Week 11a. Neurolinguistics and bilingualism: Aphasia

Language and the brain

- How is language represented in the brain?
- What are the differences between the language representations found in monolingual speakers and in bilingual speakers (of varying degrees of L2 proficiency)?

Localization

- Brain = mass of interconnected neurons.
- Divided into two halves, left and right hemisphere.
  - The hemispheres are quite separate but for the corpus callosum which connects the two.
  - The connection to the outside world is generally contralateral—right hemisphere has control of left side motor control, receives left visual and aural input, etc.
- Certain areas of the brain have specific functions (visual cortex; auditory cortex; motor cortex) despite high levels of interconnectivity.
- Does language specifically have its own area?

Broca’s area

- After several more patients were studied postmortem, the pattern emerged—lesions in the left hemisphere in this region seemed to correlate with this language deficit.
- >95% of right-handed people have primary language functions lateralized to the left hemisphere (and over 90% of people are right-handed).

Broca, French surgeon, 1861.
- Saw patient who lost his ability to speak (could only utter the monosyllable tan except if agitated—reputedly often—when he could swear).
- Intelligence, comprehension spared
- Gradual paralysis of right side of the body.
- In autopsy, a lesion was discovered in what became known as “Broca’s area”—left hemisphere, frontal lobe.
Aphasias

- **Broca’s aphasia.** Spontaneous speech effortful, closed-class words omitted, verbal comprehension of simple sentences is good, repetition ability limited. Frequently accompanied by right-side paralysis. Awareness of deficit.

- **Wernicke’s aphasia.** Fluent speech but with many non-words. Verbal comprehension, naming, repetition impaired. Often accompanied by blindness in right visual field. Lack of awareness of deficit.

Function areas

- We can make some guesses as to what the functions of the areas of the brain are, based on what happens in aphasic patients.

- Anywhere between Broca’s area and Rolandic fissure results in non-fluent speech.
### Function areas

- Anywhere between Broca’s area and Rolandic fissure results in non-fluent speech.
- Anywhere between Wernicke’s area and Rolandic fissure results in poor comprehension.

### Concepts

- Verbal motor memory
- Acoustic word memory

### Aphasias

- Broca’s nonfluent comp ok rep poor
- Wernicke’s fluent comp poor rep poor
- Conduction fluent comp ok rep poor
- Anomic fluent comp ok rep ok
- Transcortical sensory nonfluent comp poor rep poor
- Transcortical motor nonfluent comp ok rep ok

### Lateralization

- The two hemispheres of the brain also seem to have somewhat different functions.
- Left hemisphere generally controls the majority of language function.
- Right hemisphere appears to be involved in maintaining focus of attention, and also possibly prosody.
  - Right hemisphere lesions have been known to severely affect ability to analyze metaphors, summarize complex texts, as well as disrupt prosody in otherwise normal language.

### Dichotic listening

- Consider three kinds of audio stimuli (verbal, environmental noise, music).
- Present two different kinds of stimuli to each ear of a subject simultaneously, have them write down what they heard.
- Turns the right ear (processed by the left hemisphere) is superior for the purposes of identifying verbal stimuli, left ear (processed by the right hemisphere) superior for the others.

### Verbal-manual interference

- A similar task: Get subject to tap a key as rapidly as possible with left hand, then with right hand. Record control condition result.
- Then, have them perform a verbal task (recite days, count, etc.), and test the tapping.
- Right-hand (left hemisphere) interference will be greater—right-hand tapping will slow down more than left-hand tapping will.
Memory

- A primary concern of neuroscience has been the mechanisms of memory, which comes in various forms with various properties.

- Many studies carried out to determine what happens to the brain of an animal having learned a task.

Neural connections

- Individual neurons are connected to one another via excitatory and inhibitory connections, and has a certain level of activation. When a neuron’s level of activation reaches a critical threshold, the neuron fires, spreading positive activation to other neurons that it is excitatorily connected to and negative activation to neurons that it is inhibitorily connected to.

- Neurons that fire together wire together. Connections are developed or strengthened between neurons whose firings temporally coincide. Function has changed. Memory. It becomes likely now that if one fires the other will too. Long-term memory?

A neuron

- Working memory is short term, used for immediate memorization/repetition tasks, remembering what was just said.

- Working memory and long term memory appear to be doubly dissociable:
  - H.M. (Milner et al.): Long term memory storage mechanism impaired as result of brain surgery to relieve severe epilepsy. Working memory, intelligence, linguistic competence unimpaired; old memories retained; no new memories could be stored (didn’t recognize therapist, couldn’t remember new address).

Long term memory types

- Long term memory comes in different kinds as well.

