Gall and Modern Thinking

• Dissociation research has also demonstrated this modularity
  – Semantic dementia
    • patients have lost knowledge of the meaning of words but in early stages of the disease, have intact episodic memory
  – Anterograde Amnesia
    • patients lose the ability to retain episodic information but retain memory for facts about the world. In addition, patients with this kind of memory loss can learn motor tasks quite normally.
  – Auditory short-term memory deficits
    • patients cannot repeat a short list of words in their order of occurrence, but retain semantic memory and episodic memory.
Sensory Input

Auditory STM

Repeat a short Auditory Sequence in Order (e.g. seven digits).

Episodic memory

Repeat a longer List of Words without regard to order.

Semantic memory

Retrieve the Meaning of Words (e.g. what is a shark)?

Procedural memory

Learn a New Motor Skill (e.g. mirror image copying)
Gall and Modern Thinking

• Modern Psychology
  – The goal to understand the *details* of mental computations in a particular domain, so we need to go well beyond Gall’s notion of mental organs
  • In non-modular systems, a small change to improve one part (whether by natural selection in the case of the brain or by a human designer in the case of a machine) would have consequences (often undesirable) in many other places.
Gall and Modern Thinking

• Modern Psychology
  – *Modularity*, refers to the idea that complex neural systems responsible for some task (e.g. understanding a sentence) are organized into subcomponents -- modules -- which are functionally independent of one another
  • This *principle of modularity* makes very good sense when processing tasks are very complicated (like sentence comprehension).
Cornelia Bargmann, a neurobiologist at Rockefeller University in New York, studies how genes interact with neurons to create behavior. Two years ago, President Obama named Dr. Bargmann, who is known as Cori, a co-chairwoman of the advisory commission for the Brain Initiative, which he has described as “giving scientists the tools they need to get a dynamic picture of the brain in action.”

Currently, you spend your time trying to understand the nervous system of a tiny worm, C. elegans. Why do you study this worm?

...this little worm’s brain had just been mapped — every connection between every nerve cell and the brain. That’s roughly 7,000 connections and 300 neurons. You could look at a brain cell — which you could see because the creature is transparent — and say, “I know what that cell does. I know what it’s connected to. I know what genes it expresses.” For a researcher, that’s a lot.
In 1993, we did an experiment showing that worms could smell. This wasn't known before. Our next experiment, I think the most important my lab did, is that we made a worm neuron smell an odor it had never smelled before, and we made the animal completely change its opinion of that odor by doing that.

We had an animal that loves an odor that smells like a certain food it likes. Usually, the worm runs right toward the odor. We took the gene that is a sensor for the food from where it was normally supposed to be. We put it into a different neuron that senses things the worm finds dangerous.

Then, we "asked" the worm what it thought of this smell it usually loves. It ran away from the smell, as if it were dangerous.

This said that the odor-sensing nerve cells form an innate map where each one knows whether something is good or bad about the environment.

There's a completely unlearned internal set of preferences, a set of instincts about what's good and bad.

Now, if words, which signify nothing except by human convention, suffice to cause us to conceive of things to which they bear no resemblance, why could not nature also have established a certain sign that would cause us to have the sensation of light, even though that sign in itself bore no similarity to that sensation? Is it not thus that she has established laughter and tears, to cause us to read joy and sorrow on the faces of men?
The Diagram Makers

Diagram of the brain with labels:
- Central sulcus (fissure of Rolando)
- Arcuate fasciculus
- Broca's area
- Lateral sulcus (fissure of Sylvius)
- Wernicke's area
Letter Identification

Orthographic Lexicon

Phonological Lexicon

Semantic System

Grapheme-phoneme conversion rules

PRINT

SPEECH OUTPUT
Remarks on the Seat of the Faculty of Articulated Language,
Following an Observation of Aphemia (Loss of Speech)
by Mr. Paul Broca (1861)
Surgeon of the Bicêtre Hospital
First published in Bulletin de la Société Anatomique,
6, 330-357.
Translation by Christopher D. Green
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(return to Classics index)

