)
  - Left frontal
- Central/posterior positivity (P600)
  - Basal ganglia



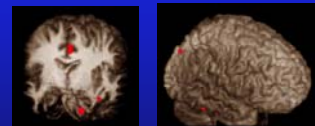
(Friederici et al. 1993, 1996, 1998; Kutas & Hillyard, 1980; Neville et al., 1991; Kotz et al., 2003; Osterhout & Holcomb, 1992)

## 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 al., 1996; Friederici, 2002, 2004)

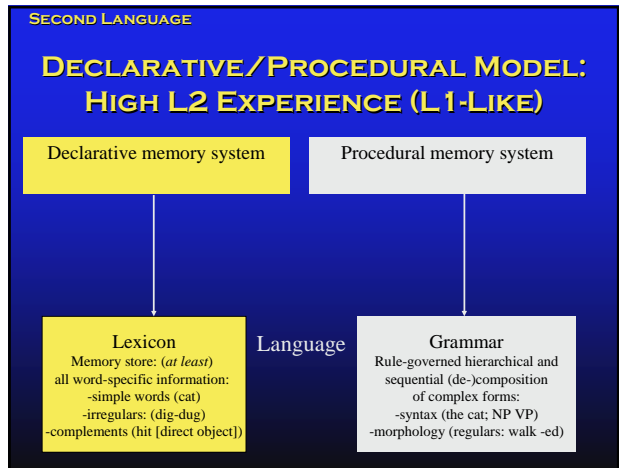
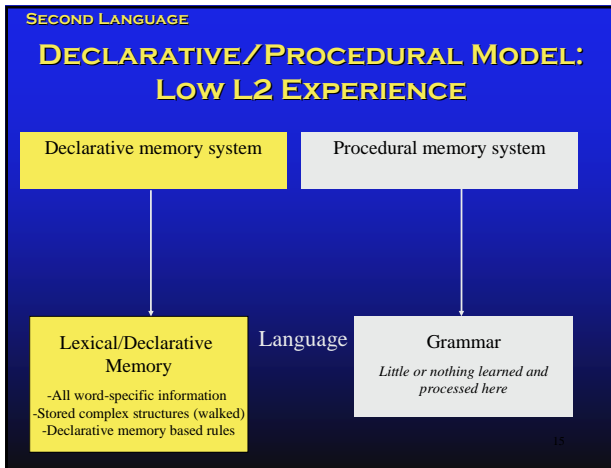
**FIRST LANGUAGE**

## 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**

## FREQUENCY EFFECTS

**Lower L2 experience** (Bovetto 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

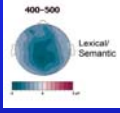
(Ku, Lachmann, & Nagler, 1996; Fabbro & Paradis, 1995; Ullman, 2001c; Zanini et al., 2004)

**SECOND LANGUAGE**

## EVENT-RELATED POTENTIALS

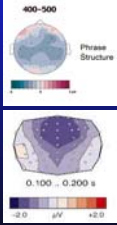
**Lexical/semantic processing**

- 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, Steinhauser & 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...

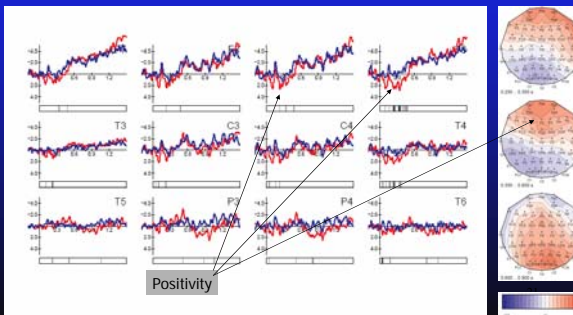
**Implicit Training:** Rapid auditory sentence presentation...

**Results:**

- 1) Behavioral: No differences between the training groups
- 2) ERP: ...

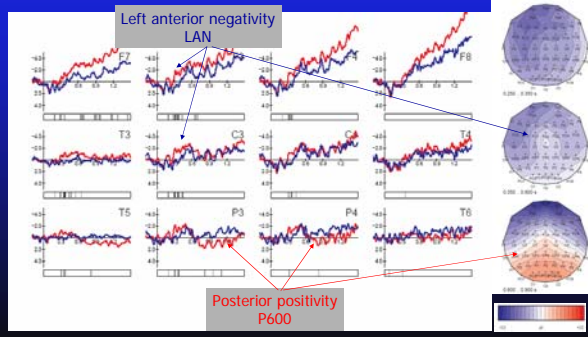
**SECOND LANGUAGE**

## EXPLICIT TRAINING: HIGH PROFICIENCY (SYNTACTIC VIOLATION)



**SECOND LANGUAGE**

## IMPLICIT TRAINING: HIGH PROFICIENCY (SYNTACTIC VIOLATION)



**SECOND LANGUAGE**

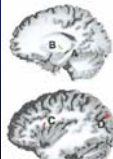
## HEMODYNAMIC NEUROIMAGING

**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 & Friederici, 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; Ruschenmeyer et al 2005; Opitz & Friederici, 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