- Explicit memory: Conscious, learned, able to be recalled and expressed. Both semantic (knowledge of world) and episodic. (Krashen’s “learning”)

- Implicit memory: unconscious, skill learning, improves with repetition. (Krashen’s “acquiring”?)

  - Should implicit memory be split into two types (driving a stick shift, learning to speak French)?
How about multiple languages?

• What about a second language?

• Are the same brain areas used for both L1 and L2? Or are they different? Or do they overlap?

• What can we learn about the comparability of L1 and L2?

Recovery from aphasia

• When a bilingual suffers from an aphasia, several things can happen during recovery (assuming recovery)

• Parallel recovery

• Differential recovery
  – L1 recovers faster (“Ribot’s law”—old before new)
  – L2 recovers faster (“Pitres’ law”—frequent first)

• Recovery generally implies that the actual language centers haven’t been destroyed, only either cut off or inhibited.

Recovery from aphasia

• The fact that L1 and L2 can recover independently implies that they are at least in part differentially represented in the brain.

• Case: Dimitrijevic (1940). Woman grew up in Bulgaria, Yiddish home language, moved to Belgrade at 34 and spoke Serbian (and Yiddish) from then on, “forgetting” Bulgarian. A brain injury at 60, after two months for recovery, resulted in her only being able to speak Bulgarian and Yiddish; she could no longer speak Serbian (though she could understand it), despite it having been her dominant language for 25 years.

Second language recovery

• Almost 1/3 of reported multilingual aphasics do not recover their L1, but their L2 (L3, …).

• Case: Minkowski (1928). Patient’s L1 was Swiss German, learned standard German in school, moved to France for 6 years, became fluent in French, then moved back to Switzerland (using SG, though still reading French). 19 years later, had a stroke. After 3 days for 3 weeks spoke only (increasingly fluent) French, then started recovering German, but for 6 months was incapable of using SG. Around Christmas, suddenly SG returned (to the detriment of French).

Factors involved in L2 recovery?

• Minkowski’s idea is that the languages are not really spatially separated, but that they exert mutual inhibition in a fairly delicate balance. A lesion will disrupt that balance and can suppress a language (including L1).

• In support, often “lost” languages can be recovered faster than usually required to “learn from scratch”.

• Also, autopsy studies don’t seem to reveal a larger extent to Broca’s area in polyglots (Sauerwin, spoke 54 languages both at poetry and prose level; normal extent and development in Broca’s area)

Factors involved in L2 recovery?

• Familiarity often is the determining factor.

• Conscious vs. unconscious knowledge.

• Conversational vs. written modality.

• Psychological, emotional factors.

• Language spoken to patient in hospital.

• Domain-specific (rote) language

• Higher inhibition levels between closely-related languages.
Recovery of non-communication languages

- Case: Grasset (1884). Patient knew only French (never studied other languages), but then had a stroke and after a few days, began speaking only Latin (single words only, primarily prayer-related).
- Case: Pötzl (1925). Professor who knew several modern languages as well as classical Greek and Latin. After a stroke, he was only able to express himself in the dead languages, which he only knew through reading.

Recovery of non-communication languages

- Case: Gelb (1937). WWI officer acquired aphasia. Pre-war had been a professor of classical languages. Post-injury he could no longer speak, but could still read and could express himself correctly in Latin. Facilitated his rehabilitation by communicating thus: he’d build a Latin sentence corresponding to what he wanted to say, then translate it into German.
- Suggests? Perhaps implicit/automatized knowledge was lost more readily in the aphasia, whereas the consciously learned languages were spared, in explicit memory. (connection to learning by writing)

Selective crossed aphasia

- Case: Paradis & Goldblum (1989). L1 Gujarati, from Madagascar (spoke Malagasy), learned French in school. After brain surgery, tested fine in French but was having trouble with Gujarati at home—fairly classic Broca’s aphasia symptoms. Malagasy was fine. Over following months, Gujarati was recovered, but at the expense of Malagasy. 2 years later, Gujarati was fine, Malagasy was impaired. 4 years later, both were fine.
- Suggests differential inhibition (rather than localization); languages differentiated at a functional level, but not necessarily neuroanatomical.

Differential aphasia

- Case: Albert & Obler (1975). Hungarian L1, Lived variously in France, England, and US, moved to Israel at 16, then had brain surgery to remove a tumor at 35. 10 days later, exhibited Broca’s aphasia in Hebrew and Wernicke’s aphasia in English (understood but could barely speak Hebrew, couldn’t understand English but spoke it fluently). Deficits in Hungarian and French were mild.
- If this is same lesion having differential effects on two languages, suggests that the two languages do have some spatial differences in localizations—still fairly hotly debated, though.