[Translator's Note: I have made an explicit attempt to keep this translation as literal as possible, which accounts for some of its clumsiness in English. For instance, I have rendered “langage articulé” as “articulated language” throughout, rather than as the perhaps more felicitous “spoken language,” in order to maintain the technical style, and to distinguish it from the more colloquial “langage parlé.” I have also refrained from using the seemingly more felicitous, but less precise, “articulate language.” In addition, I have often used “ill people” for “malades” rather than “patients,” especially in the first half of the article, because it emphasizes their condition rather than their relationship to the physician. I have also tried to retain the archaic vocabulary as much as possible. Special thanks to Classics Editorial Assistant, Daniel Denis, whose recommendations improved the translation immeasurably. -cdg-]

The paper and remarks that I am presenting to the Anatomical Society comes to the defense of the ideas professed by Mr. Bouillaud concerning the seat of the faculty of language. This question, both physiological and pathological, merits more attention than most doctors have accorded it up to now, and the matter is delicate enough, the subject obscure enough, and complex enough, that it seems useful to begin with some remarks relating the facts that I have observed.

I.
We know that the phrenological school placed at the front part of the brain, in one of the convolutions that lie on the orbital arch, the seat of the faculty of language. This opinion, which had been accepted, like so many others, without sufficient evidence, and which besides rested only on a very imperfect analysis of language

The Bicêtre Hospital is located in Le Kremlin-Bicêtre, which is a commune in the southern suburbs of Paris, France. It lies 4.5 km (2.8 miles) from the center of Paris. The Bicêtre Hospital was originally planned as a military hospital, with construction begun in 1634. With the help of Vincent de Paul, it was finally opened as an orphanage in 1642. It was incorporated into the Hôpital Général in 1656. In 1823, it was called the Hospice de la Vieillesse Hommes. In 1885, it was renamed the Hospice de Bicêtre. In its history it has been used successively and simultaneously as an orphanage, a prison, a lunatic asylum, and a hospital. Its most notorious guest was the Marquis de Sade.
The Bicêtre is most famous as the Asylum de Bicêtre where Superintendent Philippe Pinel is credited as being the first to introduce humane methods into the treatment of the mentally ill, in 1793.
The Bicêtre is referenced in The Birth of the Asylum from Foucault’s Madness and Civilization. In it, Pinel’s methods are classified as more devious than humane.
We know that the phrenological school placed at the front part of the brain, in one of the convolutions that lie on the orbital arch, the seat of the faculty of language.

This opinion, which had been accepted, like so many others, without sufficient evidence, and which besides rested only on a very imperfect analysis of language phenomena, would have without doubt disappeared with the rest of the system, if Mr. Bouillaud had not saved it from foundering by making some important modifications to it, and by surrounding it with a parade of evidence borrowed above all from pathology.
There is a general faculty of language that presides over all modes of the expression of thought, and it may be defined: the faculty of establishing a constant relation between an idea and a sign, whether this sign be a sound, a gesture, a figure, or any other trace.
Organs of emission and reception.

Organs of Emission
VOLUNTARY MUSCLES OF THE LARYNX, TONGUE, SOFT PALATE, FACE, UPPER LIMBS, ETC

Organs of Reception
EAR, SIGHT, TOUCH
All regular language supposes therefore the integrity,

(1) of a certain number of muscles, of the motor nerves that serve them, and the part of the central nervous system from which these nerves arise;

(2) of a certain external sensory apparatus, of the sensory nerve that departs from these, and of the part of the central nervous system to which this nerve connects;

(3) finally, the part of the brain that holds under its dependence the general faculty of language, such as we have come to define it.
…are cases where the general language faculty persists unaltered, where the auditory apparatus is intact, where all the muscles, not even excepting those of the voice and those of articulation, obey the will, and yet where a cerebral lesion abolishes articulated language!

This abolition of speech, in individuals who are neither paralyzed nor idiots, constitutes a symptom so singular that it seems to me useful to designate it with a special name. I will give it, therefore, the name of ________; it is only the faculty of articulating words that these patients lack.
….are cases where the general language faculty persists unaltered, where the auditory apparatus is intact, where all the muscles, not even excepting those of the voice and those of articulation, obey the will, and yet where a cerebral lesion abolishes articulated language!

This abolition of speech, in individuals who are neither paralyzed nor idiots, constitutes a symptom so singular that it seems to me useful to designate it with a special name. I will give it, therefore, the name of ________; it is only the faculty of articulating words that these patients lack.

Aphemia
This abolition of speech, in individuals who are neither paralyzed nor idiots, constitutes a symptom so singular that it seems to me useful to designate it with a special name. I will give it, therefore, the name of *aphemia*; it is only the faculty of articulating words that these patients lack.

