PSYCHOLINGUISTICS AND NEUROLINGUISTICS:
SOME INTERESTING TOPICS

Theme
A background informational lecture on psycho- and neurolinguistics, as they pertain to computational work: what it's about, what has been proved, what's suspected, and what’s hard to do.

Summary of contents
Human language is a creation of the human mind. Yet in computational linguistics we pay no attention whatsoever to what can be learned about the way the mind/brain performs language. (In that respect, the question is different from, say flight, which is external to the mind. While it’s interesting to study how birds fly, it’s legitimate to study how to build planes independently.)

In this lecture we take a look at how psycholinguists and neurolinguists respectively study human language from the psychological and neurological points of view.

1. Psycholinguistics

The goal: test by experiment the theories of language — its nature, structures, and processing. Principal areas of concern: syntax, semantics, child learning and development, and cognition in general. Psychologists’ ‘tools’: reaction time measurements, remembering and confusion effects, eye tracking.

1a. Syntax:
Work here much influenced by Chomsky school's claims about the “reality” of syntactic structures. What they mean is the presence, as a separate psychological/processing construct, of syntactic information and processing. How can this be tested?

Experiment 1. Click experiments. Fodor, Bever, and Garrett (MIT, 1965): Subjects wear headphones, hear a sentence, and somewhere hear one click during the sentence. Subjects must report where they heard the click. Example:

That he was happy was evident from the way he smiled

↑       ↑

With this kind of sentence structure (called a “cleft sentence”), the subjects’ reported experience of the click is reliably moved to the syntactic break in the sentence, i.e., just after “happy”. Why? Because processing is “busy” with something that only ends at the syntactic break. This is neither a lexical nor a semantic phenomenon, but depends on syntax alone: you can replace the words and the effect remains.

Experiment 2: Spacing experiments. Experimenters recorded someone reading a sentence, and then played the recording to subjects and asked them where major time gaps occurred. They then cut up the recording into parts and spliced a part after another sentence start, one chosen so that the syntactic structure of the transferred sentence fragment was different. Now, the subjects reported that the major
time gap ‘occurred’ at the new constituent boundary, even though it was the identical piece of tape from before! For example

As a result of their invention’s [ influence the company was given a reward ]

The chairman whose methods still [ influence the company was given a reward ]

So: What is the reality of syntactic structure or process?

**Experiment 3: Open and closed wordclasses.** Is there a difference between closed-class words (grammatical functors like prepositions, determiners, etc.) and open-class words (nouns, verbs, etc.)? Apparently so. Experimenters provide sentences in which one word has been replaced by a nonsense word, and ask subjects to indicate as soon as they recognize that it is not a real word. There is much faster recognition of nonwords in closed-class positions than in open-class positions, except for agrammatical speakers (see Figure 0 below).

**Experiment 4: Parts of speech ‘activity’ latencies.** Are there processing differences between verbs and nouns? Indeed. Experimenters in Holland (De Goede) in 2007 asked more than 400 study subjects in eight different experiments to listen to about 120 spoken sentences per experiment. While listening they were shown words on a computer screen and they had to indicate whether or not these were real Dutch words. Half of the words were related in meaning to the verbs from the sentences being played at that moment. At different points in the sentence, the study subjects were found to more quickly recognize verbs as genuine if these had a meaning related to the verbs in the sentences being played. From this it was concluded that at these points in the sentence the verb was ‘active’.

A series of experiments revealed a clear pattern: in complex Dutch sentences, consisting of a main clause followed by a secondary clause, the verb was activated until the end of the main clause. In other words, the meaning of the verb remains with the listener until the end of the main clause and subsequently disappears in the next clause.

But verb activation differs considerably from noun activation. For example, although a noun becomes active immediately after its use, this effect has virtually disappeared well before the end of the main clause. According to De Goede one reason for this is the fact that verbs nearly always have several meanings, whereas that is not the case for nouns. The exact meaning of a verb depends on the sentence context.

Levell et al. on generation.

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**1b. Semantics:**
Is there a real difference between syntax and semantics? How would you prove this?