Pathological switching and mixing

- Healthy bilinguals speaking to other bilinguals will often code-mix or code-switch.
- Aphasic bilinguals sometimes mix unconsciously without regard to the normal conversational triggers of code-mixing (often using multiple languages in conversation with monolingual speakers).
- Or, they will show fixation on one language, responding only in one language regardless of the language in which they are addressed.

Alternating antagonism

- More dramatic cases reported where patients switch week by week or day by day between near-total control and near-absent control of one language, in complementary distribution to another.
- Case: Bruce (1895): Welsh/English (Welsh, left handed, demented, docile; English, right handed, restless and destructive). Alternated sometimes several times per day.
- Bruce proposed this was due to differential hemispheric dominance; later supported by studies of subjects with severed corpus callosum. Suggested left hemisphere was home of abstract (instructable) capacities.
Child aphasia

- Acquired aphasia during childhood is almost never fluent (mutism), but they recover rapidly (lasting effects generally only slight word-finding and vocabulary difficulties).
- Recovery is faster, better than in adult acquired aphasia, but not complete.
- Early enough, right hemisphere can take over language functions after a serious loss in the left hemisphere, but it doesn’t do as good a job.

- Lenneberg’s summary of the results of left hemisphere lesions as a function of age:
  - 0-3mo: no effect
  - 21-36mo: all language accomplishments disappear; language is re-acquired with repetition of all stages.
  - 3-10ye: aphasic symptoms, tendency for full recovery
  - 11ye on: aphasic symptoms persist.
- Basis for his view that lateralization was tied to critical period.

Translation

- Aphasic deficits in translation capabilities suggest that translation too might be a separate system.
- Reported cases of loss of ability to translate (though retaining some abilities in each language).
- Other reported cases of loss of ability not to translate; Case: Perecman (1984): patient would always spontaneously translate German (L1) sentences uttered into English (L2) immediate afterward, yet could not perform translation task on request.

- Sometimes this can happen even without comprehension; Case: Veyrac (1931): patient (English L1, French dominant L2), could not understand simple instructions in French, but when instructed in English would spontaneously translate them to French and then fail to carry them out.

Paradoxical translation

- Case: Paradis et al. (1982). Patient switched (by day) between producing Arabic and producing French. When producing only Arabic, she could only translate from Arabic into French; when producing only French, she could only translate from French into Arabic.

Bilingual representation

- A number of dissociated phenomena in bilingual aphasia studies.
  - Sometimes only one language returns, not always the L1
  - Production and comprehension and translation seem to be separable, and even by language.
  - Monolingual aphasia studies seem to correlate lesion localization with function.
  - Not much evidence for localization differences between multiple languages per se.
  - Some evidence for localization differences between types of learning? (written, conscious vs. unconscious, implicit vs. explicit memory?)
Bilingual representation

- Given the postmortem studies showing no real morphological differences between monolinguals and polyglots, the most consistent picture seems to be one of shared neural architecture with inhibition between languages.
- Choice of language A inhibits access to grammar, vocabulary of language B during production.
- Comprehension is often spared even in the face of production inability, suggesting that the same kind of inhibition does not hold of comprehension.

Bilingual representation

- Many of the aphasic symptoms in production can be described in terms of changing inhibitions; the lesion disrupts the balance of inhibition and excitation between neural structures, leading to:
  - loss of inhibition (pathological mixing)
  - heightened invariant inhibition (fixation)
  - shifting inhibition (alternating antagonism)
  - psychological inhibition (repression)

Subsystems

- There also seem to be several subsystems which can be individually impaired.
  - Naming, concepts
  - Fluency of production
  - Ability to retain and repeat
  - Translation from L1 to L2
  - Translation from L2 to L1
- Some of these seem to correlate with localization differences.

More modern methods and results

- Recording electrical activity in the brain can also help us see which parts are used in language tasks
  - Electroencephalogram (EEG)
  - Event-related potentials (ERP)
  - Magnetoencephalogram (MEG)
- Functional brain imaging
  - Computer axial tomography (CT) (X-rays)
  - Positron emission tomography (PET)
  - Functional magnetic resonance imaging (fMRI)
More modern methods and results

- Wada test. Sodium amytal causing temporary neural paralysis can simulate a possible aphasia (in order to avoid it during neurosurgery).
- Electrical stimulation. Similar but shorter term, more localized.
- Results are mainly in line with other knowledge, but the problem with these tests is that a) electrical stimulation is hard to repeat (imprecise), b) both methods can only be used on people waiting for neurosurgery who may have abnormal brains.

Differences between bilingual and monolingual representations

- Best guess at this point is that there is overlap—the several languages make partial use of physiologically distinct areas of the brain, but also share a lot in common.
- Some evidence that second language has a right-hemisphere component, more diffuse than first language, although directly contradictory findings have also been reported.
- The state of things is actually a little bit disappointing—but it turns out to be hard work...!