We now use the term *aphasia* to denote any acquired disorder of language, and the term *Broca’s Aphasia* to refer to the disorder that Broca termed *aphemia*.
Is it only a species of memory, not for words, but for the procedure that must be followed to articulate words?

Are these patients comparable to a young child who understand the language of those around him but who can only stammer out a single syllable to express his understanding?

Broca thought this hypothesis quite likely.
Broca considered an alternative explanation.

Could aphemia be a form of *locomotor ataxia*?

If so, the faculty that these patients have lost would not be an *intellectual* faculty.

It would only involve the “general faculty of coordination of muscular action, a faculty that depends on the motor parts of the nerve centers”.
Could “aphemia” be a form of locomotor ataxia?

Problem: Patients like Tan could move their tongue and other organs of speech quite normally on clinical examination.

Why did Broca still consider the possibility that “aphemia” could be a form of ataxia?
Broca considered two hypotheses, therefore, about the faculty of articulated language.

1) It might be a “superior faculty”, because it is a part of our language faculty.

2) Aphemia might be a “trouble of locomotion”.
The Wernicke-Lichtheim Diagram

Ideation
Which is the **Nonlexical route**?
This type of diagram is known as a *functional architecture*.

The meaning of words
Auditory Form of Words

“BOOK”

“Buh” “ook”

“Buh” “ooh” “Kuh”

“Book”
Auditory Form of Words

“BOOK”
“Buh” “ook”
“Buh” “ooh” “Kuh” “Muh” “Ai” “Kuh”

“MAKE”
“Muh” “ake”

“Book”
MOOK

“BOOK”
“Buh” “ook”
“Buh” “ooh” “Kuh”

“MAKE”
“Muh” “ake”
“Muh” “Ai” “Kuh”

Muh + ooh + kuh
Damage to A will affect the ability to repeat WORDS and NONSENSE WORDS!

Damage to the Orthographic Lexicon will not affect the ability to read NONSENSE WORDS aloud!
What kind of damage will affect the ability to repeat nonsense words but leave the ability to repeat words intact, according to the Wernicke-Lichtheim diagram?
The meaning of words
The 'direct' route

HAND
Which is the **Direct Route**?
Task 1: Repeating a word spoken by the examiner.
Task 2: Repeating a nonsense word spoken by the examiner.
Task 3: Naming a picture.
Task 4: Matching a spoken (i.e. auditory) word to a picture amongst four semantically related alternatives.

“Tiger”
Task 1: Repeating a word spoken by the examiner.
Task 2: Repeating a nonsense word spoken by the examiner.
Task 3: Naming a picture.
Task 4: Matching a spoken (i.e. auditory) word to a picture amongst four semantically related alternatives.

Vision

The meaning of words

Impaired on Tasks 1, 2 and 4.
Intact on Task 3

Ideation

Pure word deafness

M

A
Task 1: Repeating a word spoken by the examiner.
Task 2: Repeating a nonsense word spoken by the examiner.
Task 3: Naming a picture.
Task 4: Matching a spoken (i.e., auditory) word to a picture amongst four semantically related alternatives.
Task 1: Repeating a word spoken by the examiner.
Task 2: Repeating a nonsense word spoken by the examiner.
Task 3: Naming a picture.
Task 4: Matching a spoken (i.e. auditory) word to a picture amongst four semantically related alternatives.
The capacity for speech production is maintained but with certain limitations. Observations of daily speech usage and the process of speech development indicate the presence of an unconscious, repeated activation and simultaneous mental reverberation (i.e. echo) of the auditory form of the word, which exercises continuous monitoring of the motor word form.

Apart from impairment in comprehension, the patient also presents aphasic symptoms in speech produced by absence of the unconscious monitoring of the spoken sound.
Wernicke argued that damage to Centre A in the Wernicke-Lichtheim diagram can affect the ability to produce language from Ideation (e.g. produce the name of a familiar object if shown a picture of that object).

a) True
b) False.
The meaning of words

- Task 1: Repeating a word spoken by the examiner.
- Task 2: Repeating a nonsense word spoken by the examiner.
- Task 3: Naming a picture.
- Task 4: Matching a spoken (i.e. auditory) word to a picture amongst four semantically related alternatives.
Task 1: Repeating a word spoken by the examiner. ✔
Task 2: Repeating a nonsense word spoken by the examiner. ✔
Task 3: Naming a picture. ✔
Task 4: Matching a spoken word to a picture amongst four semantically related alternatives.