**1. Syntax vs. semantics.** Syntactic structure is not remembered, but semantics is. Repeat a sentence with syntactic or semantic changes after varying lengths of time and ask subjects if it is identical to what they heard originally (Slobin p 31):

- **Original sentence:** He sent a letter about it to Galileo, the great Italian scientist.
- **Semantic change:** Galileo, the great Italian scientist, sent him a letter about it.
- **Active to passive (syntactic) change:** A letter about it was sent to Galileo, the great Italian scientist.
- **Formal (syntactic) change:** He sent Galileo, the great Italian scientist, a letter about it.
When the repeat came after no delay, subjects recognized syntactic and semantic differences correctly. After a delay of between 27 and 46 seconds, the memory of the syntactic form fades, while semantics remains. Overnight, syntax is completely gone, but semantics not.

2. Processing time. There is no correlation (when corrected for length etc.) between syntactic complexity and processing time, though there is a positive correlation with semantic complexity.

3. Some word association tests: Provided with words like “chair”, subject reliably respond with words like “table”, “stool”, etc., and never with “sausage” or “Sahara”. Why? (Slobin p 80). Miller’s work on the lexicon and mental connections (also WordNet 90); the nontransitivity of antonym/synonym from dripping-wet-dry-arid.

4. Does language determine thought or vice versa? Whorf’s claim that language determines thought. Hopi time; Eskimo snow (Slobin p 124).

5. Scripts/MOPs: What types/levels of semantics are there? Bower, Black, and Turner’s experiments with memory confusions (Black 80): read two stories (doctor visit and dentist visit): where did the person read the magazine? Interchangeability of scenes in a script.

1c. Language development:
Do you think in language or in thought? Vygotsky, a Russian linguist, believes that language and thought develop in parallel: The child starts with language to communicate everything, essentially stream-of-consciousness reporting, but after some years this becomes internalized (as thought), while only explicit communication remains external (as language). In contrast, the Swiss psychologist Piaget believes the opposite: thought develops first and language use follows it. Piaget shows examples of children learning to use “because” or “so” to differentiate CAUSE from TEMPORAL-SEQ at the age of 5 or 6.

1d. Summary:
Not a hell of a lot known. Hard to test; not clear what tests mean.

2. Neurolinguistics

The goal: Study nature, processes, components, etc., of language by studying the brain's workings. Principal areas of concern:
• identify processing by inducing impairments (shocks, etc.)
• gather knowledge by comparing aphasics to normal people

a. Location: It’s clear that language is processed in the brain (not in the torso, as the Greeks thought!). Various areas in the brain: Figures 1 and 2. Where is language? Inject one hemisphere and see when/if the subject stops counting.

Various parts of brain seem to control various aspects of language: Broca’s area (left side) seems to control syntax and Wernicke’s area, semantics. But this is not true for all people; in some it is equally spread. In some people Wernicke’s area is enlarged.

For example: Is there a difference in processing between closed-class words (grammatical functors like prepositions, determiners, etc.) and open-class words (nouns, verbs, etc.)? Yes: normal speakers show
difference is reaction time when confronted with nonwords (made up words) in closed-class or open-class sentence positions, but Broca’s aphasics (agrammatic speakers) do not. See Figure 0 below.

Figure 0. Processing time difference for open- and closed-class words between normal and agrammatical speakers.
Examples of Wernicke patient language:
I spoke to the axiom in the window. I sprintered the Green aside the window. Many times as I
looked at the Capitol I wonder the many times were engaged at the same time by the representatives
as they behaved the problems.

My wires don’t hire right.

I’m supposed to take everything from the top so that we do four flashes of four volumes before we get
down low.

b. Various dysfunctions: There are various kinds of word-access/production aphasics (anomies): see
Figures 3 and 4. The many different things that can ‘break’ illustrate the complexity of the various
aspects of a word—its sound, spelling, supertype, definition, etc.—and of the access mechanisms.

The interesting case of Sailer, an engineer, whose brain tumor was (mostly) cut out by careful mapping of
which parts of his brain were actively required for lexical access.

Williams and Downs Syndromes: in both cases, patients may have an IQ around 50, but in the former
they have markedly better language skills. See Fig. 5.

c. American Sign Language: Create reference point in space to signify each discourse referent, also use
semantics of movement to express word shadings. Doesn’t work for Wernicke’s aphasics — thus mirrors
linguistic aphasia.

d. Hemisphere dominance: Mostly in later, high-order reasoning; theory that done in both sides but the
faster one wins out. Linked by corpus callosum. Differential processing after lesions. See Figure 6.