Vision

YIFE

"You" "Wife"
"Year" "Life"
"Young" "Knife"
Task 1: Repeating a word spoken by the examiner. ✔
Task 2: Repeating a nonsense word spoken by the examiner. ✔
Task 3: Naming a picture. ❌
Task 4: Matching a spoken word to a picture amongst four semantically related alternatives. ❌

Vision

Diagram with labeled nodes and arrows indicating connections.
Task 1: Repeating a word spoken by the examiner.
Task 2: Repeating a nonsense word spoken by the examiner.
Task 3: Naming a picture. ❌
Task 4: Matching a spoken word to a picture amongst four semantically related alternatives. ✔️

Vision

Ideation

M

A
Task 1: Repeating a word spoken by the examiner. ❌
Task 2: Repeating a nonsense word spoken by the examiner. ❌
Task 3: Naming a picture. ❌
Task 4: Matching a spoken word to a picture amongst four semantically related alternatives. ✅
Task 1: Repeating a word spoken by the examiner. ✓
Task 2: Repeating a nonsense word spoken by the examiner. ✗
Task 3: Naming a picture. ✓
Task 4: Matching a spoken word to a picture amongst four semantically related alternatives. ✓

Vision

Conduction aphasia
Which tasks would be impaired given the lesion in red?

a) Task 1 only  
b) Tasks 1 and 2 only  
c) Tasks 1, 2, 3, and 4.  
d) Tasks 1, 2 and 4.
HOW CAN WE IDENTIFY THE ACTUAL MODULES OF MIND?

- Letter Identification
- Orthographic Lexicon
- Phonological Lexicon
- Grapheme-phoneme conversion rules
- Semantic System
- PRINT
- SPEECH OUTPUT
FOR READING
A DANGEROUS FELINE PREDATOR
A MEASURE OF VOLUME FOR LIQUID BODY PART

BOOK
LEOPARD
PINT
HAND

LEXICAL
BOOK IS PRONOUNCED ‘UK’
B IS PRONOUNCED ‘BUH’
B-O-O-K IS ‘BOOK’

NONLEXICAL
B-O-O-K

GRAPHEME-
PHONEME
CONVERSION
RULES

LETTER IDENTIFICATION
ORTHOGRAPHIC
LEXICON

PHONOLOGICAL
LEXICON

SPEECH OUTPUT

PRINT
TASK 1: READ ALOUD
YINT, GOOP, SIFE, LUNK ETC.

TASK 2: READ ALOUD
PINT, ACHE, BEAD, BOTH, ETC.

PHONOLOGICAL DYSLEXIA
IMPAIRMENT TO NONLEXICAL ROUTE

SURFACE DYSLEXIA
IMPAIRMENT TO LEXICAL ROUTE

WE ALWAYS MEASURE IMPAIRMENT RELATIVE TO A GROUP OF NORMAL CONTROLS
A classic double dissociation

Accuracy

100%

50%

Exception words

Pronounceable Nonsense words

Surface Dyslexic
Phonological Dyslexic
Normal Control
This is **not** a classic double dissociation

Why not?
This is **not** a classic double dissociation

Why not?

Patient A is better than Patient B on Task X. Patient B is better than Patient A on Task Y.
PHONOLOGICAL AND SURFACE DYSLEXIA TOGETHER MAKE UP A DOUBLE DISSOCIATION BETWEEN THE LEXICAL AND NON-LEXICAL READING ROUTE.

THE EXISTENCE OF THESE TWO READING DISORDERS PROVIDES EVIDENCE THAT THESE TWO ROUTES FROM PRINT TO SOUND ARE SEPARATE FUNCTIONAL COMPONENTS (MODULES) OF THE READING SYSTEM.

ANOTHER WAY TO STATE THIS IS THAT THE LEXICAL AND NON-LEXICAL READING ROUTES ARE DOUBLY DISSOCIABLE.
Associations versus Dissociations

Patients with semantic dementia *almost* always show impaired ability to read orthographically irregular words.

There is an *association* between semantic dementia and surface dyslexia.

Is there some (as yet) unknown relationship between the ability to understand a word and the ability to access its orthographic form?
Once in a while (say 1 in 50 cases) a patient can be found with semantic dementia who shows normal ability to read orthographically irregular words (i.e. the patient has semantic dementia but does not have surface dyslexia).
49 cases out of 50 show an **association** between semantic dementia and surface dyslexia.