Difference in reaction time for open- and closed-class words falls away with Broca’s aphasics (shown
above).

Optional Readings

Psycholinguistics: From Slobin, perhaps.
Neurolinguistics: From Studdert-Kennedy, perhaps.

Assignment

None.
Fig. 1: Brain areas

Fig. 6.3. Patterns of brain activity. Summarizing diagram of seven modes showing
1. Functions above 70% and below 20% of the hemisphere mean. The values
Fig. 1. Left and right lateral view of cortex with the auditory areas unfolded for expository purposes. 44/45 - Broca's area, PCG - precentral gyrus, SMG - supramarginal gyrus, AG - angular gyrus, FO - frontal operculum, I - insula, H - Heschl's gyrus, PO - parietal operculum, a(p)STP - anterior (posterior) superior temporal plane, STG - superior temporal gyrus, MTG - middle temporal gyrus.
Fig. 3: Word production aphasia types

14.3
Aphasic syndromes of the posterior sector correspond to levels in semantic or phonological realization.

14.4
Levels in language production in the posterior sector and corresponding levels in brain structure.
1. **Word-production anomia**
   a. *Articulatory initiation* Some aphasics cannot name an object (for example, comb), but a cue, the initial consonant or an open-ended sentence, often produces the correct name. This is seen most typically in Broca’s aphasia.
   b. *Paraphasic* Some aphasics produce an answer to naming requests with the correct number of syllables, but substitute one or more phonemes, producing a neologistic response. Most often this occurs in conduction aphasia.

2. **Word-selection anomia** In “pure” anomia the subject cannot produce the name of an object, but recognizes the name and can give a correct description of the use of the object. The most pure anomia is found when there is damage to area 37 of inferotemporal cortex.

3. ** Semantic anomia** In anomia of this type, words appear to lose their semantic value; though a subject may repeat the word correctly, the object cannot be named, and when the name is offered, the object cannot be selected. This disorder is usually seen when there is injury to the angular gyrus.

4. **Category-specific anomia** This is a disconnection syndrome in which the subject has notable naming disability in only a single category (for example, colors, body parts). The pathology is located in various parts of the posterior hemispheres, separating the angular gyrus from selected sensory areas.

5. **Modality-specific anomia** This also is a disconnection syndrome; for instance, a subject cannot identify an object by one sensory modality (for example, sight), but names it by others (hearing or touch). Visual agnosia is one example of such an anomia.

6. **Disconnection anomia** Following section of the corpus callosum, the isolated right hemisphere cannot name objects palpated in the left hand.

7. **Anomia of dementia** Both Alzheimer’s disease and Pick’s disease produce serious naming problems that are somewhat different from any of the above (and from each other).
Fig. 5: Text and pictures of Williams and Downs Syndrome patients

The Making of a Cognitive Profile

A part of an effort to pinpoint cognitive features that are characteristic of Williams people, investigators have compared subjects with Williams and with Down syndrome on tests of specific abilities. One test (top)—which asked adolescents to copy from memory a letter D that was built from a collection of small Ys—revealed impairment in integrating details into a larger configuration. The Williams group tended to draw only Ys, whereas the Down group tended to maintain the overall configuration but omit local details. Another test (bottom)—in which subjects had to invent a story for a series of wordless pictures—revealed that Williams people can often generate well-structured narratives.

### Task: Reproduce Image

<table>
<thead>
<tr>
<th>Williams Subjects</th>
<th>Down Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Williams Image]</td>
<td>![Down Image]</td>
</tr>
</tbody>
</table>

### Task: Invent a Story for the Pictures

**Williams Subject, age 17, IQ 50**

"Once upon a time when it was dark at night, the boy had a frog. The boy was looking at the frog, sitting on the chair, on the table, and the dog was looking through, looking up to the frog in a jar. That night he steeped and slept for a long time, the dog did. But the frog was not gonna go to sleep. The frog went out of the jar. And when the frog went out, the boy and the dog were still sleeping. Next morning it was beautiful in the morning. It was bright, and the sun was nice and warm. Then suddenly when he opened his eyes, he looked at the jar and then suddenly the frog was not there. The jar was empty. There was no frog to be found." 

**Down Subject, age 18, IQ 55**

"The frog is in the jar. The jar is on the floor. The jar on the floor. That’s it. The stool is broke. The clothes is laying there."
Fig. 6: Left- and right-brain processing