1 case out of 50 shows a **dissociation** between semantic dementia and surface dyslexia.

What does this latter result mean for the evidence that an **association** exists between semantic dementia and surface dyslexia in 49/50 cases?
Answer 1: The association is due to cortical atrophy. There is no *functional relationship* between the Semantic System and the Orthographic Lexicon.

A “mere” association

Cortical Atrophy
49/50 cases
Answer 2: The details of a functional architecture differ slightly from person to person. Most readers must access the meaning of a word like leopard in order to read it aloud.
Answer 2: For a few individuals, reading orthographically irregular words does not require access to its meaning.

Retrieving the orthographic form of a word (e.g. leopard) does not require access to its meaning.
Which theory is correct and how do we go about deciding between alternatives? The original diagram-makers were not very sensitive to this issue. Even contemporary research in cognitive neuroscience has only quite recently begun to grapple with the problem of variability and individual differences, a topic to which we shall return in Chapter 5.
According to Wernicke, the Centre for Ideation was

a) a single centre that stores the meaning of individual words.
b) a system of multiple sensory and motor representations.
c) a set of abstract rules indicating how we should use words to produce meaningful sentences.
We understand the meaning of a word like “bell” by contacting a memory of how a bell sounds, what it looks like, how it feels (if we have the chance to touch or use one), how much a typical bell weighs, and so on. The sensory and motor memories of our combined experiences with bells as physical objects constitute the meaning of the word.
MEANING IS GROUNDED IN SENSORIMOTOR REPRESENTATIONS.

MARCO TETTAMANTI ET AL

I KICK THE BALL

I GRASP A KNIFE

I BITE THE APPLE

CONTROL CONDITION: ABSTRACT SENTENCES LIKE I APPRECIATE SINCERITY.
WHAT ABOUT ABSTRACT WORDS?

George Lakoff-- the mind is "embodied". Human cognition, including the most abstract reasoning, depends on and makes use of such concrete and "low-level" facilities as the sensorimotor system and the emotions.
THE MEANING OF AN ABSTRACT WORD LIKE “ARGUMENT”

“Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature.”

METAPHOR -- AN ARGUMENT IS LIKE WAR OR FIGHTING.

- He won the argument.
- Your claims are indefensible.
- He shot down all my arguments.
- His criticisms were right on target.
- If you use that strategy, he'll wipe you out.

According to Lakoff, the development of thought has been the process of developing better metaphors.
Skeletal concepts like “go”, “place” and “agonist” maintain connections to physical reasoning….Yet as they take part in moment-to-moment thinking, they are abstract symbols, and need not drag with them images of hunks of matter rolling around”.

70
The embodied view

*Thought is carried out in the brain by the same neural structures that govern vision, action, and emotion. Language is made meaningful via the sensory-motor and emotional systems, which define goals and imagine, recognize, and carry out actions. Now, at the beginning of the twenty-first century, the evidence is in. The ballgame is over. The mind is embodied.*

George Lakoff (Preface)
Prices are going up

Up

More = Up
If I look upward when I hear the word “UP”, then that response is part of the meaning of “UP”.

How do I then go from that response to UP, to:

*The price of gasoline is up?*

Answer: Via a principle of similarity from our embodied experience of a pile of books growing upward to the abstract notion “more”.
What about UP in:

gassing up before a journey?
filling up a beer mug?
finishing up my work?
closing up shop?
mopping up the floor?

Answer: we extend the metaphor of UP=MORE to the idea of COMPLETION.

Pinker: It’s the abstractness of the idea COMPLETE that’s doing the work for us!
The abstract ideas define the dimensions of similarity...that allow a conceptual metaphor to be learned and used.  

*metaphor alone.*
The essential issue

The metaphorical flavour of language comes from the fact that skeletal concepts like “go,” “place,” and “agonist” maintain connections to physical reasoning. They are most easily triggered by the experience of seeing things move around; they are used by children in spatial senses before they are used in abstract senses...yet as they take part in moment-to-moment thinking, are abstract symbols.

versus

As far as meaning goes, we are distinguished from other animals not in that we've evolved a brand new mental organ but rather that we have recycled older systems for a new purpose. We use our primate perception and action systems not only when we're actually perceiving or acting but also when we're understanding language about perceiving or acting.